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Working Styles of Student Translators in Revision and Post-editing: an Empirical-Experimental Study with Eye-tracking, Keylogging and Cue-based Retrospection

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Working Styles of Student Translators in Revision and Post-editing: an Empirical-Experimental Study with Eye-tracking, Keylogging and Cue-based Retrospection

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Abstract and Keywords

In today's translation profession, being skilful at revision (including self-revision and other-revision) and post-editing tasks is becoming essential for translators. The exploration of the working styles of student translators in the revision and post-editing processes is vital in helping us to understand the nature of these tasks, and may help in improving pedagogy. Drawing on theories from translation-related studies, cognitive psychology, and text comprehension and production, the aims of this research were to: (1) identify the basic types of reading and typing activity (physical activities) of student translators in the processes of revision and post-editing, and to measure statistically and compare the duration of these activities within and across tasks; (2) identify the underlying purposes (mental activities) behind each type of reading and typing activity; (3) categorise the basic types of working style of student translators and compare the frequency of use of each working style both within and across tasks; (4) identify the personal working styles of student translators in carrying out different tasks, and (5) identify the most efficient working style in each task.

Eighteen student translators from Durham University, with Chinese as L1 and English as L2, were invited to participate in the experiment. They were asked to translate, self-revise, other-revise and post-edit three comparable texts in Translog-II with the eye-tracking plugin activated. A cue-based retrospective interview was carried out after each session to collect the student translators' subjective and conscious data for qualitative analysis. The raw logging data were transformed into User Activity Data and were analysed both quantitatively and qualitatively.

This study identified seven types of reading and typing activity in the processes of self-revision, other-revision and post-editing. Three revision phases were defined and four types of working style were recognised. The student translators' personal working styles were compared in all three tasks. In addition, a tentative model of their cognitive processes in self-revision, other-revision and post-editing was developed, and the efficiency of the four working styles in each task was tested.

Keywords: working styles, physical and mental activities, self-revision, other-revision, post-editing.

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Abbreviations and Glossary

ANOVA:	Analysis of Variance
Bi-:	Bilingual
CLP:	Content, Language and Presentation
CRITT TPR:	Centre for Research and Innovation in Translation and Translation Technology, Translation Process Research
CU:	Activity Units
del:	Deletion
Dur:	Duration
EAMT:	The European Association for Machine Translation
EEG:	Electroencephalography
EYE:	Eye tracking
FD:	Fixation data
fix:	Fixation
fMRI:	Functional Magnetic Resonance Imaging
FU:	Fixation unit
GPS:	Gaze percentage on screen
IELTS:	International English Language Testing System
ins:	Insertion
KD:	Keystroke data
KEY:	Keystroke logging
L1:	Mother language
L2:	Second language
LSD Test:	The Fisher Least Significant Difference Method Tests
Ma-:	Macro-
MFD:	Mean fixation duration
Mi-:	Micro-
ms:	Milliseconds
MT:	Machine Translation

NLP:	Natural Language Processing
OR:	Other-revision
ParalK:	Parallel keystrokes with fixations
PE:	Post-editing
PETT:	Post-edited Target Text
PoS tagging:	Part-of-speech tagging
ProgGraph:	Progression graph
ProgGraph:	Progression Graph
PU:	Production unit
RQ:	Research Questions
RTA:	Retrospective Think-aloud
s:	Seconds
SL:	Source language
SQ:	Sub-question
SR:	Self-revision
ST:	Source text
STAU:	Source text attention unit
TAP:	Think-aloud Protocols
TL:	Target language
TPR-DB:	Translation Process Research Database
TPR:	Translation Process Research
TT:	Target text
TTAU:	Target text attention unit
UAD:	User Activity Data
Uni-:	Unilingual
Win:	Window
WM:	Working memory
XML:	Extensible Markup Language

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Chapter 1

Introduction

The present study is an empirical investigation of the working styles of student translators in revising their own and others' translation drafts ('self-revision' and 'other-revision', Mossop, 2001, pp. 168-169), and in post-editing raw machine translation output (full post-editing). In this study, the term 'working style' is defined as student translators' coordination of physical and mental activities; 'physical activities' refers to the student translators' reading and typing activities during the working process, while 'mental activities' is confined to the underlying 'purposes' behind the physical activities in a narrow sense. The examination of the student translators' coordination of physical and mental activities shed light on their cognitive processes when doing self-revision, other-revision and post-editing, and made it possible to identify and compare their working styles.

The motivation for this study originally came from the author's personal experience as a student translator. The importance of self-revision and other-revision practice has been emphasised for a long time, not only for quality control reasons but also for pedagogical purposes. Researchers believe that by self-revising, one's language and knowledge competence can be restructured (e.g., Mizón and Diéguez, 1996); and by being revised by others, both the translation and the translator are 'revised' (e.g., Brunette, 2007). Textbooks (e.g., Mossop, 2001; 2007; 2014) provide detailed and useful guidelines on how to self-revise and revise the work of others efficiently to improve translation quality. However, for student translators, putting these descriptive 'theories' into practice is another skill they have to learn.

In recent years, empirical studies have been conducted to investigate the relationship between revision quality and time, expertise, types of revision and procedures (e.g., Künzli, 2006; 2007; Brunette *et al.*, 2005; Robert, 2008; 2013; Robert and Van Waes, 2014), to explore the revision habits of professional translators and policies (e.g., Shih, 2006a; Rasmussen and Schjoldager, 2011), and also to probe into translators' cognitive processes and patterns during revision (e.g., Shih, 2003; 2006a; 2006b; 2013; 2015). The findings of these studies have valuable implications for both translator training

and future research. With the methodological developments that have been taking place in translation studies, eye tracking and keylogging are triangulated to generate even richer and more objective data for process-oriented research. It was thus envisaged that, if the self-revision and other-revision processes of professional and student translators could be visualised and compared, the findings may provide insightful suggestions for translation pedagogy. The same expectation existed with post-editing.

1.1 Overall Aims

The first aim of this thesis is to present a data decoding and analysis method, which realises the visualisation of the self-revision, other-revision and post-editing processes in time, using the Translation Process Research (TPR) data analysis framework developed by the Center for Research and Innovation in Translation and Translation Technology (CRITT) at the Copenhagen Business School. The contribution lies in the devising of the different procedures used to decode raw logging data containing Chinese characters. Problems and relevant solutions are presented to provide researchers with ideas for troubleshooting. The second aim is to identify and compare the working styles (coordination of physical and mental activities) of student translators in revising their own output, the output of other translators and translation output done by a computer, and to test the general assumption that these working styles vary within and across tasks. The third aim, based on the general assumption that working styles affect student translators' working efficiency, is to identify the fastest working style in completing each task. Lastly, it is hoped that the findings will contribute to translator training didactics by investigating and revealing the self-revision, other-revision and post-editing behaviour of untrained student translators. In future research, their behaviour will be compared with that of professional translators, revisers and post-editors, to identify areas that student translators need to work on and to provide suggestions for a translation course syllabus.

1.2 Research Questions

The research questions (RQ) of the present study are as follows:

RQ1: What types of reading and typing activity can be identified in the self-revision, other-revision and post-editing processes?

RQ2: What are the underlying purposes behind these activities?

RQ3: What are the working styles of student translators in performing self-revision, other-revision and post-editing?

RQ4: How do the working styles of student translators vary within and across tasks?

RQ5: To what extent do working styles affect the working efficiency of student translators in each task?

1.3 Theoretical Underpinnings

This study draws largely on research from three disciplines: (1) translation (revision and post-editing) process studies; (2) cognitive psychology, and (3) text comprehension and production. Studies related to the coordination of reading and typing activities, as well as the working styles in translation, revision and post-editing, are reviewed to provide a theoretical basis for the current study (e.g., Mossop, 2014; Robert, 2008; 2013; 2014; Dragsted and Carl, 2013; Mesa-Lao, 2014; Carl *et al.*, 2015a). The cognitive information-processing model (e.g., Baddeley and Hitch, 1974; Baddeley, 1986; 2000; Baddeley, 2007) and visual attention theories (e.g., Just and Carpenter, 1980; Duchowski, 2007; Rayner, 1998; 2006; 2009) are borrowed from the field of cognitive psychology to provide a theoretical underpinning for the correlation between reading activities and mental activities in the working process. Text comprehension, analysis and production models (e.g., van Dijk and Kintsch, 1983; Kellogg, 1996; Krings, 2001; Hvelplund, 2011) are used as the basis for the analysis of student translators' mental activities in the working process.

1.4 Methodology and Data

1.4.1 Data Collection Tools

This study employed two main non-intrusive data elicitation methods to collect data: keylogging and eye tracking. Keylogging data are collected by Translog-II, a computer programme which registers all typing and mouse events in real time. Its interface consists of two windows: the upper window displays the source text and the lower window displays the target text. The programme is now embedded with the eye-tracking system which enables the simultaneous recording of eye-tracking and keylogging data. A Tobii TX300 eye-tracker unit (a remote eye tracker) is attached with a 23″ liquid crystal display (LCD) monitor at 1920 x 1080 pixels to elicit data. The sampling rate is 300 Hz.

Cue-based retrospection was conducted after the experiment sessions to collect qualitative data.

Figure 1 presents the data collection model used in this study.

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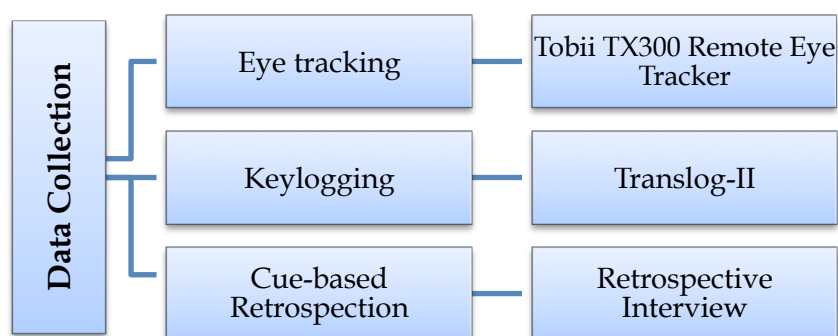
Figure 1: Data Collection Model

1.4.2 Participants

A total of 36 participants enrolled on the MA Translation module at Durham University were invited to take part in the experiment (see section 4.1). These participants, whose first language was Chinese and second language was English, were informed of the ethical principles that guided the research and were asked to sign a consent form prior to the experiment. All participants had comparable levels of language competence, and none of them had received any professional training in self-revision, other-revision or post-editing in advance of conducting any of the tasks. They were able to touch type simple Chinese characters in Sogou (Chinese input method software). Their typing speed was tested and compared prior to the experiment, and three rounds of screening were conducted during the experiment to ensure data quality: pre-experiment screening, in-experiment screening and post-experiment screening. Pre-experiment screening primarily checked the participants' educational background, eye condition and typing capability; in-experiment screening filtered out the incomplete and noisy data caused by unsuccessful or poor calibrations, and post-experiment screening confirmed the quality of the eye-tracking data by scrutinising the mean fixation duration and gaze percentage on screen. After the screenings, the data of 18 participants were selected for data analysis, and all participants were credited with a 15% discount shopping voucher as an acknowledgement (see Appendix 12).

1.4.3 Texts

Three comparable English texts (A, B and C) were chosen as the source texts for this study (see section 4.2). They were composed of the same text type (plain text) and length (100 words) (see Appendix 1). Text comparability was tested both quantitatively and qualitatively. The quantitative measures used were readability indices (Flesch Reading

Ease, Flesch-Kincaid Grade Level, Automated Readability Index, Coleman-Liau Index, Gunning Fog Index and SMOG Index), word frequency (British National Corpus) and non-literalness (text analysis). The assessment of professional translators and the participants' feedback from the pilot studies were used as the quantitative measures.

1.4.4 Lab Environment

The experiments were conducted in the eye-tracking lab in the School of Modern Languages and Cultures at Durham University. The fluorescent lamp in the room produced constant luminosity (see section 4.1.1.1).

1.4.5 Data Analysis Methods

In the study, data were analysed both qualitatively and quantitatively. The qualitative analyses were based on a translation progression graph (see section 5.2.2) and cue-based retrospection data. User Activity Data (see section 5.2.1) were used for the quantitative analysis. To reduce the risk of observing significant effects that were driven by random outliers, the distributions of all datasets were checked first. The skewed data were logarithmically transformed and saved for significance tests. One-way ANOVA with post-hoc tests were run in Statplus to do multiple pairwise comparisons (see section 5.4).

Figure 2 summarises the research questions of this study and the data analysis methods.
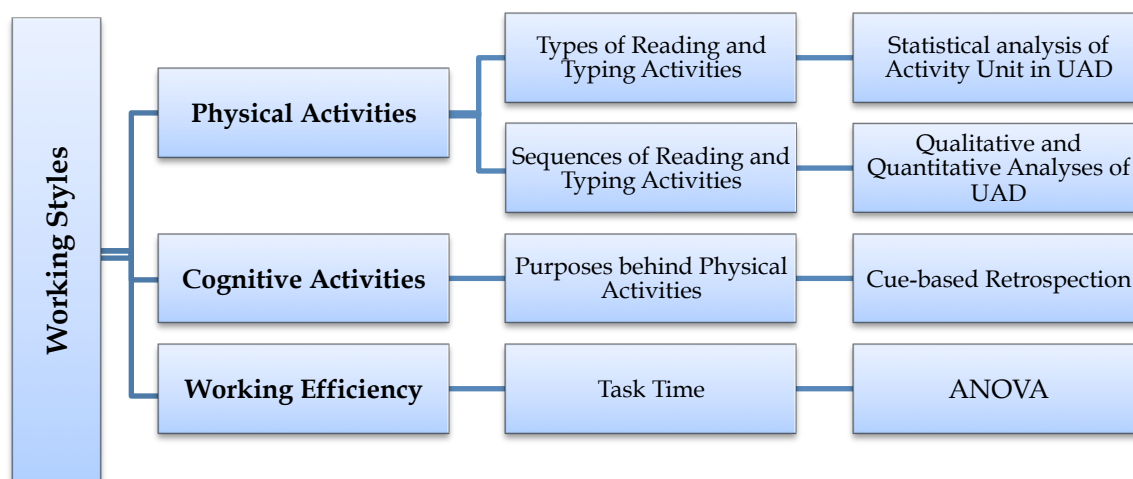
Figure 2: Research Questions and Data Analysis Methods

1.5 Delimitation

As briefly mentioned in section 1.1, the author had hoped to conduct a comparison between the working styles of professional translators or post-editors and student translators. Owing to time and space constraints, however, the present study took the investigation of student translators' self-revision, other-revision and post-editing styles as

a starting point. Similar studies with professional cohorts are in plan so that both groups' performance can be compared in the future.

This study was process-oriented and did not include any analysis of text quality. In future, the data collected in this study will be further analysed from a combination of linguistic, behavioural and cognitive perspectives, comparing the correlation between the types of error, detection speed, gaze patterns and translators' mentalities.

Given that every individual has a self-tailored way of thinking, reasoning and acting, the types of working style identified in this study may not be representative of all working styles. In addition, since there are numerous sequences of reading and typing activities in the data, it is impossible to interpret them all from a micro-view at the current stage. With the help of statistical modelling, it is hoped that in the future, human annotated cognitive data, together with the sequential activity data, will be learned by computers to produce analytical results regarding the translation, revision and post-editing processes of human beings.

1.6 Structure of the Thesis

This thesis consists of nine chapters.

Chapter 1 provides a general introduction to this study.

Chapter 2 reviews the theoretical reflections on revision, translation and post-editing working styles, and introduces the cognitive information processing model, as well as the text comprehension, analysis and production models.

Chapter 3 presents the data collection tools, settings and data analysis methods.

Chapter 4 outlines the research design of this study by describing the considerations for participants' recruitment, the selection of research texts, the arrangements made for tasks and experiment procedures, and the feedback from two rounds of a pilot study.

Chapter 5 focuses on the data compilation process that took place preparatory to the qualitative and quantitative analyses. In this chapter, the UAD compilation procedures dealing with raw logging data containing Chinese characters are demonstrated within the CRITT TPR data analysis framework; data analysis tools used for translation process studies (i.e., process data units and translation progression graphs) are presented, and the post-experiment data quality assessment and the statistical analysis tools used in this study are discussed.

Chapters 6, 7 and 8 present the results and findings of this study.

In Chapter 6, the student translators' reading and typing activities are statistically analysed and compared both within and across tasks. The cue-based retrospection data

are presented and analysed to provide insights into the student translators' mental activities.

Chapter 7 presents the three working phases that were identified in the self-revision, post-editing and other-revision processes. In each phase, the types of reading and typing activity sequences are compared by analysing the gazing and typing patterns in progression graphs. Based on the sequences of reading and typing activities, and combined with the cue-based retrospection data, the student translators' mental activities in each phase are analysed; a tentative cognitive revision and post-editing model is constructed, and four different types of working style are identified.

Chapter 8 examines the impacts of working style and task type on the student translators' working efficiency.

Chapter 9 provides a conclusion which sums up the findings, strengths and weaknesses of this study, and suggests possibilities for future follow-up work.

Chapter 2
Theoretical Underpinnings

In this chapter, the relevant literature on translation revision and post-editing processes is reviewed, and multidisciplinary theories from cognitive psychology and text comprehension and production are presented. These provided the theoretical underpinnings for the current study. Section 2.1 introduces the basic concepts of revision and empirical investigations of revision styles. Section 2.2 presents the basic concepts of post-editing and reviews the existing literature on post-editing styles. Section 2.3 provides an insight into the human brain, eyes and actions from the perspective of cognitive psychology. Section 2.4 introduces the theoretical framework of text comprehension and production. Section 2.5 reviews and analyses the various types of reading and typing activity and the purposes underlying these activities in the translation and post-editing processes.

2.1 Revision

2.1.1 Basic Concepts of Revision

Before the publication of the new European norm for translation services in 2006 (*The European Standard EN 15038: Translation Services – Service Requirements*), there were two major issues concerning revision: terminology inconsistency and different emphases on 'New Rhetoric Formula' elements (Nord, 2005, p.41).

(1) Terminology Inconsistency

The terms that are used to describe the revision process of a translated text vary among translation agencies, researchers and even translators themselves. 'Proofreading', 'editing', 'checking', 'reviewing' and 'correcting' are used as general terms in the translation industry to refer to the task of revision. Martin (2007, p. 58), in his article concerning risks and resources management, mentions another set of synonyms which are increasingly being used to convey the concept of revision: 'cross-reading', 're-reading',

'quality controlling', 'proofreading' etc. Terminology inconsistency is an important issue that should not be ignored, as it may cause confusion to both translators and clients, incur unnecessary costs and even have legal ramifications.

In 2006, *The European Standard EN 15038: Translation Services – Service Requirements* was published. One of its aims was to unify the terms used in the domain of translation:

> To revise: to examine a translation for its suitability for the agreed purpose, compare the source and target texts, and recommend corrective measures.

> Reviser: the reviser shall be a person other than the translator and have the appropriate competence in the source and target languages. The reviser shall examine the translation for its suitability for purpose. This shall include, as required by the project, comparison of the source and target texts for terminology consistency, register and style.

> Checking: On completion of the initial translation, the translator shall check his/her own work. This process shall include checking that the meaning has been conveyed, that there are no omissions or errors and that the defined service specifications have been met. The translator shall make any necessary amendments.

> Review: examine a target text for its suitability for the agreed purpose and respect for the conventions of the domain to which it belongs and recommend corrective measures.

> Proofreading: checking of proofs before publishing.
> (*BS[1] EN 15038*, 2006, p. 6)

(2) Different Emphases on 'New Rhetoric Formula' Elements

Despite the clarification of *The European Standard EN 15038*, since researchers have been paying attention to translation revision since the 1980s (e.g., Graham, 1983), the usages of the terms relating to revision in translation studies still vary.

According to Nord (2005, p. 41), there are two pivotal factors that determine a text's communicative function: extratextual factors and intratextual factors, the interplay of which can be expressed by the set of WH-questions (who says what, how, when, where, why, to whom, with what effect). This is also called the 'New Rhetoric Formula' (Nord, 2005, p. 41). The lack of conformity in the definitions of revision is derived mainly from the fact that researchers attach different weights to the elements of the 'New Rhetoric Formula'. In translation revision, the WH-questions can be slightly adapted to

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[1] BS is for British Standard.

'who revises what, how, when, where, why, to whom, and with what effect'. Different emphases on the above elements lead to different understandings of revision.

To present the various existing definitions of revision in the literature, the method of permutations and combinations of the 'New Rhetoric Formula' elements (the WH-questions) is used in this study.

2.1.1.1 Revision as a Part of the Translation Process

'Who' revises 'What' and 'When'?

Revision has long been considered a part of the translation process by many researchers. For instance, Chesher (1991) considered revision as an integral part of the translation process, taking place both during and following the drafting phase. Rose (1991, pp. 5-6), from a cognitive perspective, suggested three steps in the translation process: comprehension of the source text, the actual transfer, and the expression that entails revision. From a practical view, Sorvali (1998, pp. 143-148) described the stages of the translation process as familiarisation with the text to be translated, production of a (rough) translation, and editing to produce the final version. Seeing translating as a writing process, Jääskeläinen (1999, p. 116) categorises the stages of the translation process as 'the pre-writing stage, the writing stage and the post-writing stage'. Jakobsen (2003, p. 192) identifies three different phases in the translation typing events according to the logged keystroke data: an initial orientation phase (the activities before the typing of the first letter), a drafting phase (from the first to the last letter during the first translation draft) and an end revision phase (the activities after the drafting phase). He distinguishes 'online revision' from 'end revision', in keeping with their stages of occurrence. Online revision is undertaken in the drafting phase, whereas end revision takes place immediately after the first full drafting of the target text (TT) has been completed, with the purpose of checking the translation (Jakobsen, 2003, p. 193).

In a more recent study, Carl *et al*. (2010) consider the phases in the translation process as: gisting (a period when the translator acquires a preliminary notion of the ST), drafting (when the actual translation is typed) and post-editing (when some or all of the drafted text is re-read, typing errors are corrected and sentences are rearranged or reformulated). While not all researchers regard revision as a separate phase in the translation process, they all seem to share the same view as Séguinot (2000) and Breedveld (2002) on how revision takes place: the translators themselves are the performers of revision, revising their own drafts.

2.1.1.2 Revision as Translation Quality Control

'Who' revises, 'Why' and with 'What Effect'?

Translation quality is undoubtedly a key issue in any of the translation norms and standards, and is seen as extremely important by both translation agents and clients. Revision is often associated with quality control (assessment, management) and is considered as 'a way to assure the quality of the translation products before they finally reach the clients' (Graham, 1983, pp. 103-104). It is understood as the evaluation of a translation from both process-oriented and product-oriented perspectives (e.g., Reiss, 2000; House, 1997; 2001; Hansen, 2010) and is designated by Chakhachiro (2005) as a subfield of translation criticism. From a financial starting point, Martin (2007, no page) sees revision as 'a valuable and costly resource […] best deployed in a spirit of active risk-management'. He suggests that no revision is better than poor or unnecessary revision. Mossop (2007, p. 121) agrees with Martin (2007) on this point and notes that the mere fact that a translator spends time on quality control is meaningless. The real question should be: 'to what extent is the time that a translator is spending contributing to the quality of the final product?' It can be seen that, from Mossop's point of view, quality is not simply related to the final translation. It also refers to the quality of revision, and the quality (expertise) of a reviser. In an interview conducted in 2007 by the *Journal of Specialised Translation* (issue 08), Louise Brunette, the co-author of the first revision guideline book *Pratique de la Révision*, defines revision as 'a comparative operation of the source text and target text in order to detect what is acceptable, what needs to be changed and change it if needed' (Brunette, 2007). In the interview she emphasises the fact that revision is not only an operation performed on the text itself, but that it also has a didactical or pedagogical aim; in other words, 'we revise a text, but we also revise a person; we revise a translator' (Brunette, 2007). This explains the reason why a growing number of researchers have started to conduct longitudinal studies on revision training (e.g., Hansen, 2005; 2006; 2008) and comparative studies on revision procedures (e.g., Brunette *et al.*, 2005, with a creed of 'even better for less cost'). The rationale lies in the fact that revision is a costly method of translation quality control, and that there is a real need for professional revisers who are able to create more value in the limited time available in the market. The percentages of work time and production cost are usually correlated with quality assessment results in translation service companies (Mossop, 2007, p. 121).

2.1.1.3 Revision as Correction or Self-correction

'Who' revises 'Whom' and 'Why'?

To revise is to correct errors. In a survey study of revision policies in Danish translation companies, Rasmussen and Schjoldager (2011) found that many respondents considered revision to be simply the correcting of errors. Mossop (2007b, p. 109), defines revision as 'that function of professional translators in which they identify features of the draft translation that fall short of what is acceptable and make appropriate corrections and improvements'. This definition points to the function of revision, i.e., to improve the translation by making proper corrections. In order to distinguish between revision activity carried out by the translator or by somebody else, Mossop (2007b, p. 167) creates two terms to refer to the different concepts - 'self-revision' and 'other-revision'. Gile (1995, p. 53) defined revision as 'the inspection and correction of a translation by a reviser after the translator has completed the task.' He believed that the reviser should normally be an experienced translator (other than the original translator) who reads and corrects the translations. This definition is inconsistent with the terminology defined in *Translation Services – Service Requirements; the European Standard EN 15038* (2006). In an article where they suggest using self-correction as a methodological tool in translation courses, Mizón and Diéguez (1996, p.75) proposed the term 'self-correction', on the grounds that students' language and knowledge competences can be restructured during the activity of self-correction. In a more recent article, Malkiel (2009, p.150) states that 'revision involves a series of self-corrections […] which is not necessarily a change from incorrect to correct, but can involve a subtle alteration.' He categorises self-corrections into three types: self-corrections of grammar; self-corrections of meaning, and instances in which the students type a word or phrase, delete it and then retype it verbatim. What should be noted here is that the concept of 'correction' proposed by Gile (1995) is different from the concept of 'self-correction' put forward by Mizón and Diéguez (1996) and Malkiel (2009). These two terms are in effect variants of the terms 'other-revision' and 'self-revision' (Mossop, 2001; 2007; 2014).

2.1.1.4 Revision as a Reading Process

'Who' revises 'What' and 'How'?

Revision is a reading process. According to Delisle *et al.* (1999, p. 175), the term revision refers to 'a detailed comparative examination of the target text (TT) with the respective source text (ST) in order to verify that the sense is the same in both texts and to improve the quality of the target text'. This definition indicates that, during the revision process,

the reviser needs to read the ST and the TT to compare the two texts in order to achieve consistency of register, style and terminology. The processing of the TT is described by Mossop (2001, p. 116) as 'unilingual re-reading', the purpose of which is to find words or phrases that do not make sense in the translation. The comparable reading of the ST and the TT is called 'comparative re-reading'. Its aim is to detect inaccuracies and omissions, and then make suitable changes. Other similar terms include 'unilingual revision' and 'comparative revision' (Rasmussen and Schjoldager, 2011). Brunette *et al.* (2005) propose two similar terms - 'monolingual revision' and 'bilingual revision'. However, it should be noted that, in Brunette *et al.*'s (2005) definition, a translator who conducts 'monolingual revision' revises the TT without the presence of the ST, whereas the translator who carries out 'bilingual revision' is provided with both the ST and the TT.

2.1.1.5 The Borderline of 'Revision' in this Study

Apart from the definitions mentioned in section 2.1.1, there are other terms created by researchers based on different considerations (see Table 1). For instance, 'pragmatic revision' and 'didactic revision' (Brunette, 2000) are used to describe the purposes of revision. 'Full revision' and 'less-than-full revision' (Mossop, 2007) refer to the degree of revision. 'Justified changes', 'hyper-revision', 'over-revision' and 'under-revision' are criteria used to describe the effectiveness of the changes (Künzli, 2007). 'External revisions' are actual changes that are made, whereas 'internal revisions' only take place in the translator's mind (Künzli, 2007). Some translators prefer to revise on paper ('on-paper revision'), while others are used to revising with the use of computers ('on-screen revision') (Robert, 2008). If the two consecutive changes being made in a text are very close together, they are called 'short-distance revisions'; and if they are far away from each other, they are categorised as 'long-distance revisions' (Carl *et al.*, 2010).

	Considerations	Terminologies
Typology of Revision in Translation Studies	Function (For what purpose)	Pragmatic Revision and Didactic Revision Brunette (2000)
	Reviser (Who revises whom)	Self-revision and Other-revision Mossop (2001; 2007)
	Phase (When)	Online Revision and End Revision Jakobsen in Hansen (2003)
	ST (With or without ST)	Bilingual Revision and Monolingual Revision Brunette *et al.* (2005)
	Degree (To what extent)	Full Revision and Less-than-full Revision Mossop (2007)
	Effectiveness (With what effect)	Justified Changes, Hyper-revision, Over-revision and Under-revision Künzli (2007)
	Place (Where)	External Revision and Internal Revision Künzli (2007)
	Instrumentality (By what device)	On-screen Revision and On-paper Revision Robert (2008); Haussteiner (2009)
	Revision Interval (Distance)	Long-distance Revision and Short-distance Revision Carl *et al.* (2010)
	Processing method (How)	Unilingual Revision and Comparative Revision Rasmussen and Schjoldager (2011) Monolingual Re-reading and Comparative Re-reading (Mossop, 2001)

Table 1: Typology of Revision in Translation Studies

Most translation agencies require translators to revise their own translations after completion of the first draft, and translators are sometimes asked to revise other translators' work for quality assurance purposes. This study compared student translators' physical and mental activities in revising their own translation drafts and in revising the translations of others: how they read and type during revision, and why they revise in a certain way. From the various types of revision presented above, the term 'revision' in this study is dichotomised and confined to:

- **Self-revision**, where a student translator revises his/her own work after the completion of the translation draft. The **drawer time,** that is, the time during which the TT is put away from the student translator (Shih, 2006a, p. 295) was set at **one night**. The student translator who conducts self-revision is called a 'self-reviser'.

- **Other-revision**, where a student translator revises a translation produced by a second translator. The student translator who conducts other-revision is called an 'other-reviser'.

- Unlike the EU definitions of 'revision' and 'reviser' (see section 2.1.1), the term '**revision**' as used in this study refers to **both self-revision and other-revision,** as defined above. However, the purposes of self-revision and other-revision are the same as the purpose of 'revision' established by the EU: 'to examine a translation for its suitability for the agreed purpose… and recommend corrective measures' (BS EN 15038, 2006, p. 6).

It is important to point out that:

- This study only considers the actual linguistic changes registered by the key logger.

- **The revisions made during the initial translation process were not examined. Instead, this study focuses on the revision activities made on the first translation draft after one night's drawer time.**

- The present study does not follow Jakobsen's (2003) definition of the three phases in the translation process (orientation, drafting and end revision). Instead, the three phases identified in the processes of self-revision, other-revision and post-editing in the current study are **the planning, drafting and final check phases.** This will be discussed in section 7.1 in detail.

With respect to the types of reading in the revision procedures, in this study the following terms are used:

- **Unilingual ST reading**: a single ST reading without TT reading.

- **Unilingual TT reading**: a single TT reading without consulting the ST.

- **Bilingual reading**: comparative ST and TT reading.

With regard to the types of revision made during the different reading behaviours, the following terms are used:

- **Unilingual revision**: reading and revising the TT without consulting the ST.

- **Bilingual revision**: reading the ST and the TT comparatively and making changes.

Please note that in order to be consistent in the use of terminologies, and to avoid confusion, in this study the different terms used by other researchers are compressed into the above confined terms.

2.1.2 Revision Styles

As discussed in section 2.1.1, revision has both pragmatic and didactic functions in translation studies. Many researchers have looked into the cognitive process of revision in translation, with the aim of discovering the revision styles that professional and student translators remain faithful to, and which style results in higher working efficiency and better translation quality.

This section presents studies that discuss revision styles, the cognitive processes of revision and the types of revisers in translation studies. The literature review gives an insight into translators' coordination of the reading and typing activities in the revision process as discussed by different researchers.

<u>Mossop (2014)</u>

Mossop's book *Editing and Revising for Translators* (2014) is in its third edition, the two previous editions having been published in 2001 and 2007.

Mossop (2014, pp. 134-149) categorises revision parameters into four groups. The first group is ST meaning transfer problems (Transfer), which refers to the accuracy and completeness of the ST meaning transfer in the expression of the TT. The second group concerns content problems (Content), that is, whether the TT is logical and whether it contains any factual, conceptual or mathematical errors. The third group relates to the problems of language style (Language), which includes the smoothness, sub-language (genre, terminology and phraseology), rhetorical effects and tailoring of the target language (TL) to suit the target readers, as well as the rules of grammar, spelling, punctuation and style used in the TL. The last group is the problems of presentation (Presentation), including layout, typography and organisation. Based on these four groups of problems, he further categorises the revision parameters into two kinds: transfer parameters (accuracy and completeness) and CLP parameters (problems in the categories of Content, Language and/or Presentation).

Although studies examining revision parameters and revision problems have provided useful insights into translation pedagogy (e.g., Künzli, 2006; 2007), Mossop (2014, p. 165) states that simply knowing *what* to look for is not enough; instead, attention should also be focused on *how* to look for the problems.

In Chapter 12 of Mossop (2014, pp. 151-166), two aspects of the revision procedure are discussed. These may be summarised as follows.

(1) Procedures for Finding Errors

Mossop discusses five questions concerning the procedures for finding errors during the other-revision process.

The first question concerns how to check the Transfer parameters and the CLP parameters. Should one check both parameters in one run-through of the texts, or run two separate checks, one for Transfer and the other for CLP? Mossop (2014, p. 166) suggests that, time permitting, two separate checks are preferred, as 'detecting one type of error can get in the way of detecting the other type'. However, two separate checks may still cause a dilemma for translators, because it is hard for someone to focus on the 'micro-problems' (problems at a word or phrase level) and 'macro-problems' (problems at a text level) at the same time. This dilemma mainly affects unilingual revision, as it focuses both on micro- and macro-problems, whereas bilingual revision focuses primarily on micro-level problems. He suggests that, if time permits, two unilingual revisions should be run, with the first looking for macro-problems and the second looking for micro-problems. A further separate check is recommended, but from a practical point of view this is not often possible.

The second question concerns the order of the separate checks; which should be done first, the bilingual revision or the unilingual revision? Mossop considers the bilingual revision to be the check for Transfer parameters and the unilingual revision the check for CLP parameters. He takes three factors into consideration. Firstly, all other things being equal, a unilingual revision should be carried out before a bilingual revision, because this gives the reviser a golden opportunity to read the TT from a reader's point of view. Secondly, revisers should consider their own error-introducing tendencies during the other-revision process. If they know that they have a tendency to introduce a lot of CLP errors into a text they are revising, then they should do the bilingual revision prior to the unilingual revision, to make sure there is still an opportunity to do a final check for CLP problems. If they tend to make Transfer problems more often, then the unilingual revision should be conducted prior to the bilingual revision. Thirdly, if the job emphasises the importance of avoiding CLP problems, then the unilingual revision should be done last; and if the avoidance of Transfer problems is more important, the bilingual revision should be carried out after the unilingual revision.

The third question concerns the level of reading and revision. Should one carry out a unilingual revision at text level to check the CLP problems first, and then do a bilingual revision at text level and check the Transfer problems; or should one do a unilingual revision at sentence or paragraph level to check the CLP problems and then do a bilingual revision on the same sentence or paragraph to check the Transfer problems,

before moving on to the next sentence/paragraph? Mossop suggests that a unilingual revision at text level should be carried out first. Even if there is some ambiguity which requires referral to the corresponding ST segment(s), one should make some kind of mark and come back to it in the following bilingual revision. His explanation is that one should not lose track of the macro-features of the TT, such as the flow of the argument.

The fourth question relates to the timing of ST reading. Should one read the ST first or last during bilingual revision? Mossop's suggestion is that one should read the ST last in all circumstances. This is because, on the one hand, reading the ST may influence one's judgement about the quality of the TL; and on the other hand, after reading the ST one loses the reader's viewpoint, thus it is harder to find Transfer problems in the TT.

The last question proposed is about the size of reading unit during bilingual revision. How many words should one read at a time during revision? Since no empirical study has researched this question, he suggests that one should not read a small unit in one language and then read a large unit in the other language, as this may cause failure to notice some bad literal translations.

In this problem-detecting phase, it seems that Mossop suggests two run-throughs of the texts - one unilingual revision and one bilingual revision. With regard to the order of the entire revision operation, he provides another version of the procedures.

(2) Order of Operations

Since revision is a costly act, and most of the time revisers do not have time for lengthy procedures, Mossop (2014, p. 174) suggests the following revision procedures:

a. Work as a proofreader and carry out a unilingual TT reading to check Presentation parameters (layout, typography etc.).

b. Conduct another unilingual TT reading to check the CLP parameters. Consult the ST only when there are logic problems.

c. Do a bilingual revision to check for Transfer problems, during which you should keep looking for style changes (problems in Smoothing, Tailoring and Sub-language). This step is only for translators translating into their first language.

d. Carry out two read-throughs - one unilingual reading and one bilingual reading - in whatever order is preferred.

Although Mossop's suggestions relate the revision procedures to working efficiency and revision quality, his recommendations are actually quite confusing, as his statements are

in places contradictory. For instance, in the section entitled '(1) procedures for finding errors', he suggests not reading the ST during unilingual revision until bilingual revision starts, even if there is ambiguity in the TT. However, in this section (Order of Operations), he suggests reading the ST when there are logic problems in the TT. Also, in section 1 (Procedures for Finding Errors) he suggests keeping the checks for Transfer problems and CLP problems as two separate procedures when detecting errors, since those two types of error may interact and confuse the reviser. However, in this section (Order of Operations), he suggests continuing to look for CLP problems while detecting Transfer problems (in step 3).

This is probably because, as Mossop (2014, pp. 167-169) himself claims, the whole point of empirical testing is to provide evidence, and determine the most effective method of revision, in terms of working efficiency and quality assurance. However, the lack of any empirical foundation obliges him to rely on logic alone to devise a recommended procedure which is only hypothetical in nature.

Brunette *et al.* (2005)

The GERVIS project (*Groupe de Recherché en Revision Humaine*) conducted by Brunette *et al.* (2005) is an empirical study which set out to find the most effective method for improving the quality of revision. The study hypothesised that monolingual revision (unilingual revision without referring to the ST) was just as effective as comparative revision (with the presence of the ST), and that the former could be practised at a lower cost and was also less time-consuming than the latter.

In their study, 14 professional translators (seven males and seven females with an average of 15 years of experience) were classified into two groups to revise texts that had been translated from English into French and from French into English respectively. The texts were selected from a corpus which included texts that had been translated and revised by other translators in 2001. The participants were asked to do the monolingual revision first, and no time constraints were imposed. A few days later, they were asked to perform comparative revisions using both the ST and the TT.

The findings, however, ran contrary to the research hypotheses. It was found that comparative revision out-performed monolingual revision in terms of revision time, the number of errors detected and the quality of the final TT. Brunette *et al.* (2005, p. 43) pointed out that, to some extent, monolingual revision was even less helpful than no revision. However, they proposed that a reviser who works exclusively in one language

might produce a satisfactory monolingual revision. This gave rise to another question: are there any translators or revisers who carry out monolingual revision in real-life scenarios?

Robert (2008)

Robert (2008) provided a good response to the question raised above. In order to explore professional revisers' working procedures in other-revision, she conducted two small-scale surveys. In the first survey, carried out in 2006, the respondents were asked to select the revision procedure(s) which best described their normal working style in revising others' translations. The following seven revision procedures were provided (p. 10):

A. A unilingual revision without reference to the ST at all (i.e., a monolingual revision for Brunette *et al.*, 2005).
B. A unilingual revision (only referring to the ST when necessary).
C. One run-through of bilingual revision.
D. A unilingual revision followed by a bilingual revision.
E. A bilingual revision followed by a unilingual revision.
F. A unilingual ST reading first, followed by a bilingual revision and a unilingual revision.
G. A unilingual ST reading first, then a unilingual revision, followed by a bilingual revision.

117 questionnaires were sent out and respondents were asked to choose their most commonly used procedure, as outlined above. Based on the 48 answers obtained, the statistics showed that:
- 56% of the revisers selected E (Bilingual revision +[2] Unilingual revision).
- 21% of the revisers selected D (Unilingual revision + Bilingual revision).
- 12% of the revisers selected C (Bilingual revision).
- 9% of the revisers chose 'either D or E'.
- 5% chose B (Unilingual revision).
- 2% selected A (Monolingual revision).
- None for F (Unilingual ST reading + Bilingual revision + Unilingual revision).
- None for G (Unilingual ST reading + Unilingual revision + Bilingual revision).

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[2] The symbol 'A + B' means 'A together with B'.

Taking into account the fact that the data might be slightly skewed owing to the 'guidance' of the choices, a second small-scale survey was conducted in 2007. In this survey, descriptions of procedures E, D, C and B (the most popular ones identified in the first survey) were provided, and the respondents were asked to select those that best described their revision behaviour. 101 email messages were sent to the same group of respondents, and data from 21 respondents were deemed valid for analysis. This time, the statistics showed that:

- 36% of the revisers selected E (Bilingual revision + Unilingual revision).

- 29% of the revisers chose B (Unilingual revision).

- 20% of the revisers selected C (Bilingual revision).

- 15% of the revisers chose D (Unilingual revision + Bilingual revision).

It was also found that most of these respondents were flexible in the selection of these procedures because:

- 47.6% of the respondents selected a description of all four procedures.

- 28.4% selected a description of only one procedure.

- 14% chose a description of three procedures.

- 10% chose two procedures.

Based on the findings from these two surveys, Robert (2013) and Robert and Van Waes (2014) further tested the impact of the above four popular procedures (E, B C, D) on revision.

Robert (2013) and Robert and Van Waes (2014)

Robert (2013) set out to investigate whether the choice of revision procedure matters in terms of revision process (revision time and error detection potential) and product (quality).

16 professional revisers were invited to revise four comparable TTs of 500 words, each using a keylogging computer programme, *Inputlog*[3]. Each time, they had to employ a

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[3] Inputlog is keylogging software which records all keystrokes and mouse events. Visit http://www.inputlog.net/ for details.

different one of the four procedures to revise (B: Unilingual revision; C: Bilingual revision; E: Bilingual revision + Unilingual revision; D: Unilingual revision + Bilingual revision) according to the revision parameters provided. There were four different kinds of revision parameter: (1) a 'loyal' revision considers only the ST content and meaning transfer; (2) a 'functional' revision takes only the TL and its readability into consideration; (3) a 'minimal' revision concerns grammar, spelling and transfer, and (4) a 'full' revision considers all the previous three aspects. No time constraints were set for the tasks, and participants were provided with Internet access and printed dictionaries (Dutch into and from French dictionaries). During all the experiment sessions, the participants were asked to verbalise their revision processes (think-aloud). Immediately after the experiments, short retrospective interviews were conducted to collect the subjects' conscious data. A cohort of senior professional translators were invited to revise the final revised translations using the same criteria. The ANOVA Friedman test was used as the method of statistical analysis.

The statistics indicate that, with respect to the quality of revision, a significant effect was discovered in full-, loyal- and minimal-revision settings, but not in a functional-revision setting. Revision duration was only measured for a full-revision setting, and the statistics show a significant effect of the procedure on revision duration. With respect to error detection potential, a significant effect of the procedure was found in full- and loyal-revision settings, but not in functional- and minimal-revision settings. In other words, revision procedures have an effect on quality, total task time and the number of errors detected in different revision parameter settings.

Based on these findings, Robert and Van Waes (2014) analysed the same set of data using Multilevel statistical tests (Leijten, 2007, p. 130) to investigate further which revision procedure is to be recommended in terms of working efficiency and quality. After analysing the data, they provided answers to the three most commonly asked questions:

(1) Does one need the ST to revise the translation?

In full-, loyal- and minimal-revision settings, the answer is yes. Bilingual revision is significantly more efficient than unilingual revision in terms of quality and error detection, and it does not take significantly more time.

However, in a functional revision setting, the choice is free. Unilingual revision is as efficient as bilingual revision with the ST, but it does not take significantly less time.

(2) How many times should one read the translation, once or twice?

In all settings, it is suggested that if time is more important than quality, a unilingual revision is most appropriate, as it is considerably faster than the two two-step procedures (unilingual revision + bilingual revision; bilingual revision + unilingual revision). When the quality is more important, unilingual revision should be avoided, and the choice is free among bilingual revision, unilingual revision + bilingual revision and bilingual revision + unilingual revision. There are no significant differences between these three procedures in terms of revision time and error detection potential.

(3) If one intends to revise twice: i.e., one bilingual revision and one unilingual revision, which order should be followed?

In all settings, the answer for this question is clear-cut. Translators can choose freely either way, as there are no significant differences between these two procedures.

To summarise, Robert (2013) and Robert and Van Waes (2014) found that:

- Regarding the quality of revision and error detection potential, in full-, loyal- and minimal-revision settings, bilingual revision =[4] unilingual revision with bilingual revision = bilingual revision with unilingual revision >[5] unilingual revision.

- Regarding the quality of revision and error detection potential, in a functional setting, bilingual revision = unilingual revision with bilingual revision = bilingual revision with unilingual revision = unilingual revision.

- Regarding revision time, in all settings, bilingual revision = unilingual revision with bilingual revision = bilingual revision with unilingual revision > unilingual revision.

These answers correspond well with Mossop (2014), and it seems that empirical investigations have proved that the order of bilingual revision and unilingual revision in two subsequent separate checks does not affect either the quality or the duration of the revision. However, there are several issues that arose in Robert's studies.

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[4] The symbol '=' here means 'be equal to'.

[5] The symbol '>' here means 'be better than'.

The research design used in Robert (2013) and Robert and Van Waes (2014) was based mainly on the previous research findings of Robert in 2008, in which four types of revision procedure preferred by professional revisers were identified through two small-scale surveys.

The first and most important question to be asked is: to what extent do these revisers do what they claim to do in real revision scenarios? Künzli (2007) and Englund Dimitrova (2005) both found that professional translators did not always do what they said they would do in experiments, probably because, as professionals, they were aware of the rules of revision, but behaved differently in specific situations.

Secondly, in two of the small-scale surveys, respondents were provided either with the seven revision procedures (A, B, C, D, E, F, G) formulated by the author, or with the descriptions of the four most popular procedures (E, D, C, B). A more ecological design of the study should have asked the revisers briefly to describe their revision procedures, rather than giving them a list of the procedures or descriptions; and a more valid data collection method, such as think-aloud, video recording or a triangulation of eye tracking with keylogging should have been used to observe the revisers' working procedures in real-life scenarios. Since the subsequent studies (2013; 2014) asked the revisers to work with the texts using one of the four procedures at a time, they had no opportunity to demonstrate their real working process, but were required to act in a controlled environment.

Thirdly, data obtained from the first survey showed that five out of seven procedures were selected by the revisers, whereas they only had the choice of four procedures in the second survey and in the subsequent studies. Since both surveys were small-scale, it is possible that the translators would normally employ other procedures to work on certain text types.

Lastly, it seems that the four types of revision procedure described by Robert (2008; 2013; 2014) included only two run-throughs of the texts at most: bilingual revision with unilingual revision, or unilingual revision with bilingual revision. However, in real circumstances, do revisers only read through the texts twice? If not, how should one fit the 'more than two run-throughs' working style into the four types of revision procedures?

Despite the above questions, Robert's (2008) study was one of the earliest empirical studies carried out to investigate the types of revision procedure, and it has not only provided useful insights into the cognitive process of other-revision, but also paved the way for future research into this area.

Rasmussen and Schjoldager (2011)

This study employed online questionnaires and interviews as data collection methods to investigate the revision policies in translation companies, taking Denmark as a case in point. The online questionnaire data showed that although not all translations are subject to other-revision in the translation companies, the majority of respondents (15 out of 24) claimed that they sent 91-100% of their translations for other-revision. It should be noted that, in most cases, the translations were not revised by professional or contract revisers, but by translators working in the same company who not only translate but also revise the work of colleagues. Feedback was given in a peer-to-peer fashion. The statistics also show that 15 out of 22 respondents submitted 91-100% of their translation for bilingual revision, while other respondents claimed that because revision was costly, they would only conduct unilingual revision if they had doubts about the TT content. The interview data also indicate that the revision was for the most part comparative. Some of the translators preferred a full bilingual revision followed by a unilingual revision, whereas others stated that they normally carried out a unilingual revision first and then a bilingual revision, but only referred to the ST when necessary.

According to the paper, only three of the revision procedures discussed by Robert (2008; 2013; 2014) were mentioned by the professional translators in Denmark: unilingual revision, unilingual revision with bilingual revision, and bilingual revision with unilingual revision. It seems that bilingual revision is carried out by choice among professional translators in the translation industry. The limited sample size might be an explanation for this, but another question worth investigating further is whether language pair and the directionality in revision are factors that influence the revision procedures.

Shih (2006a)

Shih (2006a) conducted one of the earliest empirical investigations of professional translators' self-revision working styles. Using interviews as the data collection method, Shih (2006a, p. 299) studied the following questions:

(1) How many times do translators think they revise?
(2) How long and in what circumstances do translators claim they put their drafts away?
(3) Which aspects do translators think they check for during revision?
(4) What revision procedures do translators think they use?

Twenty-six professional non-literary translators were invited to attend the interviews and answer these questions based on their personal experience. The results show that the

translators were aware of the length and urgency of the task. Most of them thought that revising once or twice was essential, and others claimed they would revise three to four times. With respect to the duration of drawer-time, the translators' answers ranged from zero to seven days. Two of the most common answers were immediate revision with no drawer-time, and a drawer-time of one day. It seems that they were aware of the importance of their flexibility in drawer-time, because its length is mainly decided by external factors, such as time constraints, text length and translation quality.

Shih (2006a) also compared the revision checklist summarised from her interview data with Mossop's (2001) revision parameters. The checklist included additional categories to those found by Mossop. One possible explanation for this is that translators' gaining of higher levels of expertise involves self-awareness of their own weaknesses and the formation of working styles tailored specifically to their individual revision processes.

With regard to the most commonly used revision procedures, seven translators stated that they would do bilingual revision at sentence level (i.e., sentence by sentence) in their first revision; two translators claimed that they would do bilingual revision either in the first or the later revision, but not at sentence level; seven translators said they would carry out unilingual revision, referring to the ST only when necessary, and the remaining two declared that they would only do unilingual revision, without comparing the TT with the ST at all.

As briefly mentioned above, since the subjects interviewed were professional translators, it is likely that they had a good knowledge of how to revise their own work. Shih (2006a) suggests that student translators should do a bilingual revision at the end of the revision phase to check for accuracy problems. Besides regular reflection on one's revision practice, Shih (2006a, p. 310) also recommends that student translators 'explore the dynamics and the description of their own practices' in order better to understand the nature of revision and to enhance their translation performances.

Shih (2006b)

With the aim of exploring and analysing the revision behaviour of practising translators' in real scenarios, Shih (2006b) examined 26 professional non-literary translators' strategic revision (self-revision) approaches and behaviour. The aim of the study was to find out 'when, how, in what circumstances, and potentially why translators revise, particularly after the first draft' (Shih, 2006, p. 3). In other words, it investigated translators' global revision approaches and strategic revision behaviour, especially after the completion of the first translation draft. Global revision approaches refer to translators' beliefs about

and principles of revision, their translation/revision maxims[6] and the disparities between different translators' revision approaches. Strategic revision behaviour denotes translators' revision processing patterns (how translators strategically manage their time and effort in revision), differences in translators' revision styles, and the interplay between the decision-making and problem-solving mechanisms in their strategic revision behaviour.

Shih (2006b) employed interview and think-aloud protocols (TAP) as data collection methods and used 'processing lines' to analyse the TAP data. 'Processing lines' is an analytic instrument adapted from Gerloff's (1988) 'patterns of movement'. Based on a general assumption that the segments being verbalised by a translator are also being processed by the translator, Gerloff (ibid.) used wavy and straight lines to record the translators' patterns of movements in the translation process. These lines not only traced the segments that were being processed, but could also be used to analyse the translators' problem-solving activities. In order to measure these lines quantitatively, Shih (2006b) designed numbered coloured lines to distinguish source text processing from target text processing and target text writing. In Figure 3 below, the upper window presents sample TAP data collected by Shih (2006b, p. 119). The red lines are ST reading and the blue lines are the verbalised TT. According to Ericsson and Simon (1993), these red and blue lines are 'Level 1 verbalisations', which indicate that the information is stored in linguistic form in the working memory (see section 2.3.1) and can be directly verbalised. The black lines are 'Level 2 verbalisations', as the information is not stored in linguistic form in the working memory and thus needs to be encoded into linguistic form before verbalisation. The lower window presents the coding of processing lines. The red lines depict the ST processing, the blue lines indicate TT processing, and the dashed lines represent the verbalisation of previously verbalised segments (repetition). These lines are numbered in order to quantify the frequency or intensity of the processing and to monitor translators' backtracking behaviour.

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[6] Translation/revision maxims refer to two notions. The first is a principle which acts as a guideline for translators/revisers to translate or revise. It is more explicit, and the translators/revisers are more likely to be aware of their own principle. By contrast, the other is more implicit, and indicates a typical cluster of related parameters that translators/revisers may not be aware of.

TAP data	Level 1	• Provide the single most powerful link to our distant origins.
	Level 2	• 這句話它要說的是 (Back translation: This sentence wants to say that . .)
	Level 1	• 嗅覺讓我們和最原始的人類有了強力的連結 (Back translation: Smell makes us have a strong connection with the most primitive humans.)
	Level 2	• 所以應該是說 (Back translation: So it is supposed to say . .)
	Level 1	• [嗅覺]讓我們和最原始的人類或遠古時代的人類 (Back translation: [smell] makes us with the most primitive humans or humans in the ancient era . . .)
	Level 1	• distant origins

	Coding of processing lines in relation to the ST	. . providing the single most powerful link to our distant origins.
		
		1._____
		
		2. _____
		
		3. _____ _ _ _ _ _ _ _ _ _ _ _ _____
		
		                    4. _____
		
		                    5. _____

Figure 3: Processing Lines

This data analysis method is in fact very similar to the data analysis tool, the progression graph (see section 5.2.2), used in the current study. Progression graph (ProgGraph) also uses different coloured symbols to illustrate the ST and TT processing, but it combines both eye tracking and keystroke logging data, and can be used to provide a holistic view of the entire revision process or a selected part of the revision process. With the eye tracking, keystroke logging and the aligned ST and TT data, the sequences of the reading and typing activities, as well as the different revision phases, can be mapped out.

The findings regarding translators' global revision approaches are reported in Shih (2006a). With respect to translators' strategic revision behaviour, Shih (2006b) found that:

- On the one hand, the translators dealt with the revision problems they encountered while reading through the TT; on the other hand, they applied their revision maxims and actively searched for the problems for revision.

- Most of the professional translators did not refer back to the ST on a regular basis while revising, however, they did check the TT segments against the mentally tagged ST segments. This means the TT was checked/revised based on the mentally processed ST propositions or macrostructures of the text (see section 2.4). This not only explicated why professional translators seldom referred back to the ST while revising, but also explained why some translators were left with serious translation mistakes even after revision – their mentally tagged ST had been misinterpreted in the initial comprehension stage during the translation process.

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- The majority of the professional translators spent the most time and effort producing the first translation draft. After that, they were allowed to take a break and then revise. Findings showed that two revision processing patterns were identified. The first revision pattern involves one run-through of the TT, during which substantial changes/efforts were made. In other words, the translation draft was revised once, but the ways in which the translators managed their time and efforts in translation and revision were very similar. The second revision processing pattern involved two or more run-throughs of the text, but after the intensive translation process, in the revision phase, the translators simply glanced through the TT in later run-throughs.

- One explanation for the first revision processing pattern is that the break served as a 'cognitive refreshment' (Shih, 2006b, p. 171), after which the translators were able to regain their concentration. The other is that during the break the translators could defamiliarise themselves with the TT to give themselves a fresher view of it.

- Another finding was that the more a translator revises, the longer stretch of chunks s/he can process at one go. This is because repeated reading of a text accelerates a translator's comprehension of the text and enables the translator to go beyond the micro-structural level of the text to a more macro-structural level (see section 2.4). This explains why in the second revision processing pattern, the translators were able to process the TT much more quickly in later run-throughs – they had become better readers of the text. This confirms Gerloff's (1988) finding that more experienced translators can process longer chunks of text at a time. In addition, in her later work (2006b), Shih confirms one of the findings of her earlier (2003) study. That is, some translators have a re-checking phase towards the end of the revision process to make sure that they have solved all problems and/or to justify the changes they have made.

Shih's (2006b) research is the first empirical study which has touched upon both the global revision approaches and the cognitive revision behaviour of professional translators from English to Chinese. Her findings regarding the revision processing patterns and earlier/later run-throughs are highly relevant to some of the research questions of the present study: the working styles of student translators and the different phases in the process of self-revision, other-revision and post-editing. More comparisons will be made in Chapter 7: Working Styles of Student Translators.

Shih (2003; 2015)

With regard to the cognitive process of self-revision, Shih (2003; 2015) made the earliest attempts to uncover the mental processes taking place in the human 'black-box' from an empirical perspective.

Shih (2003) conducted two consecutive experiments, inviting three student translators at a post-graduate level to translate a 300-character Chinese text into English on the first day, and to revise their translation draft on the second day, while thinking aloud in both sessions. No time constraints were set for either task, and participants were provided with different kinds of reference tools (e.g., monolingual and bilingual English/Chinese dictionaries, collocation and technical dictionaries and a thesaurus). Interviews were conducted after the completion of the self-revision task.

By scrutinising the think-aloud and interview data, a cognitive self-revision process diagram (Figure 4) was constructed, which includes the following five cyclical steps (Shih, 2003, p. 10):

a. Evaluating the translation draft by phrasing (and re-phrasing) or reading a ST/TT segment.

b. Identifying a problem by first realising and then verbalising a problem.

c. Evaluating preliminary solutions.

d. Using inference strategies to propose problem solutions by back-translating a segment, re-reading the ST/TT segment, re-reading the revised TT (the preliminary solution), verbalising the mental organisation of the ST/TT segment, reading the corresponding ST segment, re-calling what was done before.

e. Using referencing strategies to propose problem solutions by checking dictionaries.
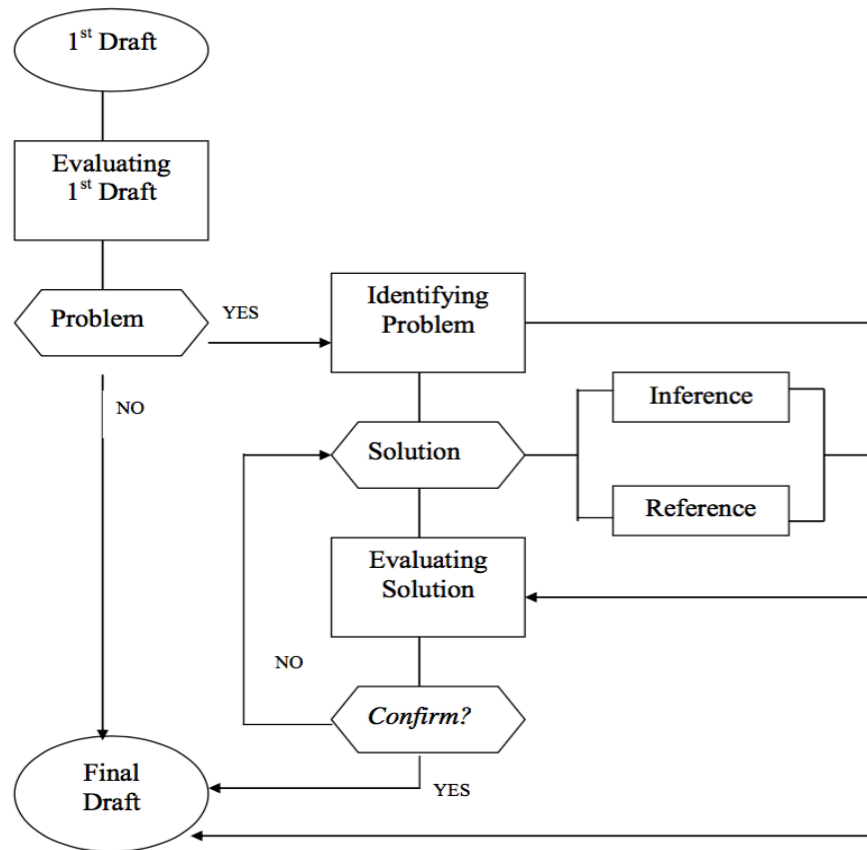
Figure 4: Shih's Revision Model

The findings of this study were quite inspiring for the present study, as not only were the mental activities in the self-revision process revealed, but also, the physical activities with the potential underlying purposes were identified in each sub-process (e.g., in step 4, physical activity: ST reading; corresponding purpose: using inference strategies for problem solution).

By examining two professional translators' end-revision processes with think aloud data, Shih (2015) further explored the decision-making and problem-solving processes of the translation end-revision process, drawing on theories from both cognitive psychology and translation studies. Based on her findings, Wilss's (1996) decision-making model was adapted into a tentative model of end-revision decision making and problem solving (Figure 5), which included the following cyclical procedures (p. 87):

a. Identify a problem.

b. Define a problem (unlike the decision-making model in translation, this procedure is optional in the end-revision process).

c. Generate a solution.

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d. Test or evaluate the solution (by using different strategies, e.g., 'monitoring strategies'[7], to make positive or negative judgements; internalised decision-making criteria were drawn on).

e. Accept the solution (by using different strategies, e.g., 'bolstering strategies' or 'de-emphasising',[8] to determine the final solution when there are competing solutions). In this stage, the acceptance of a solution can either lead to the termination of the focus on a particular translation problem, or bring the decisio - maker into a post-choice stage where the solutions are re-assessed.

OR

f. Reject the solution.
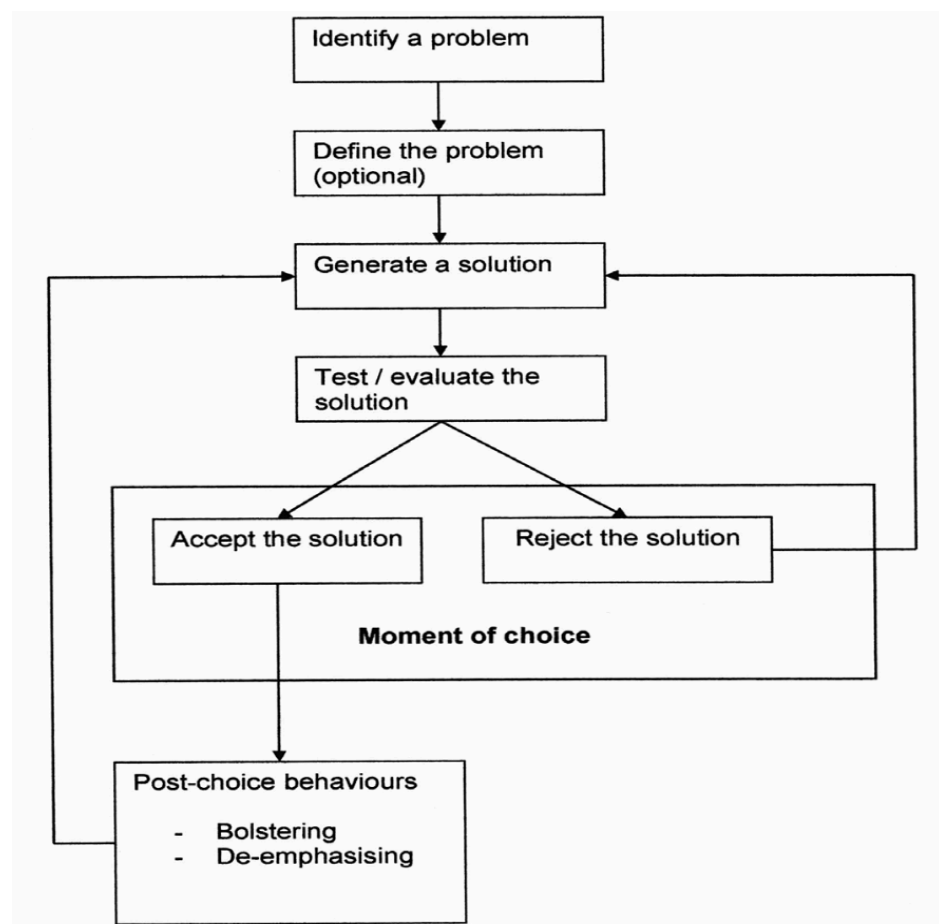
Figure 5: Shih's Tentative Model of End-revision Decision making and Problem solving

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[7] 'Monitoring strategies', as identified by Krings (1986), refers to the evaluation procedure carried out immediately after a translation segment has been produced.

[8] 'Bolstering strategies' and 'De-emphasising strategies' are two of the decision-making strategies identified by Montgomery (1989, p. 25). The former refers to the act of strengthening the advantages of the choices and making the choice more attractive, whereas the latter de-emphasises the disadvantages of the choices.

This study found that, although the problem-solving model in translation studies is slightly different from that in the end-revision process, the decision-making models in translation serve the translation revision process well.

By comparing Shih's (2003; 2015) models with Hayes *et al.*'s (1987) revision process model in writing studies (Figure 6, from Alamargot and Chanquoy, 2001, p. 105), it can be seen that the revision procedures are in fact quite similar (i.e., positive or negative evaluation, problem identification and solution), with the exception of 'modification of text and plan' in the problem solution procedure 'redrafting'. Translators are much less flexible than writers in manipulating the content of the TT in translation, since they have to be loyal to the original ST.

Besides the process of revision, Hayes *et al.* (1987) also incorporated revisers' knowledge into the model to reveal the correlation between a person's physical and mental activities. Since reading is a key process in revision, it is interesting to discover what types of reading and typing activities there are in the revision process, and what purposes motivate these physical activities. These points are discussed in more detail in section 7.2.2.3.
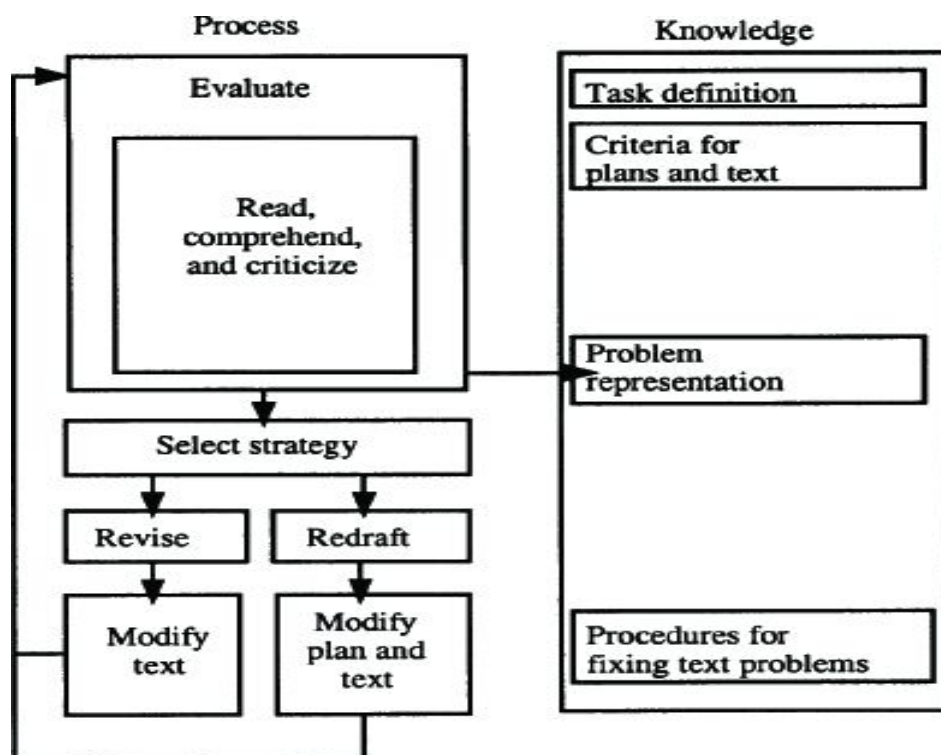
Figure 6: Hayes *et al.*'s Revision Model

2.1.3 Summary

In sections 2.1.1 and 2.1.2, the literature on the various definitions of revision, as well as the textbook suggestions and empirical investigations on the procedure and process of translation revision, were reviewed.

By reviewing the existing literature on revision procedure, it was found that:

- Owing to a shortage of empirical studies on revision procedures, researchers rely on 'logic' to 'deduce a recommended procedure from a hypothesis' (Mossop, 2014, p. 169). It is vital that translation revision theories should be backed up with empirical evidence. A good example is the reading of the ST in the revision process. Mossop (2014, pp. 168-169) suggested that the ST should always be read last in all circumstances, and that the reviser should not read the ST during unilingual revision until bilingual revision starts. However, according to Shih (2006a, 2006b) and Rasmussen and Schjoldager (2011), professional translators do not refer to the ST on a regular basis when revising. Robert and Van Waes (2014) also found that in a functional revision setting (only taking the TL and its readability into consideration), unilingual revision is as efficient as bilingual revision with ST reading. Since the studies mentioned above focused on the revision behaviour of professional translators, what is the situation with student translators? Do they adopt similar or different approaches when revising? Which approach is more efficient? What suggestions can we make? These questions need further investigation and empirical evidence is required. The present study answers these questions based on empirical data (see Chapters 7 and 8).

- Owing to a lack of solid and objective grounding in the data collection methods used by Robert (2008; 2013; 2014), the four types of revision style she identified need to be re-examined.

- Following Shih's (2006a, p. 310) suggestion that student translators should 'explore the dynamics and the description of their own practices' in order better to understand the nature of revision and improve their translation performances; and given that most studies have examined the revision procedure of professional translators, an empirical study investigating student translators' revision styles is necessary.

- Shih (2006b) identified two prominent revision processing patterns, but as she noted (ibid., p. 171), there might be other revision patterns. This study will draw on her previous findings and explore other possible revision processing patterns (working styles) adopted by student translators in self-revision, other-revision and post-editing.

In translation process studies, User Activity Data (UAD, see section 3.2.3) are collected by triangulating eye tracking with keylogging, and are generated by combining and

compiling the process data with the product data (see Chapter 5). It provides both quantitative data (e.g., fixation unit, production unit, activity unit) and qualitative data (i.e., translation progression graphs) to analyse the translation process from an objective approach (see section 5.2).

By observing translators' translation progression graphs, Jakobsen's (2003) classification of the three phases of translation (initial orientation, translation drafting, final revision) was confirmed by empirical evidence. Carl *et al*. (2011) and Dragsted and Carl (2013, pp. 148-149) identified several different translator styles. For instance, in the initial orientation phase, some translators read through the ST systematically before translation ('systematic planners'); some quickly scanned the ST before translation ('scanners'); some read the first couple of words or sentences before translation ('quick-planners'), and other translators started to press the first key right away without much ST reading ('head-starters'). In the translation drafting phase, some translators read the ST at sentence level ('sentence planners') or text level before typing ('broad-context planners'); some frequently fixated the word(s) being typed, but rarely read an entire sentence far in advance ('narrow-context planners'), and others re-fixated the ST or TT words that had been translated (backtrackers). With respect to revision behaviour in translation, some translators made a considerable number of changes in the drafting phase ('online revisers'); some spent 20 per cent of the time, or more, making changes during the final revision phase ('end-revisers'), and others made many changes in the drafting phase, and spent a long time revising in the final revision phase ('constant revisers').

By observing the translation progression graphs, Jakobsen (2011, p. 48) also detected a complete 'micro-cycle' which consists of six steps in the translation process: '(1) reading the next chunk of the new ST (and constructing a translation of it); (2) moving the eyes to the TT input area to read the current TT anchor word(s); (3) typing the translation of the ST chunk; (4) monitoring the typing process as well as the screen outcome; (5) moving the eyes to the ST area to read the relevant ST, and (6) reading the current ST anchor word(s)'. As noted by Jakobsen (2011, p. 48), some of these steps can be skipped or repeated several times.

From the above studies on the translation process and translator styles, it can be seen that UAD provide a holistic view of the translation process, and the translation progression graphs clearly demonstrate a set of fine-grained translator behaviour.

The aim of the present study was to analyse student translators' working styles by examining their revision and post-editing progression graphs. Only in this way can the revision and post-editing processes be visualised and analysed from a clear and objective perspective.

2.2 Post-editing

This section introduces the concepts of post-editing (section 2.2.1.1); post-editing effort (section 2.2.1.2); post-editor profile and the needs of training (section 2.2.1.3); types of post-editing and the relevant guidelines (section 2.2.1.4), and studies investigating post-editing styles (section 2.2.2). Section 2.2.3 summarises this section.

2.2.1 Basic Concepts of Post-editing

> **Machine translation (MT)** is the application of computers to the task of translating texts from one natural language to another. One of the very earliest pursuits in computer science, MT has proved to be an elusive goal, but today a reasonable number of systems are available which produce output which, if not perfect, is of sufficient quality to be useful in a number of specific domains. (EAMT, 2015).[9]

MT has received considerable attention over the last few decades, and notable improvements have been made in recent years with the advances in the field of Natural Language Processing and with a growing number of researchers dedicated to the development of this area. Many companies, such as Google and Yahoo, provide free online MT services, attracting a large audience from all over the world who make use of the time-saving and cost-free systems. Concerning the quality of MT, nowadays, human-aided machine translation (HAMT) has replaced the fully automated high quality translation (FAHQT) in the translation industry. As mentioned by EAMT (2015), the MT output does not have to be as perfect as Human Translation (HT), as long as it provides useful information for specific purposes.

2.2.1.1 Definition of Post-editing

Before inserting the ST into an MT system, pre-editing is often needed to allow machine processing to improve the translatability of the ST, and to enhance the readability of the MT output. Post-editing (PE) is conducted to 'edit, modify and/or correct pre-translated text that has been processed by an MT system from a source language into (a) target language(s)' (Allen, 2003, p. 296), or to 'revise the output of a machine translation program' (Mossop, 2001, pp. 168-169). PE is defined as 'the correction of machine translation output by human linguists or editors' (Veale and Way, 1997), which entails 'corrections of a pre-translated text rather than translation from scratch' (Wagner, 1985), and which may be characterised as 'repairing texts' (Krings, 2001).

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[9] EAMT is the abbreviation for the European Association for Machine Translation. For more information, visit http://www.eamt2015.org/en/WELCOME-MESSAGE.html.

Obviously, PE is different from translation. A translator deals with two texts during the translation process - the ST and the newly produced TT - whereas a post-editor coordinates three texts: the ST, the MT output and the post-edited TT. According to Krings (2001, pp. 165-166), the language flaws in the MT may interfere with translators' normal reading patterns, and the already provided MT may affect translators' normal translation process.

Although revision and PE may both be considered as methods of 'text repair, Löffler-Laurian (1984, p. 237) states that 'post-editing is not revision, nor correction, nor rewriting. It is a new way of considering a text, a new way of working on it, for a new aim'. The main differences between revision and PE lie in the types of error that the reviser or the post-editor needs to deal with, the time spent on the task, and the final quality of the translation. As Krings (2001, p. 7) points out, the MT output contains recurring and predictable errors, while the task of revision is mainly to check for mistranslations, omissions etc. Although MT output and human translation contain errors of different types, they sometimes overlap to some extent. In PE, the post-editor is usually advised to spend a minimum amount of time in producing an understandable TT; while revision, as discussed in section 2.1, is conducted mainly for quality assurance purposes, and thus we assume it requires more time and effort on the part of the revisers.

2.2.1.2 Post-editing Effort

Krings (2001) classified post-editing effort into three categories: temporal effort (total time spent on PE), cognitive effort (mental processing) and technical effort (physical activities such as the number of insertions and deletions).

Cognitive effort is more difficult to examine directly than temporal and technical effort. Researchers have proposed various ways to measure cognitive effort in PE. For instance, O'Brien (2006b) suggested triangulating pause analysis with temporal and technical effort analysis to obtain a deeper insight into the cognitive processing in PE. Lacruz *et al.* (2012) introduced the average pause ratio (average time per pause/average time per word), a metric to calculate the cognitive effort in PE. Lacruz and Shreve (2014) developed another metric called pause to word ratio (number of pauses/number of words in a post-edited MT segment) to work as an indicator of cognitive effort in PE. Koponen *et al.* (2012) used post-editing time as a measure of cognitive effort, and concluded that PE time was affected by the type of error (e.g., missing word, incorrect word form, wrong punctuation etc.). The shorter the editing time, the less cognitive effort the post-editor needs to put in. In a recent study, Koglin (2015) triangulated eye tracking data related to total fixation duration and keystroke logging data, such as insertions,

deletions and pauses, to compare the cognitive effort in PE and translation from scratch. The results showed that PE requires less cognitive effort than translation.

No empirical studies have been conducted to compare the amount of cognitive effort required in PE and in revision (self-revision and other-revision after one night's drawer time). However, according to the results of Guerberof's (2013) survey study, the aim of which was to investigate professional translators' opinions on the effort required in PE and revision[10], 40% of the translators thought that PE requires more effort than revision; whereas 20% held the opposite opinion - that PE requires less effort than revision. Thirty per cent thought that PE requires the same amount of effort as revision, and the other 10% of the respondents did not have a clearly defined view on the comparison.

However, rather than making a statistical comparison between the cognitive effort involved in carrying out PE and in revision, the principal focus of the present study is on the different types of working style in self-revision, other-revision and post-editing, with the aim of identifying the most efficient working style in all tasks.

2.2.1.3 Post-editor Profile and the Needs of Training

Regarding the post-editor profile, Arnold *et al.* (1994, p. 12) state that 'the post-editor must be a translator', and should have access to the ST (Kay *et al.*, 1994, p. 43), because 'only a translator can judge the accuracy of a translation' (Krings, 2001, p. 12). In describing the competence of a post-editor, McElhaney and Vasconcellos (1988, p. 142) point out that:

> The translator is one of the best able to pick up errors in the machine translation (e.g., misparsed or unparsed ambiguities), he has a fund of knowledge about the cross-language transfer of concepts, and he has technical resources at his disposal which he knows how to use in the event of doubts. Moreover, for the very reason that translators are best suited to the task, the more experienced they are, the more effective they will be. An inexperienced translator – to say nothing of the non-translator – is apt to waste precious time unnecessarily reworking passages or trying to deal with a problem whose solution would be obvious to a seasoned professional.

However, in Mesa-Lao (2015, p. 6), it is stated that, occasionally, PE can be done by a native speaker without reference to the ST. The job simply targets the conformity to the language and the layout conventions of the TL. However, he also mentions the risks of doing so, as the MT can be misleading to a certain extent, and wrong alternatives could be given by doing monolingual post-editing.

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[10] In Guerberof (2013), 'effort' refers to productivity and temporal and cognitive effort in a broad sense.

Offersgaard *et al*. (2008) investigated the use of domain-specific MT and put forward a profile of the 'ideal post-editor': good post-editors should have the same competence as good translators, but at the same time, they should also have the capacity to decide quickly whether an MT segment should be post-edited or re-translated from scratch. Considering the fact that not every translator is able to make a decision with the required speed, especially under the pressure of very short deadlines and expected high productivity, de Almeida (2013, pp. 47-48) pointed out that not all translators are suited to work as post-editors. With this in mind, she further questioned whether or not PE can be taught and developed as a skill, and if so, what is the best way to do so. By empirically investigating the correlation between translators' previous translation experience and their performance in post-editing, de Almeida (2013) found that participants' levels of experience and their productivity in post-editing were not correlated. Post-editing training and guidelines should be designed to be relevant to language groups – languages of the same or different families – rather than to individual languages.

Quite a few researchers also mentioned the importance of post-editor training (e.g., Vasconcellos and León, 1985; Somers, 1997; Krings, 2001). O'Brien (2002, p. 100) pointed out that:

- Post-editing training would help meet the increasing demand for translation and faster production times;

- Post-editing skills are different from translation skills and we cannot assume that a qualified translator will be a successful post-editor;

- Post-editing training would produce graduates who are already 'comfortable' with post-editing and who are more ready to be productive in a machine translation environment upon graduation, and

- Post-editing training could improve the uptake of machine translation technology by improving translators' perceptions of MT and its capabilities.

Based on the skill sets discussed by several other researchers (e.g., Johnson and Whitelock, 1987), O'Brien (2002) proposed a set of skills which she suggested should be incorporated into the post-editing teaching content. These include: knowledge of MT, terminology management skills, pre-editing/controlled language skills, programming skills and text linguistic skills. These skills were considered to be compulsory for a qualified post-editor.

2.2.1.4 Types and Guidelines of Post-editing

The degree of post-editing is decided by several factors, such as the engine used, the language pair, the desired quality specified by the client, the purpose of the translation etc. (Mesa-Lao, 2015). Taking these factors into consideration, two types of post-editing

are distinguished: light post-editing (also called gisting, rapid or fast post-editing) and full post-editing (also called conventional post-editing).

Light post-editing aims to 'provide minimal editing on texts in order to remove blatant and significant errors and therefore stylistic issues should not be considered' (Allen, 2003, p. 302). It is meant to be done in the shortest time with the minimum number of changes and keystrokes (Mesa-Lao, 2015). By contrast, full post-editing takes less time than translating from scratch, but produces a higher quality text, so that readers cannot tell where it originally came from, a machine or a human translator (Allen, 2003).

In all PE tasks, short and precise guidelines should be provided to the post-editors based on the specific purposes of the task, as well as the factors discussed at the beginning of this section. O'Brien (2009) suggests three sets of post-editing rules, one for general post-editing, one for light post-editing and one for full post-editing.

2.2.2 Post-editing Styles

Many studies compare post-editing with human translation in terms of time, quality, production and effort (e.g., Bowker and Ehgoetz, 2007; Fiederer and O'Brien, 2009; O'Brien, 2006a). Few studies, however, have examined the different types of post-editing style and compared the efficiency of different styles within the task of post-editing. The two studies that investigated post-editing styles found in the existing literature are those of Mesa-Lao (2014) and Carl *et al.* (2015a).

Mesa-Lao (2014)

Based on Jakobsen and Jensen (2008), who found that eye movement behaviour varied according to the different purposes of reading (reading for comprehension; reading in preparation for translation; reading for sight translation; reading for translation), Mesa-Lao (2014) constructed an initial hypothesis that the eye movement behaviours of translators in reading an ST are different when carrying out translation and post-editing. In addition to testing the above hypothesis, he also aimed to detect the different reading patterns of translators in doing different tasks.

Mesa-Lao (2014) compared the eye movement behaviour of six professional translators when reading the same text for different purposes: translation and light post-editing. The measures he used were: task time, number of fixations (see section 2.3.2), total gaze time duration[11], and transitions[12] between the ST and the TT areas on the

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[11] The fixation duration threshold was set at a minimum of 100 milliseconds. Total gaze time duration was worked out by multiplying fixation count by fixation duration.

monitor screen. He also compared the reading patterns of post-editing with that of translation (Carl and Kay, 2011) by analysing the translation progression graph. It was found that, compared with the translation process, which includes three phases - initial orientation, drafting and final revision - there is only one phase in post-editing, which is drafting. Most of the post-editors either read the TT at the start of the post-editing process, or just read a few ST words and then shifted their eyes to the TT to look for errors.

Mesa-Lao's (2014) study was very successful in discerning translators' working styles in carrying out different tasks, but since there were only six participants in the sample, the variation of individual working styles in post-editing was not thoroughly explored.

Carl *et al.* (2015a)

In a more recent study, Carl *et al.* (2015a) identified more post-editing styles by analysing translation progression graphs; the results of their analysis correspond to the findings of the present study. The three phases found in translation were also observed in the post-editing process, but with slightly different styles. In post-editing, there was an optional orientation phase, a drafting phase and an optional final revision phase. In the orientation phase, some post-editors conducted a unilingual TT reading; some did a unilingual ST reading; some read the entire ST first and then read the TT at text level, and others read the entire TT first and then read the ST at text level. In the drafting phase, some participants read the ST and the TT comparatively, while others mainly focused on the TT, consulting the ST only when necessary. Carl *et al.* (2015a) assume that the latter approach might be more productive, as the post-editor tries to focus on one text (the MT output) rather than on two texts (the MT and the ST), and then cross-checks the meaning transfer. He suggests further investigation into this, and also into the underlying purposes behind the activities. In the final revision phase, the TT was mainly read in a unilingual fashion, with very few consultations of the ST. This is quite similar to the situation in translating from scratch.

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[12] Transitions were understood as the shifts in gaze between the ST and the TT windows in Translog-II.

2.2.3 Summary

The above review of the literature on post-editing reveals that:

- Post-editing work is increasingly in demand in the translation profession, and post-editors should be trained to produce a better performance.

- The reading patterns of translators are different when carrying out different tasks.

- As suggested by Carl *et al*. (2015a), there is a need to investigate the various post-editing styles used by translators, to ascertain which style is more efficient. It is also worth studying the purposes underlying translators' behavioural activities in post-editing.

Based on the general assumption that student translators' reading patterns would also be different when carrying out different tasks, the aim of the present study was to take self-revision, post-editing and other-revision as independent variables to examine the extent to which student translators' working styles were affected by task type. Since none of the participants in the present study had received any training in light post-editing, or had any experience in conducting light post-editing, they were provided with the full post-editing guidelines (see Appendix 8).

The UAD (with cue-based retrospection, see section 3.2.1.3) were analysed in order to: (1) discover the basic types of reading and typing activity involved in the processes of self-revision, post-editing and other-revision, and to identify the physical activities of student translators during the working process; (2) explore the purposes (mental activities) underlying these physical activities, and to understand why student translators conduct these reading and typing activities; (3) investigate the sequences of the reading and typing activities, as well as the student translators' purposes underlying these sequences, in order to identify the student translators' working styles in performing different tasks (e.g., how the reading and typing activities are coordinated in the drafting phase, and whether they do unilingual or bilingual reading and revision); (4) examine how task type affects the student translators' use of working styles both within and across tasks, to find out whether there is any working style that is used in one task but not in the other, and to find out whether thestudent translators' personal working styles vary in different tasks, and (5) test which working style is the most efficient within each task, in terms of task time only.

2.3 Cognitive Insights into the Human Brain, Eyes and Actions

This section presents the theoretical underpinnings of translators' coordination of physical and mental activities during the revision and post-editing processes, from the field of cognitive psychology.

Cognition is 'the acquisition of knowledge' (Reed, 2000, p. 4). Cognitive processes employ existing knowledge to generate new knowledge based on a set of mental skills, such as language, comprehension and memory, problem solving, expertise, creativity and decision making (Reed, 2000, pp. 287-437). Cognitive processes consume cognitive resources. These resources are assumed to be a limited pool of mental processing capacity (Baddeley, 2003, p. 835). In a given task, cognitive resources are allocated to one or several cognitive processes by attention (Eysenck and Keane, 2010, p. 3). Attention is defined as:

> '…the possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thoughts. Focalisation, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others' (James, 1890, pp. 403-404).

In cognitive psychology, cognition is often considered as 'human information processing' (Reed, 2000, p. 5). 'The acquisition, storage, retrieval, and use of information comprise a number of separate stages, and the information-processing approach attempts to identify what happens during these stages' (Haber, 1969).

In this study, the processes of revision and post-editing are considered as instances of human information processing. In what follows, key concepts related to cognitive information-processing stages (short-term memory, long-term memory and attention) are introduced in section 2.3.1. Section 2.3.2 focuses on the visual attention theory. Section 2.3.3 introduces van Dijk and Kintsch's (1983) action theory in text comprehension and production. Section 2.3.4 provides a summary.

2.3.1 Cognitive Information-Processing Stages
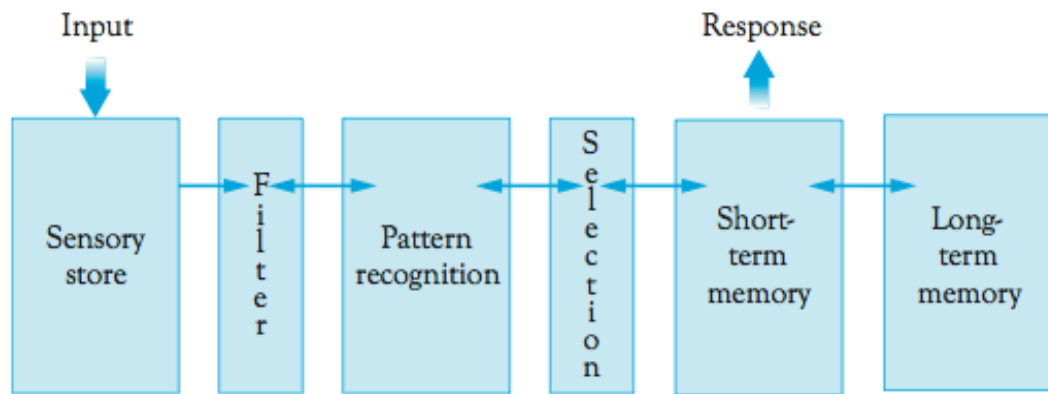
Figure 7: Stages of an Information-processing Model

Figure 7 (graph from Reed, 2013, p. 3) provides a general account of the information-processing stages based on Atkinson and Shriffin's (1968) model. Basically, there are four main stages in information processing: sensory storage, pattern recognition, short-term memory (working memory) and long-term memory. According to Reed (2013, pp. 3-4):

- When visual or auditory information is input, the sensory store will temporarily grip unanalysed information for a fraction of a second before the cease of a stimulus. The information in the sensory store will disappear unless the stimulus can be identified in the pattern recognition stage;

- Before getting to the pattern recognition stage, attention, as a filter, confines the amount of information that can be recognised at a time;

- After the stimulus is recognised (the selection stage), attention limits the amount of information that can be entered into the short-term memory. In other words, attention decides how much and what information a person will remember. The short-term memory is often called the 'working memory'. However, they are different concepts. Short-term memory was first defined by Atkinson and Shriffin (1968) in their multi-store model, referring to the memory storage system that only passively preserves information for a short time. Baddeley and Hitch (1974) and Baddeley (1986) replaced Atkinson and Shriffin's (1968) short-term memory with a working memory model, and considered working memory as a memory storage system which not only stores but also actively processes information and outputs corresponding responses.

- Working memory has a limited capacity. By constant rehearsal or elaboration, the information in the working memory can be stored into the long-term memory, which has an unlimited storage capacity.

2.3.1.1 Working Memory

Working memory plays a vital role in language comprehension, as well as in other complex tasks, such as reasoning, problem solving and decision making (Just and Carpenter, 1992, p. 122). It is needed for most of the cognitive tasks, during which information can only be held for up to 20-30 seconds if it is not rehearsed (Reed, 2000, p. 82).
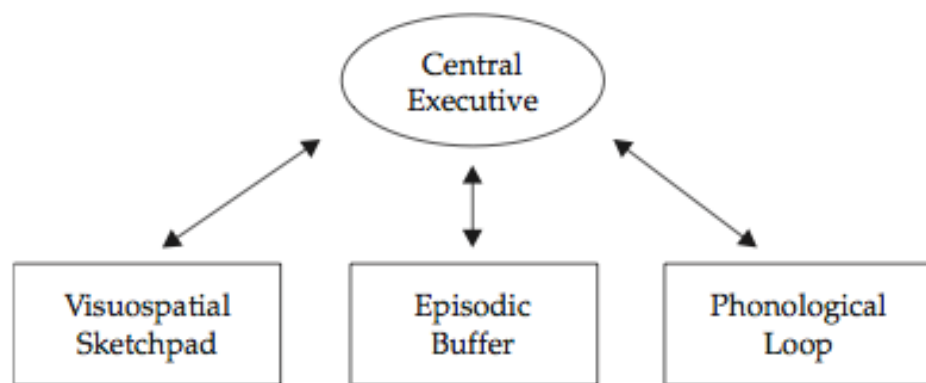
Figure 8: Baddeley's Working Memory Model

According to Baddeley (2002, p. 93), the working memory model consists of four main parts (Figure 8):

- Central executive, which is the key controller which coordinates attention to allocate cognitive resources and deals with cognitively demanding tasks (i.e., reasoning, reflecting, evaluating etc.);

- Visuospatial sketchpad, which provisionally stores and processes visual and spatial information (e.g., a word and its position on the screen);

- Phonological loop, which temporarily stores and rehearses acoustic and verbal information;

- Episodic buffer, which enables different parts to interact with each other and facilitates comprehension by retrieving the information from the long-term memory.

Just and Carpenter (1992, p. 124) compared the limited capacity of working memory to 'an energy source', and the central executive is responsible for distributing this limited energy. Inspired by Norman and Shallice's (1986) model of attentional control, Baddeley (2003, p. 835) identified two types of the central executive's control processes during the

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allocation of cognitive resources: 'automatic (or habitual) processes' and 'controlled (or supervisory) processes'.

Automatic processes are the unconscious control of information processing and require few or no processing resources (Anderson, 2000, p. 98). They are guided by a person's habit patterns. The controlled processes are conscious control of the distribution of attention. One example Reed (2000, p. 64) provides is learning to ride a bicycle. While in the initial learning process, we need to pay attention to balancing in order to stop ourselves falling off (controlled processes). Once we have mastered the skill of how to ride a bicycle, consciously intended balance will not be needed while riding (automatic processes). In the controlled processes, there is a 'supervisory activating system' (Baddeley, 2003, p. 835). This activates the controlled processes when automatic control is insufficient. Therefore, these two control processes occur concomitantly.

Jääskeläïnen and Tirkkonen-Condit (1991) compared professional translators with student translators and found that the professional translators spent less time producing the TL segments; they took this as evidence that there was more automatic processing during the translation process for professional translators than for student translators. However, Dragsted (2004, p. 47) argued that 'translation is inherently non-automatic', since it always involves the activation of the working memory. As noted by Posner and Snyder (1975, quoted in Reed, 2000, p. 64), for a skill to be considered automatic, it needs to meet the following three criteria: the skill '(1) occurs without intention; (2) does not give rise to conscious awareness; and (3) does not interfere with other mental activities'. This seems to support Dragsted's (2004, p. 47) opinion that the translation process will always be non-automatic since a translator has constantly and intentionally to 'construe the meaning of the ST or reformulate the TT'. Nonetheless, Hvelplund (2011, pp. 59-60) pointed out that there might be some automatic processing during the sub-processes of translation, such as automatic ST reading and TT reading, which does not consume many working memory resources. Hvelplund (2011) proved that parallel processing does occur (typing the TT while reading the ST), and concluded that during this process, TT typing occurred automatically while the translator focused attention on non-automated ST processing. His conclusion was based on Baddeley (2007) and Anderson (2000) who state that 'the human cognition system cannot focus attention concurrently on two different tasks…It is more likely that only one activity actually receives the translator's conscious attention, while the other process occurs in parallel but more or less automatically' (Hvelplund, 2015, pp. 19-20).

In order successfully to revise or post-edit a translation draft, a reviser (or post-editor) will also need constantly and intentionally to comprehend the meaning of the ST, evaluate the quality of the TT, and make decisions on how to fix the TT. This process, for

the most part, is conscious since the comprehension, evaluation, decision-making and production processes do consume a large portion of available cognitive resources. Since it is very likely that the processes of revision and post-editing are similar to those of translation in terms of the occurrence of parallel activities (see section 6.1 for activity type data), in this study, we followed Hvelplund's (2011, p. 60) definition of 'automaticity', i.e., 'the sustention of one (or more) processes with little involvement of working memory executive processes', and considered the processes of revision and post-editing to be automatic.

We also assumed that most of the gazing and typing activities undertaken by revisers and post-editors are triggered by different and specific intentions, such as 'reading to comprehend the text's meaning potential well enough to make it possible to transfer every possible interpretation from the ST to the TT' (Hvelplund, 2015, p. 19). The intentions behind the gazing and typing activities are discussed in Chapter 6, based on an analysis of the retrospection data. It should be noted that the activity of the unconscious mind (intention) behind the reading and typing activities was beyond the scope of the current research.

2.3.1.2 Long-term Memory

Compared with working memory, long-term memory is unlimited in its capacity, although inputting new information is not always easy (Reed, 2000, p. 116). However, once successfully entered, information can be preserved for years in the long-term memory (Anderson, 2000, p. 205).

According to Eysenck and Keane (2010, p. 253), long-term memory consists of two types of memory: 'procedural memory' and 'declarative memory'. Procedural memory is memory for actions, skills and operations, which do not consume many of the cognitive resources for people with expertise in certain skills, such as professional typists. Declarative memory encompasses two different subsystems: 'episodic memory' and 'semantic memory' (Tulving, 1985). Episodic memory is more related to the recollections of personal experiences in the past, such as the kind of translation experience you have acquired in the past; while semantic memory contains factual information, such as the meaning of a word or an idiom.

As described by Hvelplund (2011, p. 44), the translation process involves both the procedural memory and declarative memory. The former is involved in the reading of the ST and the TT, as well as in TT typing processes when these activities occur automatically; the latter is involved during the language comprehension and production process, when a translator tries to construe the meaning of an ST segment and transfer it into a corresponding TT segment. Since the processes of revision and post-editing also involve

language comprehension and production, we assume that the above two types of memory also become involved during the revision and post-editing processes.

2.3.1.3 Attention

Attention is a limited resource. It is responsible for 'allocating resources, perceptual or cognitive, to some things at the expense of not allocating them to something else' (Harris and Jenkin, 2001, p. 1). This indicates that different sub-tasks will be competing for the allocation of cognitive resources in a task.

In Baddeley (2002, pp. 90-91), three potential controlled sub-processes (executive processes) were identified:

- Focused attention (attentional focus): the capacity of the central executive allocating the limited cognitive resources to one particular task at a time by inhibiting other potential information.

- Divided attention (attentional division): the capacity of the central executive allocating the limited cognitive resources between tasks at the same time.

- Switching attention (attentional shift): the capacity of the central executive allocating the limited cognitive resources between tasks alternatively.

According to Hvelplund (2011), in the translation process, attention can be focused on either ST processing (e.g., ST reading) or TT processing (TT reading or TT typing). It can also be divided and switched between these sub-tasks and retrieve procedural and declarative knowledge from the long-term memory to help complete the tasks (see section 2.3.1).

All three types of attention also occur in the revision and post-editing processes (see section 6.1 for different types of activity unit). For instance, at the start of a revision task, a reviser will need to direct his attention either to the ST or the TT to comprehend the text (focused attention). To compare an ST segment with its corresponding TT segment, both segments need to be read at least once separately to extract meaning (switching attention). During the actual TT typing events (making changes), attention is not necessarily focused on the TT. Parallel activities (TT typing while reading the ST) are good examples of divided attention.

2.3.2 Visual Attention

Attention is a selective process, and we have limited cognitive capacity in processing visual information. According to Jonides (1983), visual attention is operated in two stages. In stage one, attention is evenly distributed over the external visual stimulus, and information is processed in parallel. In stage two, attention is focused on a specific area of

the visual stimulus, and information is processed in a serial fashion. Selective attention 'intervenes after this stage to select information that will be entered into visual short-term memory' (Raftopoulos, 2007, pp. 5-7).

Attention (selective attention) is studied for the purposes of translation-related research because it decides when we move our eyes, to where, and for how long. It is also because the perception of a scene is obtained through a combination of attention, eye movements and memory (Theeuwes *et al.*, 2009). The aim of the current study was to detect the types of reading and typing activity that occurred during the processes of self-revision, post-editing and other-revision by triangulating eye-tracking and keylogging technologies (see section 3.2.1). Cue-based retrospection data were also combined (see section 3.2.1.3) to enable the researcher to identify the potential purposes that lay behind these reading and typing activities.

The following two sub-sections introduce the basic characteristics of eye movement behaviour in reading, and two general assumptions that eye-tracking research normally draws on.

2.3.2.1 Basic Characteristics of Eye Movements in Reading

According to Rayner (1998, p. 373), eye movements in reading are composed of a series of fixations and saccades.

Fixations are defined as 'the eye movements that stabilize the retina over a stationary object of interest' (Duchowski, 2007, p. 46). The intuitive fact regarding fixation is that when eyes fix on a particular word or area, no movement occurs. However, Rayner (1998, p. 373) points out that the eyes, in fact, are never absolutely still, and that 'visual fixations are characterised by the miniature eye movements: nystagmus (tremor), drifts and microsaccades. The nystagmus is a slight and constant tremor of the eyes, which is assumed to be the movements that help the nerve cells in the retina to keep firing. Drifts are small and slow movements of the eyes that occur when a person's nervous system is not perfectly effective in controlling the oculomotor system. When eyes drift, a small but much more rapid eye movement, a microsaccade, happens. This brings the eyes back to their original locus.' These small movements are seen as 'noises' (Rayner, 1998, p. 373) in reading research. Most experiments tend to ignore them. The assumption in the current study was that these 'noises' would not have an influence on the participants' cognitive processing of the revision and post-editing tasks.

According to Rayner *et al.* (2006, p. 243), not all the words in a text receive fixations. The content words receive fixations 85% of the time whereas function words are only fixated for 35% of the time (Starr and Rayner, 2001, p. 158). Words may be fixated more than once (regressions), especially long or difficult ones (Rayner *et al.*, 1996, p. 1189).

Fixation data can be highly informative about reading and the nature of the underlying cognitive processes involved (Staub and Rayner, 2007, pp. 327-329). However, the value of fixation duration can be influenced by text or task difficulty, reading skill and the characteristics of the writing system (Rayner, 2009, p. 1460). According to Rayner (1984), the duration of a fixation varies in tasks of different levels of complexity. For example, in silent reading, mean fixation duration (MFD) is 225 ms; in oral reading (reading aloud), MFD takes about 275 ms, and in reading while typing the emerging text output in monolingual text production, MFD takes approximately 400 ms. As the text gets more challenging, fixations normally get longer, saccades become shorter, and more regressions (attentional shifts) are produced (Rayner, 1998). There is also evidence that typographical variables such as font influence eye movements (e.g., Slattery and Rayner, 2010). If fonts are difficult to encrypt, this will also make fixations longer, saccades shorter and regressions more (Rayner, 1998). The other factor that affects fixation and saccade duration and number of regressions is reading skill. Rayner (1998, p. 393) found that beginner and dyslexic readers tend to have longer fixations, shorter saccades and more regressions than skilful readers. With respect to the writing system, Chinese (characters) is considered to be the most different from English. However, Rayner (2009, p. 1461) found that 'Chinese readers tend to have average fixation durations that are quite similar to readers of English, and their regression rate does not differ dramatically'.

This study took the task types (self-revision, post-editing and other-revision) as independent variables. To ensure that the eye movement data were not affected by text complexity, size of font or reading skill, all these factors were controlled for in the research design (see Chapter 4).

Saccades (macro-saccades) are 'quick jumps of the eyes from one fixation to another' (Rayner, 1998, p. 373). They can reach speeds as high as 500° (1° is approximately 4 letters) per second (ibid.). According to Clifton *et al.* (2007, pp. 341-372), meaningful information will only be perceived during the fixations period, because the vision is inhibited during saccades and the information the retina obtains cannot be registered by the visual system.

When comparing saccade duration with fixation duration, it can be found that fixations account for most of the eye movements in reading at a percentage of approximately 85–95; while only 5–15% of the eye movements are saccades (Hvelplund, 2011, p. 67). The computation of gaze duration usually discards saccade duration and only calculates the fixation duration (Rayner, 1998, p. 378), because no visual input is transferred from the retina to the working memory during saccades (Wright and Ward, 2008, p. 133).

2.3.2.2 *'Immediacy Assumption' and 'Eye-mind Assumption'*

Since 'the third era of eye movement research began in the mid-1970s' (Rayner, 1988, p. 372), numerous studies have begun to develop eye movement data analysis methods, taking eye movement behaviour as a medium to infer cognitive processes (ibid.). Eye movements are good indicators of focuses of visual attention (Klein *et al.*, 1992), and shifts of attention are indicated by saccades (Deubel and Schneider, 1996).

In 1980, Just and Carpenter posited the '**immediacy assumption'** and the '**eye-mind assumption'** based on an experimental study they conducted to investigate the relationship between eye fixation and comprehension in reading. With the 'immediacy assumption', they deduced that 'the reader attempts to interpret each word in a text as it is encountered even at the expense of making wrong guessing, rather than holding it internally to buffer until there is time to process it semantically' (Just and Carpenter, 1980, pp. 330-331). The 'eye-mind assumption' claims that, 'the eye remains fixated on a word as long as the word is being processed', and 'there is no appreciable lag between what is being fixated and what is being processed' (pp. 330-331). Extended to reading, these two assumptions denote that, as soon as a word comes into the sight of a reader, he will start to process its meaning cognitively until this word disappears from the retina. The duration of fixations on this word reveals the reader's cognitive processing time and also indicates the cognitive effort he spent on this word. Anderson (2000) supports these two assumptions and believes that the object being fixated is at the centre of cognitive focus; this view was given further support by Hvelplund (2011), who found that 'eye fixation and cognitive processing co-occur without delay'(p. 68).

However, some researchers hold different opinions from Just and Carpenter's 'eye-mind assumption'. For instance, Posner (1980, pp. 5-6) argued that 'attention can be moved independently without moving the eyes, although in most cases people move their eyes to identify objects'. He identified two types of attention in the reading processes: overt attention and covert attention. Overt attention is the act of directing the eyes to the object of interest, while covert attention is the act of mentally focusing on an object (ibid.). In other words, Posner (1980) believed that there is no complete certainty that a person is cognitively processing the object that he is fixating on.

The other concern pertains to the 'immediacy assumption'. Staub and Rayner (2007, p. 329) raised the question of 'eye-mind span', that is, whether the eyes move ahead of the mental processing associated with each word. It has been found that the link between the eyes and the mind is not perfect, as preview effects exist. Readers do get a preview of the next word to the right of fixation when reading, which infers that the cognitive processing begins even before moving the eyes towards the word (Staub and

Rayner, 2007). Hence, the time spent on a word cannot be a precise indication of the time taken to process it.

With respect to the 'eye-mind assumption', it has been found that during eye movements, there can be spillover effects; in other words, the processing of difficult words can spill over into the processing of subsequent (sometimes simple) words (Reichle, 2011, p. 769).

With regard to preview and spillover effects, Staub and Rayner (2007, p. 329) concluded that, although these effects should be considered in eye movement research, generally speaking, fixation duration is an accurate reflection of the processing time associated with the word. In the current study, the focus was not on the processing of any particular word, phrase or sentence. Instead, the ST and TT were taken as the areas of interest. Preview effects and spillover effects were unlikely to be potentially confounding variables for this study.

In respect of covert attention, Hvelplund (2011, p. 69) stated that it is still not experimentally possible to identify and distinguish between overt attention and covert attention in the process of translation, nor to what extent covert attention will affect the results of a study. For this reason, the present study followed Hvelplund (2011), and generally assumed that covert attention would not vary between participants, their translations, revisions or post-edited texts.

2.3.3 Action Theory

Action theory (or the theory of action) is mainly discussed in sociology and philosophy. In philosophy, debates have centred on whether reason-explanations for actions are causal or not (e.g., D'Oro and Sandis, 2013). Bratman (1999) deems that it is one's intention that causes the action. This viewpoint was previously put forward by van Dijk (1975; 1976), who applied action theory to the field of discourse analysis. Later, van Dijk and Kintsch (1983) built a model of strategic discourse processing and claimed that 'a strategy that involves human action is a goal-oriented, intentional, conscious and controlled behaviour' (p. 62).

According to van Dijk and Kintsch (1983), an action takes place with certain intention(s) and purpose(s). The 'intention' is defined as the 'representations of doings plus their result' (e.g., opening a door and the fact that the door is opened) and 'purpose' is defined as the 'representation of wanted consequences of an action' (e.g., to walk out of the room) (p. 63). These cognitive representations lead to the actual actions and at the same time control the actions. Other factors also influence a person's action, such as preference and decisions.

One's internal intentions and purposes in doing something might interact with external intentions and purposes; therefore actions can be very complex. The ordination of such complex actions requires a higher level of organisational skills, and making plans is one of them.

A plan is defined by van Dijk and Kintsch (1983, p. 63) as 'a cognitive macrostructure of intentions or purposes'. Two types of plan are identified: global plans and local plans. The former are considered to be 'a hierarchical schema dominated by a macroaction' (p. 63) (e.g., building a house), and this macroaction monitors the sequences of detailed actions triggered by the plans made at a local level (e.g., breaking up the ground, building the walls and roof, working on the interior etc.).

Actions are considered successful if the results meet the initial purposes. In real life, normally a goal can be achieved in a variety of ways. For instance, you could choose between a couple of routes to walk from home to school. Assume the routes are of different lengths, and suppose you know that route A takes the least time, then route A will be the optimal choice for you in terms of effectiveness. Comparatively speaking, the other route is more time-consuming and will bring about a 'cost of the action' (van Dijk and Kintsch, 1983, p. 63).

Purposes do not guarantee the success of actions, as they are the wanted consequences of the action and are beyond one's control. According to van Dijk and Kintsch (1983), the success of actions and the choice of a selected action sequence depend on the purposes that have been set and the circumstances of each action in the sequence, as well as on the actor's knowledge of the actions and the possible outcomes.

With respect to revision and post-editing, translators need to perform a sequence of actions to make sure that the TT is revised or post-edited to an acceptable degree (the purpose of the action). During this process, they need to operate on three texts (the ST, the original TT and the revised TT) in order to comprehend, evaluate and make necessary changes. Generally speaking, the sequences of revision and post-editing action are built on, but not limited to, the following three basic activities: reading the ST (ST reading), reading the TT (TT reading) and typing the TT (TT typing). Studies on the processes of translation and post-editing have identified the basic types of activity (action) and the underlying cognitive purposes (e.g., Carl and Schaeffer, 2014; Hvelplund, 2015; Krings, 2001).

Based on van Dijk and Kintsch's (1983, pp. 62-64) action theory and empirical findings in the field of translation and post-editing, we assume that each type of reading and/or typing activity (action) identified in the processes of revision and post-editing is motivated by certain purpose(s). With the purpose(s) in mind, translators make plans to choose optimal revision and post-editing procedures (sequences of actions or activities).

Translators' processing methods might be influenced by certain internal factors, such as their general knowledge of revision and post-editing (e.g., procedure, principles, criteria), strategies used in these tasks, their understanding of the possible outcomes of their actions, and some other factors, such as personal preference. External factors might also influence their methods of processing, such as text type, task complexity, time constraints, the use of the TT, target readers, prescriptive criteria in the task brief etc.

In designing the current study, the aim of which was to investigate the types of reading and typing activity (action) the student translators performed to execute the tasks, as well as the purposes behind these activities, certain variables were controlled (e.g., source text complexity and time constraints; see Chapter 4 for details).

2.3.4 Summary

In section 2.3 it was shown how a theoretical framework was built for the present study based on theories from cognitive psychology, in order to analyse the different types of eye movement behaviour and typing activity that take place during revision and post-editing processes.

It is generally assumed that:

- The processes of revision and post-editing are instances of human information processing.

- The processes of revision and post-editing are automatic, in line with Hvelplund's (2011, p. 60) definition of 'automaticity', that is, 'the sustention of one (or more) processes with little involvement of working memory executive processes'.

- Both procedural and declarative memories become involved in the revision and post-editing processes.

- Covert attention does not vary between participants, their translations, revisions or post-edited texts, in line with Hvelplund (2011).

- Most of the gazing and typing activities undertaken by revisers and post-editors are triggered by different and specific purposes.

Finally, Just and Carpenter's (1980, pp. 330-331) 'immediacy assumption' and 'eye-mind assumption' were adopted as part of the theoretical framework for the present study.

2.4 Text Comprehension and Production

This section presents the text comprehension and production theories that were used to underpin the analysis of the purposes underlying the student translators' reading and typing activities during the revision and post-editing processes.

Any translation-related work begins with text comprehension and ends with the completion of text production. From a cognitive psychological viewpoint, the processes of revision and post-editing consist of a set of processes on different levels, which are fundamental to the completion of the task. Based on van Dijk and Kintsch's (1983) discourse processing model, Krings (2001) developed a text analysis model to study post-editing processes (including post-editors' behaviour and their purposes underlying this behaviour). Since this study has a similar interest to that of Krings (2001), his text analysis model was used as a part of the theoretical framework. For the text production process, Kellogg (1964) was drawn on as another part of the theoretical framework.

In this section, the theoretical part of Krings' (2001) model is briefly summarised and introduced adopting a bottom-up approach, that is, from a word to a text level (section 2.4.1). Section 2.4.2 introduces Kellogg's text production model. The findings of Krings (2001) regarding the post-editing processes are presented in section 2.5.1.

2.4.1 Kring's Text Analysis Model

2.4.1.1 Word Level

2.4.1.1.1 Word Recognition

According to Krings (2001), as soon as the visual input of a text begins, lower level processing of words and signs starts. During this stage, orthographic units and phonological units are identified and recognised to prepare for the higher-level cognitive textual processing. Although this is the initial stage of the text comprehension, 'the acquisition of meaning starts before the pure visual perception processes are completed' (Krings, 2001, p. 235). According to Krings' findings, word recognition processes are barely captured at all in the Think-aloud Protocols (TAP) data unless there are problems such as faulty printing and typographical errors. His explanation is that this process takes place in a very short time and is largely automated. It should be noted that the cognitive processes in text comprehension are not simply bottom-up. Word recognition processes appear in every level of the text comprehension process. The top-down possessing is interlinked with the bottom-up processing.

2.4.1.1.2 Concept Formation

Once the meaning of a word (words) has been perceived, the concept of the word(s) is formed. This is the lowest level of semantic representation of the visual input. Concepts are extralinguistic but are generated from linguistic codes. According to Krings (2001, p. 236), concepts 'represent the most important link between the knowledge structure of the text, objectified through its linguistic structures, and the prior knowledge of the text recipient'. Since concept recognition is an active reconstructive process, Krings (2001) suggests using the term 'concept formation' rather than 'concept recognition' or 'concept reception'. He found that concept formation is an important part of the post-editing process.

According to Krings (2001), concept formation is usually expressed as X means Y. If the meaning of X can be extracted to formulate Y, the formation process is complete. Otherwise, it is possible that the eyes will keep fixating on X to allocate more effort to extract the information. Inference processes will also be involved (see section 2.4.1.4.2).

2.4.1.2 Morphosyntactic Level

After the concept formation process has taken place at word level, morphosyntactic reception (parsing) starts. Morphosyntactic reception includes 'recognition of the morphological structure, word classes, phrases and sentence structure' (Krings, 2001, p. 237). This is a higher level of text processing and is also called 'semantic-syntactic processing' (van Dijk and Kintsch, 1983, p. 27). Once the semantic relationships underlying the text surface are extracted, other levels of text processing start and the text surface will be gradually forgotten. The semantic relationships tend to be remembered for a longer time than the text surface. However, during the morphosyntactic processing, readers often quickly run through the sentence to extract the semantic information. This often leads to a failure in comprehension and thus requires re-reading of the sentence. This could be part of the reason why there are many regressions (a vision measure) during the translation, revision or post-editing processes.

2.4.1.3 Proposition Level

2.4.1.3.1 Simple and Connective Proposition Formation

Proposition is a concept proposed by Kintsch and van Dijk (1978) in their construction-integration model. There are two types of proposition: simple propositions and complex propositions. A simple proposition consists of one predicate and one or more arguments, whereas a complex proposition consists of more than one simple proposition by the creation of logical relationships. For example, 'I married him' and 'He is rich' are two

simple propositions. By combining these two propositions, we could say 'I married him because he is rich' or 'The reason I married him is not because he is rich'. Such sentences connected by logical connective words, such as 'because' or 'if', are complex propositions. These new propositions can be combined with other propositions to form even more complex propositions, normally by inferences. Owing to the connective nature of the complex propositions, Krings (2001, p. 241) called them 'connective propositions'.

During the text comprehension process, 'sentence elements are integrated to form propositional units and stored as such in memory' (Krings, 2001, p. 239). In the cases of revision and post-editing, proposition units from the ST, the original TT and the revised TT all need to be formed and memorised for other levels of processing. Owing to the limited capacity of the working memory, it is not difficult to imagine that there would be many re-readings of the same segment or sentence.

According to Krings (2001, p. 241), the proposition process and the concept formation process are interlinked: 'the concept formation can limit the number of the possible propositions from the bottom up…concept formation can be made more precise or even revised by the creation of propositional relationships from the top down'.

2.4.1.4 Textual Level

2.4.1.4.1 Text Coherence Formation

Text coherence is formed by constructing proposition groups. According to Kintsch and van Dijk (1978), text coherence is characterised by two features: overlapping arguments and embedding. The former relates to the reoccurring argument(s) in a text which make certain propositions overlap with each other; the latter refers to the suggestive nature of one proposition to the arguments in another proposition. The processing of proposition groups in short-term memory is cyclic (Kintsch and van Dijk, 1978). Only when coherence has been established can a proposition group be accepted into the short-term memory. If it is not, 'processing will be interrupted and inference processes occur' (Krings, 2001, p. 241). Longer fixations and a higher number of fixations might also account for the failure of the formation of text coherence.

2.4.1.4.2 Text Basis and Inferences

The text basis consists of all the propositions in a text, including the hierarchical and logical relationships among them (van Dijk and Kintsch, 1983). It abstracts the surface structure of a text. The text basis can be constructed only if the relationships between the different propositions are explicitly presented on the text surface; otherwise, inference

processes will start, inferring 'the casual, conditional, intentional, temporal or local connection between the propositions' (Krings, 2001, p. 243).

In the cases of revision and post-editing, besides the internal relationships among the propositions within the ST or the TT, the propositions in the ST should also match the corresponding propositions in the TT to form an acceptable translation segment (proposition pair). When the proposition pairs do not match each other, inference processes will be heavily involved in the revision and post-editing processes.

2.4.1.4.3 Text, Superstructure and Macrostructure

Superstructures are 'schemata for conventional text forms' (van Dijk and Kintsch, 1983, p. 54), such as the typical features, function, style of a text type etc. For instance, news is usually formal and structured (style). It provides readers with accurate information in an accurate context (function), thus the requirements for news writing are precision and clarity (features). Knowledge of superstructure is related to a reader's external knowledge of a particular text type. As a result of his/her external knowledge, a reader usually has certain expectations regarding the text being read (e.g., if you know news is written in the form of an inverted pyramid with the first paragraph functioning as the lead, then you will not expect the lead to appear in the last paragraph) and these expectations will lead to a top-down processing of the text, interwoven with the bottom-up information extraction that takes place during the comprehension process.

After reading a text, some of the information enters a reader's short-term memory and will be forgotten in time; other information registers in the reader's long-term memory and can be retrieved if necessary. Macrostructures contain only the most important information that one memorises (e.g., the topic, the structure of the text, the main arguments etc.) and are 'the entire internal structure of a text' (Krings, 2001, p. 245). According to van Dijk and Kintsch (1983), a microproposition consists of a series of propositions. Micropropositions construct macropropositions through the reduction process, and a reader establishes a macrostructure of a text based on these macropropositions.

In other words, a reader's external knowledge regarding superstructures affects his/her expectation of the reading, and thus influences the way s/he reads a text. The formation of macrostructure is influenced by a reader's purpose, motivation and personality, as these factors decide which type of information enters the long-term memory.

With regard to revision and post-editing, we assume that student translators have certain external knowledge regarding the superstructures of the ST and the TT, as well as knowledge about translation, revision and post-editing (e.g., translation theory, revision

principles, the function and criteria of the TT, the target readership etc.). These factors are interactional during the text comprehension and production processes, and thus influence the way they process the texts. We assume that student translators have different knowledge bases, and that partially explains why they revise or post-edit the texts in different ways.

According to action theory, during the revision and post-editing processes, we assume that student translators make both global and local plans to achieve certain goals. This will influence their formation of a macrostructure of the text, and in turn affect the way they read it.

2.4.1.5 Prior Knowledge

Krings (2001) discusses three principal types of knowledge in text comprehension in the post-editing process: text type knowledge, context knowledge and world knowledge. Text type knowledge is a reader's knowledge of the superstructure of the text types, which brings certain expectation(s) during reading. Context knowledge is the knowledge that readers gain from reading a text, and the knowledge they obtain can be different. The remainder is the world knowledge. Knowledge and text comprehension are interdependent. On the one hand, knowledge facilitates comprehension of the text. On the other hand, the knowledge gained from text comprehension is integrated with an individual's prior knowledge and changes his/her entire knowledge structure.

In text comprehension, 'mental representation is constructed that has a holistic character from the beginning and that is increasingly elaborated and differentiated during processing' (Krings, 2001, p. 248). According to Krings' findings, prior knowledge was activated at some points during the process of post-editing from a global perspective, and was also allocated to comprehend the local text in order to deal with the machine translation problems (Krings used translations done by a computer), by, for instance, reconstructing sentence structure.

Prior knowledge about translation, revision or post-editing is important in terms of working efficiency and quality. In addition to text type knowledge, content knowledge and world knowledge, the current study also takes subjective knowledge (e.g., knowledge about translation, revision or post-editing theories, procedures or criteria) as a particular type of prior knowledge, because it distinguishes professional translators, revisers or post-editors from the non-professional ones, and may affect their working process and working styles.

2.4.1.6 Pragmatics and Diasystematic Analysis

Krings (2001) found that post-editors' pragmatic considerations appear much more regularly in the revised TT analysis than in the ST and the original TT (MT raw input) analysis. Pragmatics deals with the readers' ability to understand the translation in the post-editing process. Typical articulations regarding pragmatics are: 'no, that demands too much of the user'; 'that is really a bit misleading now'; 'otherwise no one will understand' etc.

Diasystematic analysis processes are also a key component of the revised TT analysis in post-editing. Krings (2001, pp. 458-461) detected six subtypes of diasystematic analysis in his TAP data:

- Diatechnical analysis: whether or not a TT segment should be used in a special purpose language (e.g., 'well, since it is a leisure time activity, here I would say do not speak so technically specifically about a user but rather…'). This type of analysis appears especially in a technical context.

- Diafrequent analysis: the familiarity or common use of an expression rather than the semantic-related analysis (e.g., the word 'partner is unusual in German').

- Diaintegrative analysis: whether the integration of two or more words from a foreign language can be accepted into the target language (e.g. 'I think we do also say *Hairstyle* in German um').

- Diasituative analysis: whether an expression should be more colloquial or more formal.

- Diachronic analysis: whether an expression is up to date or old-fashioned.

- Diastylistic analysis: whether the TT reaches a certain stylistic effect (e.g., 'oh baloney, that is much too awkward'; 'that is not very elegant').

The above subtypes of diasystematic analysis are summarised from the English and German language pair. Owing to linguistic varieties, some of the subtypes listed above might not appear in certain language pairs, and other subtypes might exist beyond Kring's (2001) categories. Although the main focus of the current study was not to identify which subtypes of diasystematic analysis were missing in the English and Chinese language pair, the categorisations above do, however, shed light on participants' revision or post-editing criteria during the TT evaluation process.

Krings' sections on 'paratext' (Krings, 2001, pp. 246-247) are not presented here, as the contents are irrelevant for the current study.

2.4.2 Kellogg's Text Production Model

Kellogg's (1996) text production model (Figure 9, from Alamargot and Chanquoy, 2001, p. 19) is introduced here because it not only provides a theoretical framework for the analysis of the translation production process but also correlates the cognitive representations with the text production.
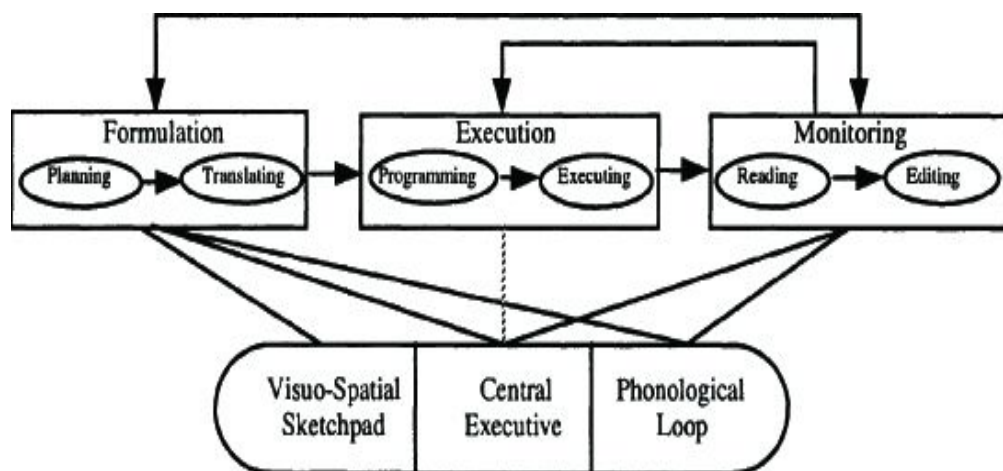
Figure 9: Kellogg's (1996) Text Production Model

Kellogg's model was developed on the basis of Baddeley's (1986) working memory model, which takes three main components into consideration: central executive, visuo-spatial sketchpad and phonological loop (see section 2.3.1). In this model, there are three stages in the text production process: formulation, execution and monitoring.

Formulation is a stage when visual and/or phonological information is registered, the central executive directs attention to processing the information and to planning the writing, which consists of setting goals, retrieving the relevant prior knowledge and organising the retrieved information. The second process in this stage is Translating. This should not be confused with the translation process (e.g., translating the linguistic codes from one language to another). The Translating process here refers to the transformation of ideas into linguistic structures according to the goals set in the Planning process.

Execution is composed of two processes: Programming and Executing. Before outputting the formulated information, the message is programmed and then executed by bodily movements (e.g., typing or handwriting).

The **monitoring** process is conducted through Reading and Editing. Reading can take place both during or after executing. The purpose is to verify the messages being or

having been written down. During the Editing process, the writer compares the original intention(s) with the output (evaluation and diagnosis) and forms a feedback loop, on the basis of which the writer edits the text or creates new segments.

Although the writing process is to some extent different from the translation process, the above three-stage production process in writing is heuristic in research into the translation production process. Hvelplund (2011) borrows Kellogg's (1996) model and proposes a TT processing model (see section 2.5.3).

2.4.3 Summary

In this section it was shown how a theoretical framework based on text comprehension and production theories was constructed for the present study, to analyse the purposes underlying each type of reading and typing activity during the revision and post-editing processes. It was found that five factors may influence translators' reading patterns.

- The first factor is success or failure in comprehension at different language processing levels. For instance, failure in morphosyntactic processing, where readers quickly run through a sentence to extract semantic information, often leads to re-reading of the sentence(s).

- The second factor is translators' prior knowledge regarding text type, i.e., the superstructure of the text.

- The third factor is the knowledge of the context that a translator obtained through reading the text(s).

- The fourth factor is the translator's subject knowledge regarding revision and post-editing, e.g., translation, revision and post-editing theories, quality assessment criteria and working procedures.

- The final factor is the translator's world knowledge concerning the linguistic differences between the two working languages.

2.5 Reading and Typing Activities and the Underlying Purposes

In this section, literature on the reading and typing activities and the underlying purposes in the translation and post-editing processes is reviewed. Section 2.5.1 focuses on the analysis of Kring's (2011) findings regarding post-editing, and sections 2.5.2 and 2.5.3

present relevant work in translation process studies. Section 2.5.4 provides a brief summary of section 2.5.

2.5.1. Analysis of Krings' Work on Post-editing processes

One of Krings' (2001) aims was to investigate human translators' post-editing process from a psycholinguistic perspective. He invited 50 students who were enrolled in the technical translation degree programme at the University of Hildesheim to translate and post-edit (with and without the ST) 11 technical texts (four in English, four in French and three in German). These subjects were divided into three control groups and one experimental group. The control groups were asked to translate or post-edit either with think-aloud, or with dialogue only, or with retrospective commentary and think-aloud. The experimental group performed all tasks while thinking aloud. The MT systems used were SYSTRAN[13] and METAL[14].

2.5.1.1 Adaptation of Krings' (2001) Findings

Krings (2001, pp. 321-522) conducted a very thorough analysis of the different post-editing processes, in which eight types of process were identified: source text-related (ST-related) processes, machine translation-related (MT-related) processes, target text production-related (PETT[15]-related) processes, TT evaluation-related (PETT evaluation-related) processes, reference work-related processes, physical writing-related (PETT writing-related) processes, global task-related processes and non-task-related processes.

Since not all the processes were relevant to the current study (e.g., reference work-related processes), the following adaptations were made to reveal the reading and typing activities, in addition to the purposes underlying these activities, as identified by Krings (2001).

1. The types of processing were narrowed down to: ST-related processes, MT-related (machine translation-related) processes and PETT-related processes (post-edited TT-

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[13] Visit http://www.systransoft.com/ for more details about SYSTRAN.

[14] Read White (1985) for a detailed introduction to the characteristics of METAL. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.97.5168&rep=rep1&type=pdf.

[15] To distinguish Krings' 'TT-related' processes (which only include the newly produced output and exclude the raw machine translation-related processes) from the 'TT-related' processes in this study (which combines raw machine output with the new output produced by human translators), Krings' TT-related process is renamed 'PETT-related process', which refers solely to the new output produced by translators. In other words, in the present study, MT related-process + PETT related-process = TT related-processes.

related processes). PETT production-related processes, PETT evaluation-related processes and PETT writing-related processes were incorporated into PETT-related processes because in the current study these processes were considered as parts of the TT-related processes.

2. Reference work-related and non-task-related processes are not discussed in this thesis as the participants were not allowed to use any reference tools, and other non-task-related behaviours were restricted during the experiment. Global task-related processes are discussed separately.

3. ST-related, MT-related and PETT-related processes were reorganised into two types of activities: physical activities (reading and writing activities) and mental activities (sequences of the reading and writing activities, and the underlying purposes). To take ST-related processes as an instance:

   In ST-related processes, there are five sub-categories of activity: 'source/read' (ST reading), 'source/readmis' (ST reading with mistakes), 'source/focus' (focusing the attention on an ST element), 'source/reform' (ST element reformulation) and 'source/analyse' (analysing an ST element).

   - Firstly, the participants in this study were not required to think aloud, therefore 'source/readmis' was not considered.

   - Secondly, both 'source/read' and 'source/focus' were considered as ST reading activities, because the former includes 'reading the entire text' and 'reading by sentences' and the latter, focusing the attention on an ST element, infers the physical reading of the ST.

   - Thirdly, 'source/reform' and 'source/analyse' were considered to be the purposes of the ST reading, i.e., read to reformulate an ST element and read to analyse the ST. 'memorising ST segments' and 'preparing for other processes' in 'source/read' were also taken as mental activities behind the ST reading behaviour.

   - Lastly, it should be noted that the terms 'element' and 'segment' are used interchangeably in Krings (2001), which is somewhat confusing. In the reading-related activities Krings distinguishes three levels of reading: the text-level, sentence-level and segment-level. From the sub-categories of 'source/analyse' (morphology, syntax and text basis) we can see that the term 'element' can be used to refer to a a segment, a sentence or a text.

4. MT-related and PETT-related processes were both reorganised into physical and mental activity categories with the same logic as in the ST-related processes (see Table 2 below). In PETT-related processes, activities irrelevant to PETT production were filtered out: for instance, 'Target/prod/readdel' (reading a deleted PETT element without deviation) and 'Target/prod/focusdel' (directing attention to a deleted PETT element), since this study employed Translog-II (see section 3.2.1.1) to collect production data, and deleted TT segments could not be reviewed. Parallel activities were categorised into a separate type of activity: PETT writing and PETT reading ('Target/prod/concrete/accompany' – producing a new PETT element while reading). The physical writing without reading activity was categorised into PETT writing. PETT evaluation-related processes and PETT production processes are two main processes in post-editing. Since the evaluation processes are mainly conducted through reading, and the production processes are mainly carried out through reading and/or writing, the purposes of the evaluation processes (positive or negative evaluation) were considered as the purposes of the PETT reading behaviour. The purposes of the production processes (e.g., new segment production, new segment proposal with typing) were considered as the purposes of PETT writing with or without reading.

5. In ST-related, MT-related and PETT-related processes, one of the purposes of the reading behaviour is to (comprehend and) analyse the text-related elements at different levels (e.g., concept formation at word level, simple proposition at proposition level). The difference lies in the different amounts of time and effort distributed at these levels (see pp. 357-358). These comprehension and analysis processes can be identified and observed in studies using think-aloud as a data collection method, but owing to the limited capacity of the working memory, it would be very hard to elicit such rich data from a retrospective interview. Since this study does not focus on the amount of time and effort distributed in the ST/MT/PETT comprehension and analysis processes at different levels, these levels of processing are only used as the theoretical underpinnings for the qualitative analysis in Chapter 6.

6. Pause is presented here as another type of activity, although it was not listed in the synopsis of Post-editing processes (pp. 514-522). During a pause, neither verbalisation nor writing is taking place. Although the threshold of a pause is arbitrarily set at one second, Krings claims that the interruption of the verbalisation is already remarkable (p. 210). Data show that the PETT production process is interrupted by many pauses,

and they often occur at proposition boundaries (pp. 305-307). This infers the amount of effort exerted during the production of propositions in PETT (see section 2.4.1.3).

Table 2, below, summarises the adapted synopsis of post-editing processes from Krings (2001).

Types of processing	Activities	Purposes
ST-related	• ST reading - Reading the entire text - Reading by sentence - Focusing on an element	• To analyse [16] - Concept formation - Text basis - Simple proposition formation - Text - Connective proposition formation - Knowledge - Word recognition - Macrostructure - Syntax - Coherence formation - Diasystematic markers - Morphology - Pragmatics • To memorise ST segments (information entering into the working memory and/or the long-term memory for future processing) • To prepare other processes • To reformulate ST elements
MT-related	• MT reading - Reading the entire text - Reading by sentence - Focusing on an element	• To analyse (Same as the categories in ST reading) • To scrutinise concerning the ST • To compare an element of the ST with that of the MT • To evaluate the MT positively or negatively • To state a plan or a problem

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[16] See section 2.4 for a description of the following types of analysis.

PETT-related	PETT reading - Reading the entire target text - Focusing on an element	• To analyse (Same as the categories in ST reading) • To determine - The distribution of content over sentences - Sentence structures - Word order (sequence) - Degree of literalness of the PETT • To evaluate PETT positively or negatively - To avoid redundancy - To avoid problems • To compare an element of PETT with that of MT • To compare a segment of ST with that of PETT - Completeness - Earlier translation solutions - Consistency - Equivalence • To state a plan or a problem • To propose a new segment • To determine earlier solutions • To make a provisional or final decision
	PETT writing (production) - Making insertions or deletions	• To produce new segments • To propose a new element with typing • To rearrange the new element with the old elements • To re-translate an ST element
	PETT writing + PETT reading (production) - Typing the segment while reading - Making insertions or deletions	
	Pause - No verbalisation and writing activities	• To indicate proposition production difficulties in PETT (with a threshold of one second) (Krings, 2001, p. 210)

Table 2: Adapted Synopsis of Post-editing Processes from Krings (2001)

2.5.1.2 Types of Reading and Writing Activity

From Krings' process categories, it can be concluded that six types of reading and writing activity take place during the process of post-editing. These are:

- ST reading: reading of the source text (segments, sentences and text)

- MT reading: reading of the machine output (segments, sentences and text)

- PETT reading: reading of the newly produced target text (segments and sentences)

- PETT writing: making insertion or deletion (old machine output element or newly produced target text)

- PETT writing + PETT reading: making insertion or deletion (newly produced target text) while reading

- Pause: no registered physical activity (but mental activities are still going on)

However, if examined scrupulously, parallel activities can be found taking place during both MT-related and the PETT-related processes. During the MT-related processes, the MT is read for scrutiny of the ST, which indicates simultaneous ST and MT processing. When comparing an element of the ST with the corresponding MT, it is possible that the participant is reading the MT element only, and retrieving the corresponding ST information from the working memory (or long-term memory) to compare it with the MT. The same is true for the comparison of an ST segment with the PETT segment in PETT-related processes, and for the re-translation behaviour in the PETT production processes (TT writing, TT writing + TT reading). Thus four additional types of activity are:

- MT reading with ST processing: reading of a machine translation element while comparing it with or scrutinising the source text

- PETT reading with ST processing: reading of a newly produced target text element while comparing it with or scrutinising the source text

- PETT writing with ST processing: editing of a machine translation element while comparing it with or scrutinising the source text

- PETT writing + PETT reading with ST processing: editing of a machine translation element while reading it and comparing it with or scrutinising the source text

2.5.1.3 Reading Styles

Through verbalisation and observation, Krings identified several different reading styles in ST reading, MT reading and PETT reading.

In the ST reading processes (pp. 324-327), Krings found that:

- Generally, the translation or the post-editing process starts with the entire reading of the ST. The aim is to get an overview of the ST and to prepare for localised text comprehension (analysis).

- Actual translation or the post-editing is sentence-centred. Sentence processing starts by reading one sentence at a time to load the sentence information into the working memory for further levels of processing.

- Most sentences are read several times, especially longer sentences. The first reading usually includes the complete sentence. Re-readings are of smaller chunks and can be of various lengths and can be repeated more or less often. The aim(s) of re-reading(s) the ST is to keep the linguistic form of the ST in the working memory for other levels of processing at a later time.

In the MT reading processes (p. 361), Krings found that:

- Participants who performed the post-editing task with the ST present demonstrated exactly the same MT reading style as ST reading style.

- Participants who performed the post-editing task without the ST behaved differently. They ended their reading of the entire MT after a short time, and started to read sentence-by-sentence. This might be owing to the poor quality of the MT and the need to re-comprehend and analyse the MT.

In the final TT reading processes (reading of the completed post-edited text), Krings found that (p. 385):

- Some of the reading processes are verbalised with a planning or problem indicator. Participants either state the intention to read a particular segment of the target text or to read the entire text as a whole.

- Followed by the intense sentence-by-sentence post-edit phase, re-reading the entire target text serves as the final check of the target text.

As discussed in section 2.3.2, eye movements provide indications of the cognitive processes and the related purposes. The above reading behaviours identified by Krings (2001) reveal the different reading styles and purposes involved in the post-editing process, which is useful for research into the cognitive processes of post-editing and translation from the perspectives of real-time data (the coordination of reading and writing activities). Since reading behaviours (patterns) can be affected by a number of factors, such as text and task complexity (Rayner, 2009) and expertise (Dragsted, 2010), Krings' findings on the different MT and TT reading styles might be explained by the confounding effects produced by participant variation (foreign language competence, as well as translation and post-editing competence), language directionality (English to German, French to German), complexity of the STs (11 simple unique texts without text complexity measures), as well as the task type (post-editing with or without ST, with or without thinking aloud).

Despite the confounding effects, Krings' reading styles infer a three-phase post-editing process:

Phase 1: to get an overview and prepare for local text comprehension and analysis

- ST reading at text level at the beginning

- MT reading at text level at the beginning (with ST)

- MT reading at sentence level (without ST)

Phase 2: to load the sentence information into the working memory for intensive local text analysis

- Sentence-by-sentence reading and re-reading of the ST or the MT. The first-time reading is at sentence-level and the re-readings are in smaller chunks (segment-level).

Phase 3: to do a final check of the translation

- Re-reading of the entire or any particular segment of the final TT.

Krings (2001, p. 164) made an important distinction between the micro-level processes ('individual processes') and the macro-level processes ('phases of current overall processing'), which combine all individual micro-level processes. He claims that the micro-level processes (sub-processes) do not occur in random sequences, but are logically

related to each other. Therefore, 'one can suppose that higher-level coordination processes of a strategic nature underlie the typical sequences' (p. 167).

The aim of the current study was to identify the macro-level (working phases) and micro-level (sequences of the reading and typing activities) processes involved in self-revision, post-editing and other-revision, using eye tracking and keystroke logging data.

2.5.2 Carl and Schaeffer's Seven Types of Activity Units

Fourteen years have passed since Krings (2001, p. 165) proposed the question of the similarities and differences between the processes involved in human translation and post-editing. Great achievements have been made in methodological development in the translation and post-editing processes (see Chapter 3). From the conventional verbalisation method (think-aloud) to a triangulation of the eye tracking and keystroke logging method to elicit data, from the qualitative data analysis method to a combined qualitative and quantitative data analysis method, translation research is now becoming 'predictive' (Carl, 2015, p.1).

The exploration of User Activity Data (UAD) analysis method started with Carl *et al*. (2008). Since then, the data analysis method has been developing to triangulate the product data with the process data and to provide both quantitative and qualitative data (e.g., Carl *et al.*, 2008; Carl and Jakobsen, 2009; Carl *et al.*, 2010; Carl, 2009; 2012a; 2012b).

In 2012, CRITT TPR-DB, a database containing recorded translation process data and annotations was established, and is updated every year. Carl and Schaeffer (2014) give an overview of the latest version of TPR-DB and introduce the various types of data that can be used for process-oriented studies.

There are five types of process units that can be used for translation process study: keystroke data (KD), fixation data (FD), production units (PU), fixation units (FU) and activity units (CU) (see section 5.2.1 for a detailed discussion).

CU segments the recorded reading and typing events in a session into seven different sequences of activity (Carl and Schaeffer, 2014, pp. 39-40). These are:

- Source text reading (ST reading)

- Target text reading (TT reading)

- Translation typing (TT typing)

- Translation typing while reading the source text (TT typing + ST reading)

- Translation typing while reading the target text (TT typing + TT reading)

- Translation typing while reading the source text and the target text (TT typing + ST/TT reading)

- No recorded activity

If one compares the types of CU with the types of activity in Krings (2001), it is evident that most of the activities in Krings (2001) are identified (Table 3).

Carl (2014)	Krings (2001)
ST reading	1. ST reading
TT reading	2. MT reading 3. PETT reading
TT typing	4. PETT writing
TT typing + ST reading	9. PETT writing with ST processing
TT typing + TT reading	5. PETT writing + PETT reading
TT typing + ST/TT reading	10. PETT writing + PETT reading with ST processing
No recorded activity	6. Pause
Unidentified	7. MT reading with ST processing
Unidentified	8. PETT reading with ST processing

Table 3: Comparison of Kring's and Carl and Schaeffer's Types of Activities

Krings (2001) distinguishes the reading of the machine translation from the reading of the target text (which includes both the reading of the newly produced TT segments and the final post-edited TT). In Carl and Schaeffer (2014), Krings' activities 2 and 3 are taken as one activity, i.e., TT reading. Krings' activity types 7 and 8 are in fact covert attention (Posner, 1980, pp. 5-6), which is currently impossible to measure or compare with overt attention in empirical settings, as an eye tracker can only track the eyes and not the mind (Hvelplund, 2011, p. 69) (see section 2.3.2.2). This explains why these two types of activity are not identified in Carl and Schaeffer (2014). However, for PETT writing with ST processing (type 9 in Krings), by typing on screen, it is possible to catch the eye reading the ST while typing the TT, especially in the case of skilful typists. With respect to type 10, it is possible for a touch typist to type a TT segment while quickly shifting from the ST to the TT or from the TT to the ST.

'No recorded activity' in Carl and Schaeffer (2014) is actually a pause, as neither eye movement data nor keystroke is registered. Pause analysis has been used to infer cognitive effort in post-editing (e.g., O'Brien, 2006; Lacruz and Shreve, 2012) and translation (e.g., Jakobsen, 1998; 2002; Hansen, 2002; Alves, 2006; Dragsted, 2010). A higher number of pauses and the longer duration of a pause are indicative of more

cognitive effort being consumed.

2.5.3 The Underlying Purposes of Cognitive Processing in Hvelplund's Work

In Krings (2001), since no theoretical framework was established to study text production in post-editing, the writing-related processes are relatively simple. Hvelplund (2011; 2015) combines both text comprehension and production theories and examines reading (and writing) activities and their underlying purposes in the translation processes. This section begins with an introduction to the text comprehension theories that Hvelplund (2011; 2015) drew on to develop his levels of processing model.

Drawing on the text comprehension models (Padilla *et al.*, 1999; Anderson, 2001; Kintsch, 1988) and text production model (Kellogg, 1996), Hvelplund (2011) further refined the different levels of processing in the translation process (Table 4) in his exploration of the distribution of cognitive resources.

Types of Processing	Sub-processes	Levels of Processing
ST processing	ST Reading	- Orthographic analysis
	ST Comprehension	- Lexical analysis - Propositional analysis - Text representation and long-term memory transfer
TT processing	TT Reading	- Orthographic analysis
	TT Formulation	- Planning - Encoding - Verification
	TT Typing	- Programming - Executing
Parallel processing	ST reading and ST comprehension	- ST processing
	TT reading and TT comprehension	- TT processing

Table 4: Hvelplund's Levels of Processing in the Translation Process

Hvelplund (2011, pp. 48-58) identifies three types of processing in the translation process: ST processing, TT processing and parallel processing.

ST processing involves ST reading behaviour and the ST comprehension process. ST reading is considered as a separate process because, theoretically speaking, the cognitive processing will not start until the visual information enters the working memory at around 60 ms (Jaekl and Harris, 2007, p. 219). The goal of ST reading is considered by Hvelplund to be only to extract the physical properties of the visual input (orthographic analysis). During the ST comprehension process, the meaning(s) of the ST word(s) are identified (lexical analysis), a meaning representation of the ST is created

through propositional analysis, and finally a macrostructure of the ST is constructed and transferred into the long-term memory (text representation and long-term memory transfer).

In terms of orthographic analysis, TT reading is considered to be the same as ST reading. During the formulation process, the translator retrieves the SL text representation (planning) and encodes it into TL text representation in linguistic forms (encoding). During this process, two types of TT reading behaviour are involved: reading the emerging TT (TT reading + TT typing) and reading the TT that has been translated (TT reading). The former is deemed to be a monitoring process, whereas the latter is taken as a verification process. TT typing events are realised by directing the motor (programming) to execute the typing behaviour (execution).

Translation has been considered to be a sequential process (e.g., Gile, 1995; Danks and Griffin, 1997; Seleskovitch, 1976; Macizo and Bajo, 2004). Some researchers hold a different point of view and suggest that ST comprehension and TT reformulation could occur in parallel (e.g., Gerver, 1976; Mossop, 2003). In recent years, several empirical studies have been conducted to examine this. Evidence of parallel processing has been found to confirm the parallel view of the translation process (e.g., Jensen *et al.*, 2009; Balling *et al.*, 2014; Carl and Kay, 2011).

Parallel processing can happen at all processing levels. For instance, at the lexical analysis level, the TT equivalents can be proposed during ST comprehension (Ruiz *et al.*, 2008, p. 491). Syntactic processing of the TT can co-occur with ST comprehension (Jensen *et al.*, 2009, p. 331; Balling *et al.*, 2014, p. 251). Although TT processing is anticipated during ST comprehension (through reading), it is still possible that 'the allocation of processing resources alternates very rapidly between ST comprehension and TT reformulation' (Hvelplund, 2011, p. 64).

Hvelplund's (2011) model provides a very thorough description of the sub-processes and purposes involved in the translation process. However, the separation of the reading activities from the comprehension or reformulation processes might not be helpful in the further analysis of the purposes underlying each type of reading and/or typing activity. On the one hand, the comprehension process is mainly achieved through reading. On the other hand, the orthographic analysis takes place in a very short time span and is probably interwoven with other levels of processing in comprehension; it will therefore be rather difficult to distinguish the type of reading and its related goals.

In Hvelplund (2015), the reading activities as well as the cognitive activities and purposes underlying these reading activities during translation (Table 5) are further discussed based on Kintsch's (1988) construction-integration model.

Types of Reading Activity		Cognitive Activities and Purposes
ST reading	Source text reading without typing	- To extract meaning - To generate, test, reject or accept hypothesis - To comprehend the text's meaning potential well enough to make it possible to transfer every possible interpretation from the ST to the TT
TT reading	Reading of the emerging target text	- To re-read and re-assess TT meaning relative to ST meaning - To verify the transfer of meaning from the ST to the TT - To check the spelling or typing errors
TT typing + ST reading	Source text reading while typing	- To comprehend or analyse ST and reformulate TT - To generate, test, reject or accept hypothesis - To quickly shift attention between ST and TT - To process ST information while automatically typing - To reconfirm an original ST hypothesis - To build a propositional net for an entirely new ST segment
TT typing + TT reading	Reading of the existing target text	- To construct a pre-verbal version of an ST item in the TL - To compare an already generated meaning hypothesis of the ST segment to a meaning hypothesis of the TT segment being produced

Table 5: Hvelplund's Four Types of Reading Activities and the Underlying Cognitive Activities and Purposes

2.5.4 Summary

This section has reviewed the types of reading and typing activity, as well as the purposes underlying these activities, as identified in the post-editing and translation process studies. Based on UAD, seven types of reading and typing activity were detected by Carl and Schaeffer (2014). Since revision and post-editing are translation-related tasks, it is thus assumed that these seven types of reading and typing activity can also be detected in the self-revision, other-revision and post-editing processes. The underlying purposes behind the reading and writing activities discussed by Krings (2001) and Hvelplund (2011; 2015) provided theoretical underpinnings for the present study in the analysis of the cue-based retrospection data.

Chapter 2 has presented the theoretical underpinnings of the present study. It began with an introduction to the basic concepts of self-revision, other-revision and post-editing, as well as various empirical investigations of revision and post-editing styles. Since the processes of revision and post-editing involve language comprehension and production as well as reading and typing, relevant cognitive psychology theories used in reading research and text comprehension and production studies were then introduced. These include the cognitive information-processing model, visual attention theories and assumptions, van Dijk and Kintsch's (1983) adaptation of action theory used in discourse

analysis, and Kring's (2011) text analysis model. Existing literature on the types of reading and typing activities in the translation and post-editing processes have also been discussed.

Chapter 3 discusses the methodological model used in the present study – the data collection and analysis triangulation methods.

Chapter 3

Triangulating Key and Eye Data

One of the ultimate goals of an empirical study is to obtain unbiased data that can be analysed and discussed with objectivity. Researchers strive to design experiments in order to carry out investigations that have a high degree of validity and reliability both internally and externally, especially when dealing with cognitive processes, as is the case with this study. In translation process studies, Think-aloud Protocols (Ericsson and Simon, 1984) were once used as the approaches to probe into the human 'black box' (e.g., Dechert and Sandrock, 1986; Gerloff, 1986; Lörscher, 1986). However, as further research was conducted in this area, the limits of using verbal report methods began to emerge (e.g., Toury, 1991; Krings, 2001; Jakobsen, 2003). At the same time, the reliability of using a single research method to study the cognitive process of translation was also considered by Jakobsen (1999). In 2003, Fabio Alves introduced the method of triangulation into translation studies, in his edited book, *Triangulating Translation: Perspectives in Process Oriented Research*. Since then, a solid methodological groundwork has been established in the field of translation process research. The present study follows in the footsteps of translation process studies and triangulates the methods in both data collection and data analysis to investigate student translators' working styles in translation revision and post-editing.

This chapter first introduces the concept of triangulation (section 3.1), and then describes the methodological and data triangulation (section 3.2) used in the present study. Section 3.3 summarises the chapter.

3.1 Triangulation

The method of triangulation, most commonly used in the fields of navigation, civil engineering and surveying, is primarily based on the theory of trigonometry, in which two known points are used to allow surveyors to locate an unknown third point (Thurmond, 2001). In general research terms, it refers to the combination and application of two or more research methods in unveiling a phenomenon by scrutinising it from multi-perspectives (ibid.).

According to Denzin (1970, pp. 301-310), four basic types of triangulation method are used regularly by researchers. These are:

- Theory triangulation, which uses more than one theoretical underpinning to interpret data.

- Methodological triangulation, which implements mixed methods to gather and analyse data.

- Investigator triangulation, which engages multiple researchers in one study.

- Data triangulation, which involves data collected from different indicators, such as time, distance, velocity etc.

When more than one type of the above triangulation methods is used within one study (for example a longitudinal study carried out by two or more researchers using multi-methods to collect and interpret data) it is categorised as multiple triangulation.

During the last decade, triangulation as a mixed research method has been extensively used in translation process studies. In 1999, Jakobsen took the lead, proposing to combine Think-aloud Protocols with the keylogging software, Translog. Rydning (2002), in her article 'Brief Introduction to the Methodology of Translog and Think-aloud Protocols', suggested integrating Translog with Retrospection. In 2006, the Eye-to-IT[17] project began with the aim of constructing an integrated experiment, designed to study in depth the nature of interactions between mind-brain-behaviour-computer during cognition-for-translation tasks. This project has brought together a set of technological tools consisting of Eye-tracking (EYE), Keystroke logging (KEY), and Electroencephalography (EEG) to investigate the translators' translation comprehension and production processes. More significantly, the application of this specific set of technologies gave this branch of translation studies a comprehensive connection with cognitive psychology. Since 2006, triangulation with altered methodological combinations and theoretical groundings has become the most common, and also been considered the most appropriate approach for probing into the processes of translation.

The benefits of employing this model of triangulation are apparent. It provides complementary information and generates relatively unbiased data for interpretation, revealing findings from multidimensional perspectives through broader and deeper analysis. It also allows researchers to crosscheck the reliability of the data so as to strengthen and ensure the ecological validity of the research. However, the latent risks of

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[17] See the Eye-to-IT website: http://cordis.europa.eu/fp7/ict/fet-open/portfolio-eyetoit_en.html

adopting triangulation cannot be ignored. As pointed out by Thurmond (2001, p. 256), the weaknesses of triangulation may include:

(1) The increased amount of time needed in comparison to single strategies.

(2) Difficulty in dealing with the vast amount of data.

(3) Potential disharmony based on investigator biases.

(4) Conflicts arising on account of theoretical frameworks.

(5) Lack of understanding of the rationale for using triangulation strategies.

To avoid such drawbacks, Thurmond advises researchers to take great care before designing the research, and clearly articulate why triangulation has to be adopted, in order to assess how it will enhance the study. At the same time, he suggests that the investigators should make sure they have a comprehensive knowledge of all methods, and are capable of coping with all stages of the data collection and analysis processes.

The present study adopted a multiple triangulation model (Figure 10), consisting of theoretical triangulation (Chapter 2) and methodological and data triangulations (section 3.2), to construct a solid research methodology.
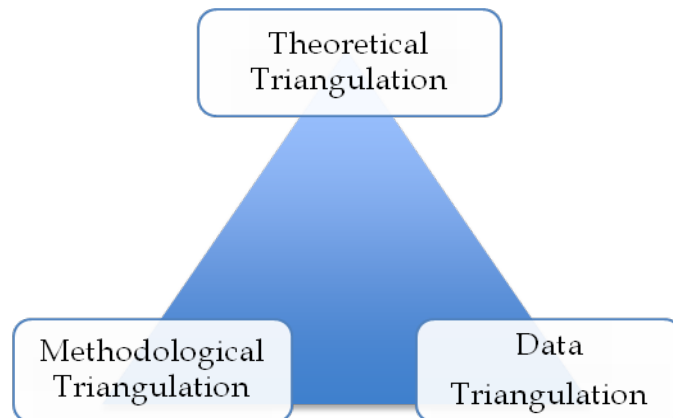
Figure 10: Model of Multiple Methodological Triangulations in This Study

3.2 Methodological and Data Triangulations

This section presents the methodological and data triangulations used in the present study, by introducing the data collection tools (section 3.2.1), data collection settings in the experiment (section 3.2.2), and data analysis tools (section 3.2.3). Software compatibility and methods of ensuring data quality are briefly discussed in section 3.2.4.

Taking a panoramic view of the data collection methods used in translation and interpreting process studies since the 1980s, it can be found that the methods employed

are borrowed from three different disciplines: cognitive psychology, neuroscience and human-computer interaction (O'Brien, 2013). These data collection methods used in translation and interpreting studies have evolved diachronically (Figure 11[18]), from verbal report methods introduced by Ericsson and Simon (1984), to the keystroke logging tool designed by Jakobsen and Schou in 1995 (Jakobsen, 1999; 2006; Carl, 2012a); then from a triangulation of keystroke logging with eye tracking in the context of the Eye-to-IT project in 2006, to a triangulation of eye tracking with neuroscience technologies from the late 2000s: for example, EEG and fMRI (Functional Magnetic Resonance Imaging) (e.g., Chang, 2009). As mentioned by Göpferich and Jääskeläinen (2009, p. 170), 'each of these methods has its particular strengths and weaknesses', but the triangulation of these methods can definitely overcome the weaknesses resulting from the use of a single method, and increase the validity of the data.
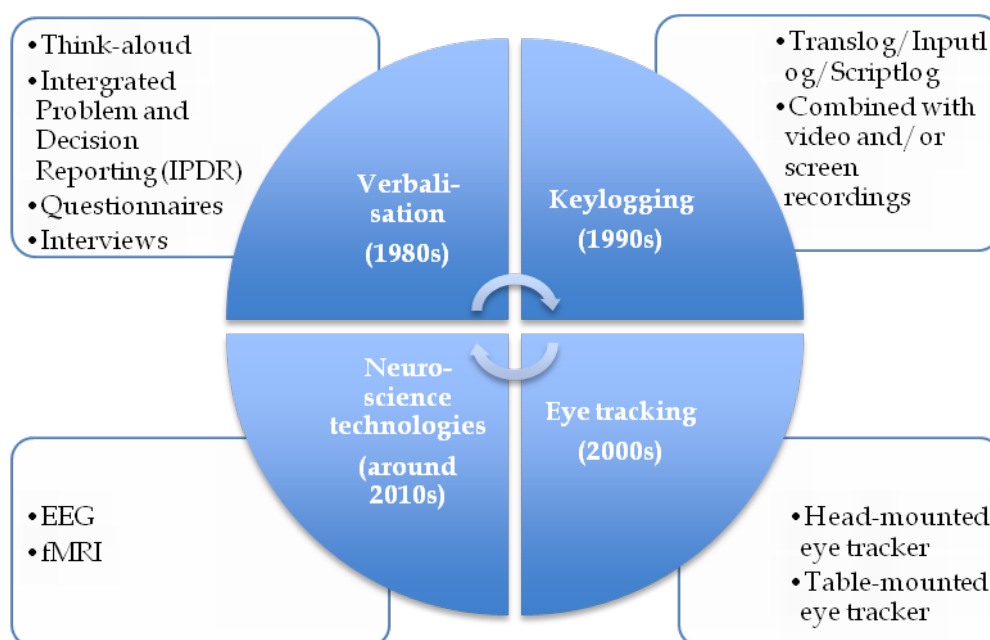
Figure 11: Overview of Data Collection Methods Used in Translation and Interpreting Studies

Considering the scope of the present study, a methodological triangulation model was used (Figure 12). It triangulated keylogging, eye tracking and cue-based retrospection to study student translators' working styles in carrying out self-revision, other-revision and post-editing tasks. Section 3.2.1 provides detailed introductions to each of these data collection tools.

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[18] For detailed analyses of the data collection methods mentioned in the graph, see Tirkkonen-Condit (2002), Gile (2004), Göpferich and Jääskeläinen (2009), O'Brien (2013) and Jakobsen (2011).
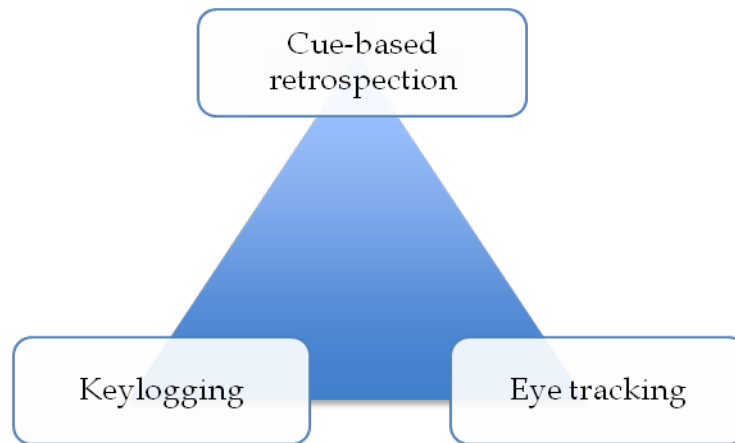
Figure 12: Model of Data Collection Triangulation in This Study

3.2.1 Data Collection Tools

3.2.1.1 Key Logger

People had begun to use computers for many writing tasks by the 1990s. Some keystroke logging tools (key loggers) were developed since then to log the keystrokes with time stamps, such as ScriptLog (Ahlsén and Strömqvist, 1999), Translog (Jakobsen, 1999) and Inputlog (Leijten and Van Waes, 2006). Now, these keylogging tools are widely used in cognitive process studies, for instance, cognitive writing process studies and translation process research.

Translog, an abbreviation for 'Translation log', has been developed for over 10 years to reach its current advanced stage of functionality. With the idea of 'revolutionizing the world of translation research by recording every keystroke in a text production session, and afterwards replaying the whole thing on screen' (Schou *et al.*, 2010, p. 37), and the aim of 'triangulat[ing] qualitative and quantitative data and test[ing] hypotheses derived from analysis of qualitative data against quantitative data, and vice versa' (Mees, 2010, p. 23), Jakobsen and his son, Lasse Schou, programmed the first version of Translog (Translog 1.0) in a MS-DOS environment in 1995. It then had three main functions: (1) displaying the source text automatically in different formats: full text, paragraphs, sentences or segments; (2) recording all keystrokes made during the translation tasks in time, including navigation and deletion keystrokes but excluding mouse clicks, and saving all data in a log file, and (3) replaying all keystrokes at different speeds. Since 1999, researchers have begun to use this new research tool in conjunction with other qualitative approaches, such as Think-aloud Protocol and video recording, in translation process studies (Mees, 2010, p. 23). Subsequently, an increasing amount of research was conducted in translation studies, as well as in writing studies, using Translog as a data collection method. As a result, further functions, such as Unicode support, XML (Extensible Markup Language) support, multiple log file support, and

compatibility with different computer operating systems (e.g., Windows OS), were required to ameliorate Translog.

The first updated version, Translog2000, consists of two independent components, Translog-Supervisor and Translog-User. Translog-Supervisor is used to create the source text; to set up projects to be run by Translog-User; to display log file data produced by Translog-User separately or concurrently with the replay function and linear representation, and to count and analyse log file data. Translog-User is an interface for displaying, entering or editing translation text. It operates with two windows, a source text window above, and a target text window below. The difference between a word processor system and Translog-User is that all keystrokes typed into the programme, including revisions, deletions, additions, cut and paste operations, and cursor movements, are recorded automatically without interfering with the operator, and can be visualised and analysed in linear representation. Translog-Supervisor includes a small statistical programme that calculates the key and time data after translation tasks have been completed. Using Translog makes it possible to visualise the translation phases and typing chunks (including the size and composition) of a translator's operations. This feature provides researchers with some important insights, as well as first-hand data that can be used to probe into the possible cognitive processes of translators. For example, by using Translog, Englund Dimitrova (2005) found that senior professional translators made far more revisions, especially online, than other participants (most of them students), who often waited until the post-drafting phase to revise.

Even though Translog monitors translators' typing events more naturally, and provides researchers with objective quantitative data, it only registers data about the translation product. Questions pertaining to the cognitive activities going on in a translator's 'black box' during pauses between translation chunks remained unclear (Jakobsen, 2011). For example, the questions of why pauses occur, why they are of different duration, and which kind of processing they are related to, were still unanswerable, and researchers could only speculate on the translation product from a linguistic perspective, rather than formally adopting a cognitive approach (ibid.). To uncover the cognitive processes by which translators comprehend and produce texts, data reflecting eye movements have to be added as supplementary evidence of their attention distribution in translation tasks (ibid.).

In 2006, Translog was released in another version, Translog2006. It was synchronised with eye-tracking technology (see section 3.2.1.2) and electroencephalography (EEG), as developed in the context of the Eye-to-IT project. According to Carl and Schaeffer (2014), it also triangulated the product data (keystroke data) with the process data (eye-tracking data) by recording gaze-sample points,

computing gaze fixations, and then mapping the fixations onto the closest character on the interface (fixation-to-word mapping, explained in sections 3.2.3 and 5.1.2). These process and product data (User Activity Data, or UAD, explained in section 3.2.3) are stored in an XML format and can be subsequently analysed using external tools such as SPSS and R. Between the period 2006-2009, over 70 articles exploring the translation process from cognitive approaches were published, triangulating the methods of EYE, KEY, and/or EEG (see Eye-to-IT Project Publication[19]). Research into process-oriented translation was thus able to probe much more deeply into the subject. Nevertheless, since Translog was then mainly used in research from and into Roman-alphabet languages, Translog2006 did not support English-into-Chinese translation, as Chinese characters could not be typed into the target text area.

In 2012, Translog-II (Carl, 2012a), the latest version of the original Translog software, was released. Based on the previous Translog versions, and continuous development of UAD analysis support functions, Translog-II solved the problem of typing Chinese, and embedded the Sogou Pinyin input method into the software. This gave process research into English-into-Chinese translation a new platform for investigations adopting multivariate triangulation methods. The current study pioneers empirical research into the cognitive process of English-into-Chinese translation revision and post-editing by triangulating keylogging data with eye-tracking data.

3.2.1.2 Eye Tracker

Eye tracking is a technology most commonly used in studies that measure eye position and eye movements in order to investigate human attention and cognitive processes. The device recording eye movements is called an eye tracker, and is capable of tracking such activities of the eye as fixations and saccades in a particular task. The earliest type of eye tracker was built by Edmund Huey at the beginning of the 1900s, using a peculiar kind of contact lens with a hole for the pupil (Huey, 1968). The lens was linked to an aluminium pointer, which moved along with eye movements, so that the scanpath of the eyes could be recorded (ibid.). In the hundred years since then, numerous new eye-tracking technologies have been discovered, and these have been applied in research in many different fields. According to Duchowski (2007), eye-tracking technology is currently in its fourth generation of development, collecting digital video-based data referring to combined pupil and corneal reflection, which is then augmented by computer vision techniques, and enhanced in Digital Signal Processers (DSPs).

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[19] Visit http://cogs.nbu.bg/eye-to-it/ to access the publication list.

At present, there are two different types of eye tracker used in research into cognitive information processing: the head-mounted eye tracker (e.g., EyeLink II, Tobii SMI eye tracking glasses, and ASL Mobile Eye-XG) and the table-mounted eye tracker (e.g., Tobii T and X series, Tobii TX300, and Tobii X1 Light, SR Research's Eyelink 1000 Remote). There are two types of head-mounted eye tracker: head-mobile, where the participants need to wear a pair of eye-tracking glasses while in tracking; and head-supported, which requires the users to keep their head still, with chin fixed in place while the device is collecting data. These two types of eye tracker have the advantages of recording all eye movement events and collecting accurate and complete eye data. However, both types of head-mounted eye tracker are considered intrusive; in the case of studying student translators' activities, asking them to wear glasses or to use chin rests would prevent the participants from experiencing their normal working conditions.

Table-mounted eye trackers also come in two types. One is a video-based remote eye tracker, which looks just the same as a regular computer monitor (e.g., Tobii T series). Around the edges of the monitor, diodes are built in to generate near-infrared beams that are reflected on the user's cornea. Below the screen, a camera is built in to capture corneal reflection, and calculate the positions of the gaze on the screen. Users do not feel any discomfort when looking at the screen, and were they not told, they may not notice the camera at all. The second type of product is a relatively recent innovation. It is a stand-alone eye tracker which can be attached to laptops, computer monitors, and certain other physical objects by means of various support brackets (e.g., Tobii X1 Light). It includes a head movement box that allows users to move their head during tracking whilst the device continues to collect accurate data. Table-mounted eye trackers are often used in translation process studies on account of their unobtrusiveness. The system tolerates head movements, so that participants are provided with a natural working environment. The main disadvantage is that these eye trackers can only record eye movement events when users are looking at the screen. Therefore, the participants need to be asked to fix their gaze as much as possible on the screen area of the monitor.

3.2.1.3 Cue-based Retrospection

Think-aloud Protocol, a verbal data collection method, has been widely used in research in different areas, such as cognitive psychology, marketing, human-computer interaction and social sciences (e.g., translation process studies, writing and reading process studies). There are two types of Think-aloud Protocol method: concurrent Think-aloud (TAP) and retrospective Think-aloud (RTA) (Hannu and Pallab, 2000). The former requires the participants to verbalise their thinking process while the task is being carried out, whereas

the latter allows the participants to perform their task as normal, and then they are asked to verbalise their working process as soon as the task is completed.

Since Ericsson and Simon (1980; 1984) introduced and developed the protocol analysis method, researchers have begun to use TAP in empirical investigations of the cognitive process of translation studies and translation revision studies (e.g., Dechert *et al*., 1986; Gerloff, 1986; Krings, 1986; Lörscher, 1991; Jääskeläinen, 1989; Jääskeläinen and Tirkkonen-Condit, 1991; Kussmaul, 1997; Shih, 2006). As an increasing number of researchers started to analyse their research findings primarily based on TAP, some researchers began to review this method and analyse its strengths and weaknesses from different perspectives (e.g., Kussmaul and Tirkkonen-Condit, 1995; Bernardini, 2001; Jääskeläinen, 2002; Tirkkonen-Condit, 2002; Hansen, 2005; Doherty, 2012). One relatively objective conclusion based on the findings of several empirical investigations is that, although TAP is successful in 'establishing a complex inventory of meaning operations or strategies performed by translators' (Carl *et al*., 2008, p. 115), it decreases the translation speed (Krings, 1986; Jakobsen, 2003) and degenerates translation segmentation (Jakobsen, 2003), because TAP 'must have an impact both on the thought processes, on the translation process and on the translation product' (Hansen, 2005, p. 519).

Retrospective Think-aloud, also called retrospection or RTA, is a non-intrusive verbalisation method which seems to be more natural than concurrent Think-aloud. In recent years, more and more research into translation or interpreting process studies has gradually begun to adopt this method as the data collection method(s) (e.g., Ivanova, 2000; Alves, 2003; Gile, 2004). However, RTA also has its limitations. One key issue is the risk of forgetting. Cohen and Hosenfeld (1981, p. 285) distinguish 'immediate retrospection' from 'delayed retrospection'. If the task itself takes 30 seconds or less and retrospection takes place immediately after that, it is categorised as 'immediate retrospection'. 'Immediate retrospection' is considered to be able to collect more complete data than TAP (Ericsson and Simon, 1993, xvi/19) because it does not interfere with the thinking process, and by the time of recalling, the information is still stored in the short-term memory (see section 2.3.1.1). If the task itself takes longer than 30 seconds, or the retrospection takes place later after the completion of the task, it is called 'delayed retrospection' (Ericsson and Simon, 1993, xvi/19). 'Delayed retrospection' involves the risk of forgetting, which means it runs the risk of distorting the report data. For most translation or revision process studies, it is unrealistic to design a task which is shorter than 30 seconds. To reduce the risk of the participants' forgetting, this study adopted a cue-based retrospection using recorded gaze data and keystroke logging data registered by Tobii Studio as stimuli (cues) for retrospection (see section 3.2.2 for data collection settings, and see section 4.3 for a full description of the experiment). The other issue pointed out by Hansen (2005) is that it is

hard to tell whether the information has been recalled from memory or is mixed up with prior knowledge, experience, emotions, inferred justifications and so on. To tackle this problem, in the current study the data were analysed from different perspectives interpolating the different data sources: EYE, KEY and cue-based retrospection, rather than from RTA only.

Although RTA has its limitations, it has been empirically proven to provide 'a valid account of what people attended to in completing tasks; it has a low risk of introducing fabrications; and its validity is unaffected by task complexity' (Guan *et al.*, 2006, p. 1253).

3.2.2 Data Collection Settings

In this study, all participants completed the tasks on Translog-II User with the ST displayed in the upper window and the TT in the bottom window (Figure 13), with the eye-tracking function activated. To ensure the quality of the collected data, both texts were double-spaced, using font size 20. The font type of the ST was Microsoft Sans Serif, and the TT was Simsun. To avoid drifting problems, the first line in both the ST and the TT window was intentionally left blank. Eye tracking data were collected using a Tobii TX300 eye tracker unit, which was attached to a 23″ LCD (liquid crystal display) monitor with a resolution of 1920 x 1080 pixels. It has a sampling rate of 300 Hz. The corresponding data collection and analysis software, Tobii Studio, provides researchers with both qualitative data (e.g., gaze plot and hot maps) and quantitative data (in both table and chart formats) through selected variables and measurements. However, in this study, the data Tobii Studio collected were not analysed, owing to the time constraints on the data collection and on the completion of this thesis. The department has agreed to store the data for five years after the end of the study. Further studies are in the planning stage to interpret the data from different perspectives. In the present study, Tobii Studio was used mainly as a stimulus for cue-based retrospection, as well as one of the data quality filters to indicate the recorded gaze percentage on screen (see section 5.3.2). By analysing the data collected from one source, i.e., Translog-II (with eye tracking activated), a higher degree of temporal synchronisation was achieved without effort.

Figure 13: Screenshot of Translog-II User Interface

The aim of using cue-based retrospection in this study was twofold. Firstly, the student translators' retrospection on their self-revision, other-revision and post-editing activities would reveal the underlying purposes behind their reading and typing activities. Secondly, by analysing their reflections on the procedures of self-revision, other-revision and post-editing, their rationale for choosing a particular working style in a certain task could be inferred. Cue-based retrospection was conducted immediately after the completion of the tasks on each day (see section 4.3). Since this could have resulted in the distortion of the data, as participants may have had a fresher memory of the latest task undertaken than of the former task, in order to compensate, the task order for all participants was randomised (see section 4.3.2). The retrospection included two parts. The first part was free cue-based retrospection delivered by the participants, where they were allowed to report anything in their minds at their own pace. The second part was an interaction part, in which the researcher asked questions on the prepared post-experiment questionnaire in the form of an interview, while at the same time replaying the participants' eye movements and typing activities recorded in Tobii Studio as cues for memory. The post-experiment questionnaire was used to guide the participants to answer the questions that are directly related to the research questions designed for this study. It (Appendix 9) contains five parts: participants' feedback on the task of self-revision (Questionnaire A), other-revision (Questionnaire B) and post-editing (Questionnaire C), the comparison of text and task complexity (Questionnaire D), and experiment validity (Questionnaire E).

Questionnaires A, B and C focus mainly on the following questions:

a. Were there any problems with the TT before you revised or post-edited it?

b. How many times did you revise the TT from start to finish, and why?

c. What were your focuses and criteria during each run-through?

d. What reading and typing activities did you perform during the revision and post-editing processes? Which was your main activity? Why?

e. Can you describe how you read the ST and the TT to revise the TT, and why?

Question d. above was aimed to elicit answers to RQ2 in this study: the purposes of student translators in conducting reading and/or typing activities in self-revision, other-revision and post-editing. Questions a., b., c. and e. were used to examine RQ3: the working styles of student translators in performing self-revision, other-revision and post-editing, and the purposes behind each type of working style.

In order to ensure retrospection data validity, the guidelines discussed by Saldanha and O'Brien (2013, pp. 27–49; 150–204) were taken as a reference. These can be summarised as follows:

- Only questions directly related to the research questions of the present study were designed for the questionnaire.

- Questions eliciting personal data were separated from the other questions.

- All questions containing specialised terminology were clearly explained to the participants.

- The research questions were set out very clearly, so as to avoid the 'researcher personal attribute effect' (Saldanha and O'Brien, 2013, pp. 29-30), i.e., participants' responses being influenced by the researcher's characteristics; and to avoid a power relationship arising between the researcher and the participants.

- The wording of the questions was kept neutral rather than leading (e.g., the question 'what were the problems of this translation?' was changed to 'were there any problems with this translation?'). A clarification that the researcher was not searching for particular answers, and was interested in recording the whole range of possible answers, was made at the beginning of the post-experiment

questionnaire section, in order to avoid the 'researcher unintentional expectancy effect' (Saldanha and O'Brien, 2013, pp. 30-31).

- Post-task debriefing (see section 4.3.4) was conducted in order to avoid the 'Hawthorne effect' (Saldanha and O'Brien, 2013, pp. 31-32), i.e., participants altering their normal working behaviour when aware that they are being studied.

- All questions were posed to all participants in the same research environment; in other words, they were all given equal opportunities to express their views.

- The researcher tried to keep a self-reflective, open-minded and socially aware attitude, in order to encourage the cooperation of the participants.

- Any participants who did not seem very willing to talk were allowed to take their time.

- The researcher carefully summarised the main points of the participants' answers to obtain confirmation at the end of each question.

- Participants were asked to add any comments, and were offered the opportunity to ask questions at the end of the post-experiment questionnaire session.

- The participants answered all questions orally. Since all the participants were native Chinese speakers, the language used in the post-experiment questionnaire session was Chinese. A digital recorder was used to record all questions and answers. The retrospection data were subsequently transcribed by the researcher by typing their scripts into a Word document to prepare for further analysis.

3.2.3 Product and Process Data Triangulation in Analysis

The data analysis method used in the present study was borrowed from a relatively new data analysis method used in translation process studies.

User Activity Data (UAD) is a term coined by Carl *et al.* (2008), referring to all eye movement and keystroke data registered during the translation process. It was introduced by Carl *et al.* (2008), as well as Carl and Jakobsen (2009), for use in the study of human translation behaviour. UAD is believed to provide us with 'direct access to the motor activity which results from the cognitive activity we wish to study' (Carl and Jakobsen, 2009, p. 116).

UAD in Translog is structured by the product data (the ST, the TT and word alignment of ST and TT) and process data (gaze sample points, fixations and keystrokes).

The translation process contains three sub-processes: (1) 'reading and construction of ST meaning'; (2) 'mapping ST meaning onto a representation in the TL'; and (3) 'typing of new representation' (Carl *et al.* 2008, p. 116). However, the product data, i.e., the TT, registered by Translog-II, is actually only the 'tail end' (Carl *et al*. 2008, p. 116) of the translation process. In order to gain a deep insight into the process of translation, eye movement data which 'give a detailed picture of the complex processing involved in constructing meaning from a string of verbal symbols and representing that meaning in the symbols of a new language' (Carl *et al.*, 2008, p. 116) should be triangulated with the product data, so that all three sub-processes of translation can be mapped (Figure 14).
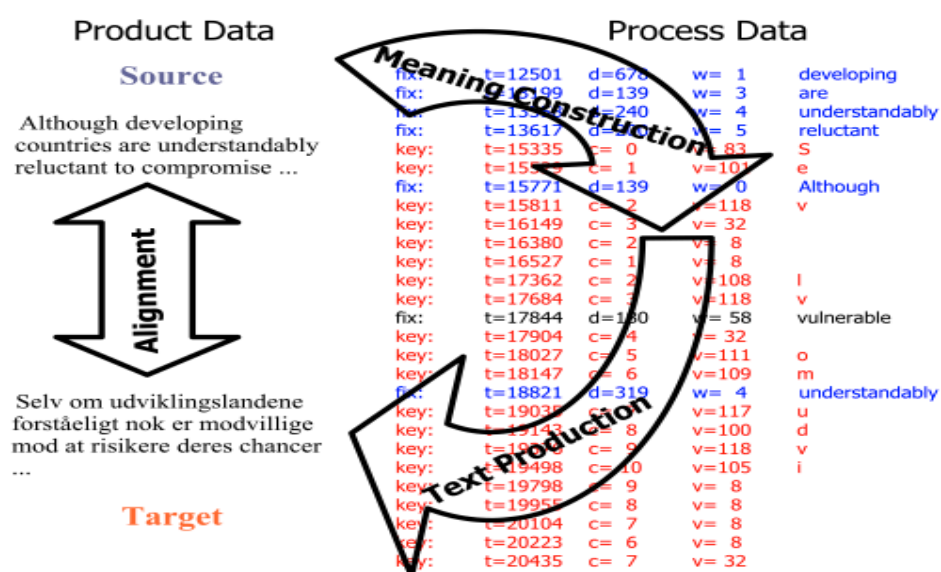
Figure 14: CRITT Translation Product and Process Data Triangulation

The product data are identified by locating the position of each ST and TT word on the screen and in the text. According to Carl and Jakobsen (2009, p. 126), 'the screen position is indicated through the top-left and bottom-right pixel position while cursor positions give the character offset from the beginning of the text' (Figure 15). Pixel position is very important for fixation-to-word mapping, that is, mapping the gaze samples onto the word(s) that is/are being fixed on. Cursor positions are used as the index of the word. Each of the ST words and the corresponding TT words are aligned in order to provide us with more information about translation units: in other words, 'which units in the ST correspond to which units of the TT' (Carl and Jakobsen, 2009, p. 126). The alignment method is discussed in section 5.1.

The process data mainly include fixations and keystrokes. 'Fixations are computed based on gaze samples, which are described by the screen coordinates looked at by the left and right eye, as well as pupil dilation at a particular time' (Carl and Jakobsen, 2009, p.

128). The gaze samples, which are reasonably close to each other, are grouped into fixations to represent the time spent on the reading of a word(s). Every fixation has a starting time, duration, ending time and cursor position (ibid.). According to Carl and Schaeffer (2014), a density-driven fixation computation algorithm is currently being used to cluster gaze samples within a distance of 60 pixels into one fixation, and the threshold for the fixation is 40 ms. The centre of a fixation is mapped onto the word which is closest to it. The keystroke information is logged by Translog-II in real time. As discussed in section 3.2.1.1, insertions, deletions, backspacing, mouse clicks and cursor navigation can all be registered. In process-oriented translation and revision studies, the interest is focused on the insertions and deletions - how a text is produced and revised.
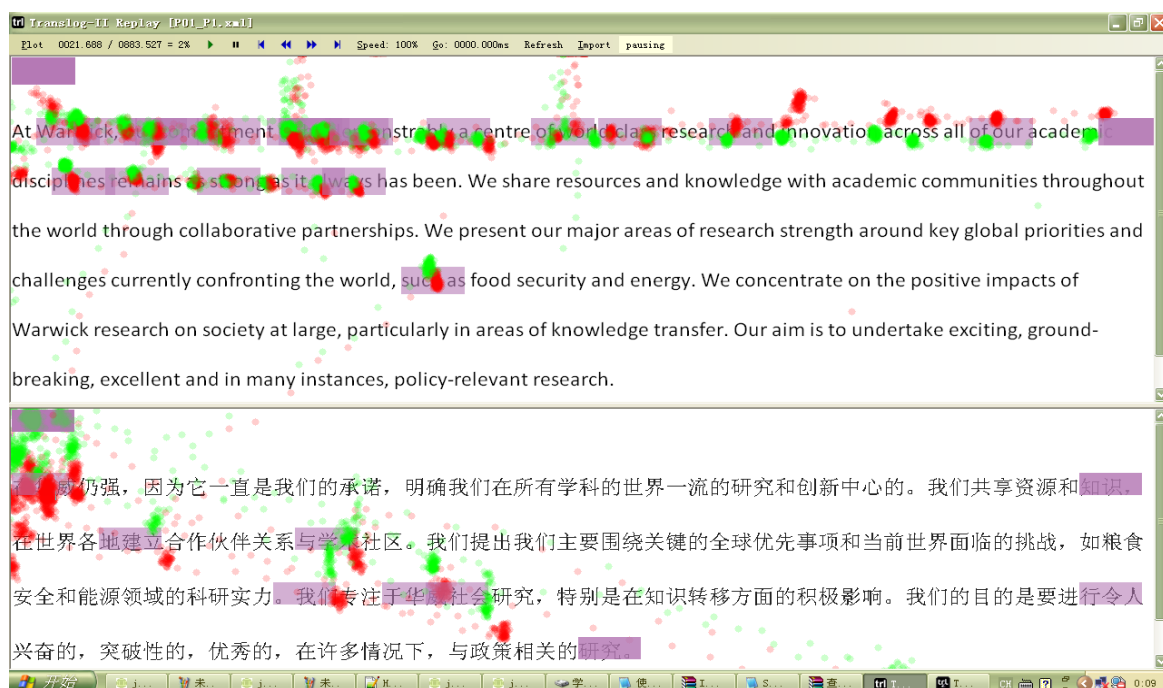
Figure 15: Screenshot of the Replay of the Translation Revision Process in Translog-II

In Figure 15, the green and red dots are gaze samples collected from the participant's left eye and right eye, respectively. The purple bars mapped the word(s) that was/were being fixed on. In the 'Plot' of Translog-II, which can be found on the top left-hand corner of the software, 'fixation' can be selected to appear on the screen.

Although the revision and post-editing processes might be slightly different from the translation process (as the reviser works on an existing TT), UAD analysis is still applicable because the basic elements for analysis, the ST, the TT, eye movement data and keystroke data, are the same. UAD relates the static product data (the ST and the TT) to the dynamic process data (fixations and keystrokes). It also relates the spatial product data to the temporal process data. How the process and product data are triangulated for UAD analysis is explained in section 5.1.

3.2.4 Ensuring Software Compatibility and Data Quality

As mentioned above, only the data produced by Translog-II were analysed in this study. However, Tobii Studio was still running in the background as a data filter method. This means these two software programs were both running while I was collecting the data. Software incompatibility can be a potential issue, but this was tested and compatibility was confirmed in the pilot studies (see section 4.4).

The eye tracking system is very sensitive and many variables can affect its functionality. In addition, experiments using keylogging have requirements for the typists selected, such as typing speed and input method. For these reasons, all variables that might have affected the validity of the data had to be controlled. Data quality control during the collection phase is discussed in Chapter 4.

3.4 Summary

This chapter has introduced the data collection and analysis tools used in the present study. Eye tracking, keylogging and cue-based retrospection were triangulated to collect both product and process data. UAD, which in this study was a combination of the product data (the ST, the TT and word alignment of ST and TT), and process data (gaze sample points, fixations and keystrokes), was briefly introduced. Software compatibility and data quality issues were considered prior to designing the research, and were tested in the pilot studies.

Chapter 4 introduces the research design of this study: the selection of participants, research texts, experiment tasks and procedures, and the two rounds of pilot study.

Chapter 4

Research Design

Research design is of the utmost importance to empirical and experimental studies, as it is a decisive factor not only in deciding whether the experiment can be carried out effectively, but also in determining whether the data collected by the chosen method(s) can answer the corresponding research question(s) in depth. A small-scale explorative pilot study normally serves as 'a fishing trip' (Holmqvist *et al.*, 2011, p. 67) for such studies, to provide the researcher with a clear and full picture of the experiment's key elements, such as sample size and experiment time; to test the effectiveness of data collection and analysis methods, as well as the quality of the data, and to detect potential interferential factors that may lead to the failure of the experiment. In this study, two rounds of pilot study were conducted prior to the formal experiment.

In order to organise and present all the research ideas in an orderly manner, this chapter first gives a detailed account of the research design, and then reviews and discusses the feedback from the pilot studies. Sections 4.1, 4.2 and 4.3 present the considerations related to participant recruitment and selection, research texts, and the arrangements made for the experiments. Section 4.4 focuses on the two rounds of pilot study conducted, and section 4.5 concludes the chapter.

4.1 Participants

In this section, the participant recruitment and selection process is first described. Ethical considerations and the solution to the problem of participant variation are presented in the following two sub-sections.

4.1.1 Participant Recruitment and Selection

A sample of 36 Chinese students enrolled on an MA translation programme at Durham University were recruited as the participants for this study. Since the data collection methods used (i.e., eye-tracking and keylogging technologies) require a very high standard of eyesight and typing ability to produce good quality data, these participants unwittingly underwent three rounds of screening (see Table 6) throughout the

experiment: pre-experiment screening (see section 4.1.1), in-experiment screening (4.3.3), and post-experiment screening (4.4.2.2). Only 18 students produced satisfactory data that were finally analysed in this study.

Participant Screening	Filter(s)	Contents
Pre-experiment phase	• Pre-experiment questionnaire	• Background information • Eye condition and typing ability
In-experiment phase	• Calibration and typing speed	• Satisfactory calibration • Successful completion of tasks meeting all experiment requirements
Post-experiment phase	• Post-experiment questionnaire • Eye movement data quality criteria • Typing speed assessment	• Participants' evaluation of the experiment and data validity • Recorded fixation percentage • Mean fixation duration (see section 5.3.1) • Post-task debriefing (see section 4.3.4)

Table 6: Participant Screening Procedures

Pre-experiment Screening:

Prior to the formal experiment, a 'call for participation' email was sent to 40 Chinese students in the above group. The email briefly introduced the aim of this research; stated the experiment requirements; clearly explained the issue of confidentiality regarding their personal information, as well as their autonomy in taking part in the experiment, and asked them to fill in a pre-experiment questionnaire (see Appendix 3).

The pre-experiment questionnaire was used as the first participant selection filter. It contained three parts: participant background information, participant eye condition and typing ability.

Language competence, practical translation or revision experience and professional training are three variables that may have a potential influence on personal

translation and/or revision styles. To control these confounding variables, the participants selected for the present study had to meet the following requirements:

- To have Chinese as their mother tongue and English as a foreign language.

- To possess comparable English proficiency (the International English Language Testing System was taken as a measure; a total IELTS score at or above 7.0 is the entry requirement for the MA programme at Durham University).

- To have comparable years of formal translator training and/or revision and post-editing training (formally enrolled in a translation programme at university or professional translation training centre which issues a degree or certificate on completion of the course).

- To have comparable years of practical translation experience (working as a full-time translator in a translation agency, or as a freelance translator, or as a full-time student translator who carries out extensive translation exercises).

- To have comparable revision and post-editing training and practical experience.

Furthermore, the selected participants were expected to have similar typing ability, as this is another confounding variable which can be misleading in data analysis.

- The participants had to be proficient in typing simplified Chinese characters, rather than traditional, complex characters, as the target language investigated was simplified Chinese.

- All participants had to be proficient in using Sogou Pinyin as the Chinese input method. The rationales were twofold: (1) amongst all other input software, Sogou Pinyin has the best compatibility with the keylogging software, Translog-II, and (2) the horizontal character selection bar of Sogou can be set more closely to the line of words being typed in the interface of Translog-II than that of other input software.

- In order to avoid too many switches between the screen and keyboard when typing, the participants were required to touch-type in Chinese.

Eye condition is also a key factor that should be taken into consideration in eye-tracking studies. Since an eye tracker is very sensitive to flickering objects, such as glasses, participants with normal eyesight would be ideal for the experiment. However, it was unrealistic to find a cohort of student translators who met all other requirements and

were neither short-sighted nor long-sighted. As long as the participants wore the right type of glasses or contact lenses, the eye-tracking system would not be disrupted.

- Prior to conducting the formal experiment, the selected participants were advised to bring all their glasses with them to the lab in order to find the pair that worked best. Participants who could not produce satisfactory calibration in the experiment were excluded.

- According to Holmqvist *et al.* (2011, pp. 116-125), participants who have droopy eyelids, downward pointing eyelashes, eye diseases or disorders, or who have had eye operation(s) in the past are not ideal for the experiment.

- Tobii TX300 is optimised for dark pupil tracking; the colour of participants' pupils was therefore checked.

A total of 36 out of 40 students responded to the 'call for participation' email by filling in and returning the pre-experiment questionnaire. After the first round of screening, 28 were selected to participate in the formal experiment as they met all the above requirements. After three rounds of screening, only 18 participants successfully completed all experiment sessions and produced satisfactory data that were considered reliable for analysis.

As can be seen in Table 7 below, of these 18 participants, 15 were female and only three were male. Currently, no studies in translation process research have provided evidence that gender difference affects findings. All the participants had comparable English language proficiency and formal translator training backgrounds. None of them had any professional translation experience, but considered their weekly translation practice in the MA programme as part of their translation experience. They had not received any training in self-revision, post-editing or other-revision, but had gained some self-revision and other-revision experience on the MA translation course.

Participant	Sex	Age	English proficiency	Formal translator training	Translation experience	Revision / Post-editing training	Revision experience	Post-editing experience
P1	M	24	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P2	F	24	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P3	F	23	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P4	F	24	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P5	F	23	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P6	F	24	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P7	F	22	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P8	F	23	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P9	M	23	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P10	F	26	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P11	F	22	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P12	F	23	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P13	F	22	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P14	F	23	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P15	F	25	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P16	F	23	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P17	M	22	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No
P18	F	22	IELTS >= 7.0	1 year	1 year	None	Yes (1 year)	No

Table 7: Participants' Background Information

Table 8 below presents the participants' typing ability. A 100-character Chinese text was selected and shown in the upper window of Translog-II. All participants were asked to copy this text in the lower window of Translog-II by touch-typing. Sogou was used as the input method (see section 4.3.3). The statistics generated in Translog-II showed that all participants completed the task in 4 minutes and the user events per minute were similar.

Participants	Chinese input method	Touch typing in Chinese	Duration of text copying	User events per minute
P1	Sogou	Yes	03:08.075	18044.18
P2	Sogou	Yes	03:29.443	18033.92
P3	Sogou	Yes	03:22.290	18034.02
P4	Sogou	Yes	03:43.692	18034.97
P5	Sogou	Yes	03:42.800	18027.47
P6	Sogou	Yes	03:50.571	18043.16
P7	Sogou	Yes	03:43.567	18033.71
P8	Sogou	Yes	03:39.619	18040.24
P9	Sogou	Yes	03:06.983	18037.58
P10	Sogou	Yes	03:43.786	18035.46
P11	Sogou	Yes	03:45.361	18039.08
P12	Sogou	Yes	03:49.791	18040.53
P13	Sogou	Yes	03:13.818	18056.99
P14	Sogou	Yes	03:41.781	18019.80
P15	Sogou	Yes	03:47.167	18026.51
P16	Sogou	Yes	03:40.757	18041.29
P17	Sogou	Yes	03:48.216	18027.89
P18	Sogou	Yes	03:27.929	18033.11

Table 8: Participants' Typing Ability

The eye conditions of all participants are summarised in Table 9 below. As can be seen, they all had dark pupils and none of them had eye diseases, droopy eyelids, downward pointing lashes or experience of eye operations. 14 of them were short-sighted and wore frame glasses. All of them did successful calibrations and produced good quality eye movement data (see section 5.3 - Data Quality - for more details).

Participant	Pupil colour	Eyesight	Glasses	Eye diseases / disorders	Droopy eyelids / Downward pointing lashes	Eye operation
P1	Dark	Normal	None	None	None	None
P2	Dark	Normal	None	None	None	None
P3	Dark	Short sighted	Frame	None	None	None
P4	Dark	Short sighted	Frame	None	None	None
P5	Dark	Short sighted	Frame	None	None	None
P6	Dark	Short sighted	Frame	None	None	None
P7	Dark	Short sighted	Frame	None	None	None
P8	Dark	Short sighted	Frame	None	None	None
P9	Dark	Short sighted	Frame	None	None	None
P10	Dark	Short sighted	Frame	None	None	None
P11	Dark	Short sighted	Frame	None	None	None
P12	Dark	Normal	Frame	None	None	None
P13	Dark	Normal	Frame	None	None	None
P14	Dark	Short sighted	Frame	None	None	None
P15	Dark	Short sighted	Frame	None	None	None
P16	Dark	Short sighted	Frame	None	None	None
P17	Dark	Short sighted	Frame	None	None	None
P18	Dark	Short sighted	Frame	None	None	None

Table 9: Participants' Eye Conditions

After the pre-experiment screening phase, the selected participants were contacted again via email to confirm their participation in the formal experiment. So that they would have an opportunity to select their preferred time slots and to avoid time clashes, they were sent a specially created doodle poll (an online scheduling tool). The email also mentioned that, as a token of gratitude, a 15% discount voucher to use at a local shop (an oriental food shop in Durham) would be given to them on the experiment day (see Appendix 12).

4.1.2 Research Ethics

The present study obtained departmental ethical approval (see Appendix 2) prior to the conducting of the experiments. As defined by the British Psychological Society (2010, p. 5) in its publication entitled *Code of Human Research Ethics*, research ethics are 'the moral principles guiding research from its inception through to completion and publication of results'. This code regulates a set of general principles that cover research with human

participants in all contexts. To comply with these principles, this research used a 'participant information sheet' and a 'consent form' as ethical issue clarification methods.

The participant information sheet (see Appendix 4) clarifies:

- The title of the study and the aims of the project.

- Data collection and analysis methods.

- Experiment tasks and time commitment expected from participants.

- Confidentiality and anonymity conditions in compliance with the Data Protection Act 1998.

- The right to refuse any of the researcher's requests, to withdraw from the study at any time, to have any supplied data destroyed with no adverse consequences in compliance with the Freedom of Information Act 2000.

- Potential risks associated with the participants (no identifiable risks for this study).

- The use of the data and planned outcomes.

- The availability of the research findings to participants.

- Planned debriefing.

- The name and contact details of the researcher.

Furthermore, based on the *Code of Human Research Ethics*, all participants were informed of the researcher's respect for their autonomy and dignity:

- Their knowledge, insight, experience and expertise would always be respected.

- Their performance in this study would be judged neither by the researcher nor by any other people.

- The researcher would respect all 'individual, cultural and roles differences, including those involving age, sex, disability, education, ethnicity, gender, language, national origin, religion, sexual orientation, marital or family situation and socio-economic status' (the British Psychological Society, 2010, p. 8).

After I had clarified all the above points with the participants and answered the questions they raised, each of the participants was provided with two copies of a written consent

form which were signed by both the researcher and the consenting participant. The consent form reviewed all the above items, and sought a formal agreement with all participants (see Appendix 5). The participant retained one copy of the consent form and the other was kept by the researcher.

4.1.3 Participant Variation

Participant variability and idiosyncrasies have to be dealt with in eye-tracking studies as 'every participant has his or her own basic setting for the value [of eye-related information]' (Holmqvist *et al.*, 2011, p. 83). The above statement was applicable to the present study, as each participant would have his or her own way of processing texts, translating and revising.

The two most common designs for participant variation management in experimental studies are the between-subjects design and the within-subjects design. The former employs independent measures; in other words, one participant only is assigned to one experimental condition, whereas the latter uses repetitive measures, inviting all participants to take part in all experiments.

According to Dancey and Reidy (2007, pp. 14-17), the between-subjects design has the advantage of enabling the researcher to avoid 'order effects' (participants' fatigue, familiarity with the experiments, and learning) and 'demand effects' (being informed about the purpose of the experiment; performance based on the needs of the research rather than normal behaviour). On the negative side, this design requires a large number of participants, and introduces inter-participant confounding variables which might distort the results. The inter-participant confounding variables are hard to control because, on the one hand, all participants are idiosyncratic, and on the other hand, even if participants are randomly allocated to different conditions, there are still possibilities that participants with similar characteristics will be assigned to one group.

The strengths and weaknesses of the within-subjects design are exactly opposite to those of the between-subjects design. This researcher was inclined to adopt the within-subjects design because it has more control over the inter-participant confounding variable, and because from a practical point of view, the size of the sample can be relatively small, but produce the same amount of data. Section 4.3.2 discusses the strategies adopted in this study to deal with the order and demand effects brought about by the within-subjects design.

To be more explicit, Table 10 and Table 11 present four possible within-subjects designs for the present study, taking into consideration the number of source texts to be translated by the participants. Participants 1, 2 and 3 are here taken as an example of a participant group. The experiment tasks (independent variables) included self-revision,

other-revision and post-editing, but in order to conduct self-revision, the participants first had to translate the source text. The translation experiment sessions were not within the scope of this study.

Participant Variation	Experiment Tasks				Pros	Cons
	Translation	Self-revision	Other-revision	Post-editing		
Within-subjects Design 1	*P1* *P2* *P3*	P1 P2 P3	P2 (on P1) P3 (on P2) P1 (on P3)	P1 P2 P3	Cross-comparison between self-revision and other-revision	Learning effects
Within-subjects Design 2	*P1* *P2* *P3*	P1 P2 P3	P1 (on P0) P2 (on P0) P3 (on P0)	P1 P2 P3	N/A	Learning effects

Table 10: Within-subjects Design with One Source Text

Participant Variation		Experiment Tasks				Pros	Cons
		Translation	Self-revision	Other-revision	Post-editing		
Within-subjects Design 3	P1 P2 P3	*A* *B* *C*	A B C	C A B	B C A	Cross-task comparison	Confounding variables: inter-participant variable and target text differences
Within-subjects Design 4	**P1** **P2** **P3**	*A* *A* *A*	**A** **A** **A**	**B** (on P0) **B** (on P0) **B** (on P0)	**C** **C** **C**	**Comparison within and across task(s) possible; controlled variables**	**Potential order and demand effects (solution: randomisation)**

Table 11: Within-subjects Design with Three Comparable Source Texts

In design 1, shown in Table 10, all participants were expected to work on the same source text. In this design, participants post-edit, translate, and self-revise their own texts, and are then rotated to revise other participants' translations (e.g., P2 revises P1's work; P1 revises P3's work). The merit of this design lay in the fact that it was possible to make cross-comparisons between the self-revision and other-revision processes (i.e., how P1 revised his/her own translation, and how P2 revised P1's translation). However, a serious confounding variable in this design was the learning effects: by the time they had completed the translation and self-revision sessions, the participants had become familiar with the source text. In design 2, in the other-revision session, participants were asked to

revise a translation produced by another student translator, P0, who was outside the participant group. This produced the same confounding problem. To minimise the learning effects, it would be necessary to use different source texts in this experiment.

However, if different texts were used for different tasks in this study, another confounding variable would be introduced, that is, text differences. As indicated by Holmqvist *et al*. (2011, p. 84), in within-subjects design, comparable texts can be used as a measure to avoid the confounding effect produced by text differences It was decided to adopt this strategy to solve the problem in the current research. The text comparability measures are discussed in section 4.2.2.

In designs 3 and 4, shown in Table 11, all participants were provided with three comparable source texts (texts A, B and C) to translate, self-revise, other-revise and post-edit. In the third design, after self-revision, the participants were rotated to revise each other's translation texts. For example, P1 revised P3's translation of text C; P2 revised P1's translation of text A. The advantage of this design is that all tasks could be cross-compared. For instance, it was possible to look into how text A was self-revised by P1, other-revised by P2 and post-edited by P3. However, if this design were to be reconsidered, it would be found that the other-revision and/or self-revision processes were incomparable with the post-editing process, because the target text differences (one was produced by a human being and the other was produced by machine) would be confounded by the inter-participant variable. What is more, within the other-revision task itself, the participants were also revising target texts with different qualities, which would make the comparison unreasonable. Taking all these factors into consideration, the decision was made to keep the design as simple as possible to control all confounding variables and generate clean data.

In within-subjects research design 4, all participants were assigned to perform on the same source text in each task. In the other-revision session, participants were asked to revise the translation of text B, which was produced by another student translator outside the participant group. This student translator was also enrolled in the MA programme in translation studies at Durham University. The student had similar translation and revision experience to all the other participants, and received clarification on all the ethical and confidentiality isses of this research (including his/her responsibility not to disclose the subject matter of the experiment to any of the other participants).

With research design 4, it would be possible to detect the processes of self-revision, other-revision and post-editing under the same conditions (same text and same task). It might also be possible to cross-compare and speculate on the similarities and differences among the different processes of self-revision, other-revision and post-editing under similar conditions (same participant, comparable texts) with the data collected. To

deal with the potential order and demand effects, counterbalancing (i.e., randomisation of the tasks) was used as the confounding variable control measure (see section <u>4.3.2</u>).

For the above reasons, it was decided that research design 4 would be the most appropriate to use for the experiments in this study.

4.2 Research Texts

To select appropriate source texts for this research, three factors had to be taken into consideration: text type, text length, and the comparability of the texts.

4.2.1 Text Type and Length

For most of the translation process research, combining eye tracking and keylogging as research methods, the participants were not allowed to use consultation tools of any kind since this would make the data analysis too complicated. For this reason, Pavlović and Jensen (2009, p. 95) suggest using non-domain specific texts (e.g., non-technical texts) of the same genre and of medium text difficulty. Medium text difficulty was also considered to be the most appropriate for the current study, because, if the text was too difficult, during the revision phase, the participants might give up trying to fix it, and if the text was too easy, there would not be much to work on.

In this study, the three source texts were all introductory texts, introducing the backgrounds to Cambridge University, Warwick University and Oxford University (see Appendix <u>1</u>). In order to make them more comparable, minor changes were made to these texts with the help of a British English-speaking language expert. The length of the texts was controlled to within 100 words, since the participants were not expected to do any scrolling in either the source text or the target text window in Translog-II, and since 100 words using font 20 and double spacing fits the Translog-II source text window space well. It was found during the pilot studies that the Chinese translation of a 100-word source text from English was also within the size of the target text window. The details of the texts can be found in Table 12 below.

Measures / Texts	Number of words	Number of complex words	Number of sentences	Number of words per sentence	Number of syllables per word	Number of characters per word
Text A	100	21	5	20	1.8	5.74
Text B	100	21	5	20	1.8	5.72
Text C	100	21	5	20	1.8	5.71

Table 12: Source Text Measures

4.2.2 Text Comparability Measures

Finding three comparable texts was one of the main challenges of this study. As the proverb goes, no two leaves are exactly alike. This research attempted to measure the comparability of the texts using two approaches: the quantitative approach and the qualitative approach. In each approach, the complexity of the texts was measured and compared. Table 13 is a summary of the text complexity measures used in this study.

Text Complexity Measures	Indicators
Quantitative measures	- Readability index - Word frequency - Non-literalness
Qualitative measures	- Professional assessment - Participant feedback from pilots

Table 13: Text Complexity Measures

4.2.2.1 Quantitative Measures

The quantitative measure is based on Jensen (2009), in which reading index formulas (including the Automated Readability Index, Flesch-Kincaid index, Coleman-Liau index, Gunning Fog index, SMOG index, Flesch Reading Ease and LIX), word frequency and non-literalness are used as text complexity measures. It is assumed that the more complex a text is, the more difficult it is for student translators to translate and revise it, and vice versa. In line with Pavlović and Jensen (2009), comparable texts are considered to belong to the same category of complexity.

Edit Central[20] is an online text readability assessment tool which uses Flesch Reading Ease, Flesch-Kincaid Grade Level, Automated Readability index, Coleman-Liau index, Gunning Fog index, and SMOG index as readability indices.

Flesch Reading Ease and Flesch-Kincaid Grade Level together are also called Flesch/Flesch-Kincaid readability tests. They are indicators of the text comprehension complexity of a contemporary English paragraph, using word length and sentence length as core measures (Jensen, 2009). The results of these two tests correlate inversely, as they have different weighting factors. The Flesch Reading Ease score is ranked from 0 to 100, with higher values for easier texts and lower values for more complex texts. A text with a score ranging from 0 to 30 is best understood by university graduates (ibid.), and for this reason, the present study attempted to control the Flesch Reading Ease score around 30. Flesch-Kincaid Grade Level scores show the approximate US school grade of the text. Since grades ranging from 13 to 16 are considered to correspond with university level (ibid.), an average grade of 13.5 was set as the baseline for the texts selected. The rest of

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[20] Visit http://www.editcentral.com/gwt1/EditCentral.html for more information about Edit Central.

the four indices, shown in Table 14, also calculated the proposed complexity of the texts. Each of these formulas focused on different weighting factors, as is shown in Java programming language in Table 15.

Indicators / Texts	Flesch Reading Ease score	Flesch-Kincaid Grade Level	Automated Readability index	Coleman-Liau index	Gunning Fog index	SMOG index
Text A	34.3	13.5	15.7	16.6	16	14
Text B	34.3	13.5	14.9	15.7	16.4	14.2
Text C	34.3	13.5	15.5	16.3	16.4	14.2

Table 14: Reading Index Scores for Text A, B and C

Index	Formula
Flesch Reading Ease	double fres = 206.835 - (1.015 * wordCount)/sentenceCount - (84.6 * syllableCount) / wordCount
Flesch-Kincaid Grade Level	double fkgl = (0.39 * wordCount) / sentenceCount + (11.8 * syllableCount) / wordCount - 15.59
Automated Readability index	double ari = (4.71 * letterNumberCount) / wordCount + (0.5 * wordCount) / sentenceCount -21.43
Coleman-Liau index	double cl = (5.89 * letterNumberCount) / wordCount - (30.0 * sentenceCount) / wordCount - 15.8;
Gunning Fog index	double fog = 0.4 * ((double)wordCount / sentenceCount + (100.0 * complexCount) / wordCount)
SMOG index	double smog = Math.sqrt(complexCount * 30.0 / sentenceCount) + 3.0;

Table 15: Reading Index Formula
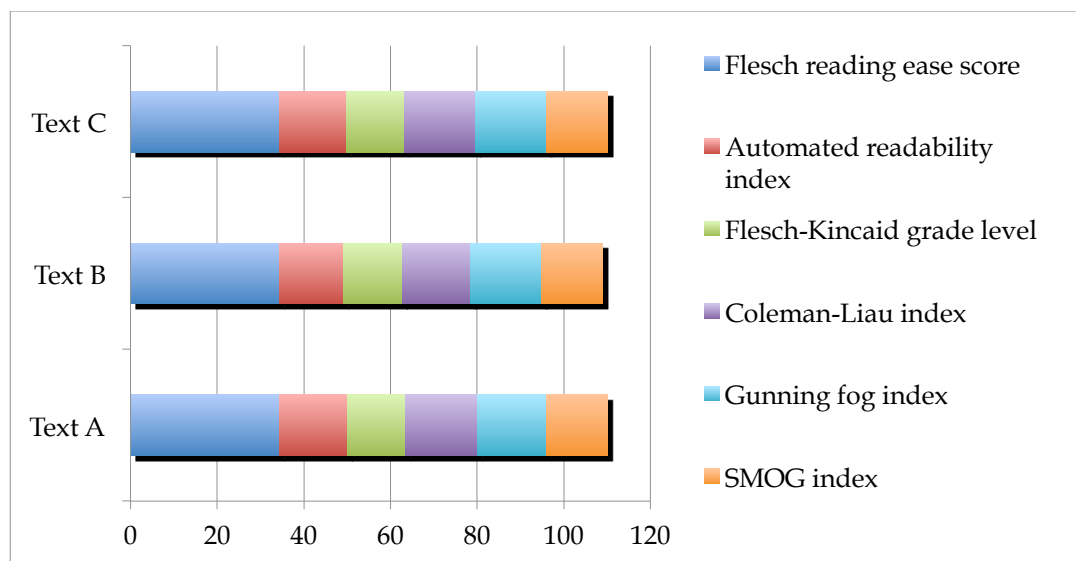
Figure 16: Reading Index Comparison for Texts A, B and C

Figure 16 provides a visual comparison of the readability of the three texts. Although for some of the indices there are minor differences in the value, it is obvious that these three texts fall into the same category of readability, as well as complexity.

In recent years there have been dissenting voices regarding the use of readability indices as indicators of text readability. For instance, Nation (2001, pp. 161-162) pointed out that the readability formulas focus mainly on what is measureable (e.g., word count,

word length and sentence length), while the semantic acceptability of a text is not considered and the meaning-related properties of an expression are not interpreted (Jensen, 2009, p. 68). Carrell (1987) also proposed that factors such as prior knowledge and motivation should be taken into consideration, as they are valuable for text comprehensibility assessment. For this reason, the present study combined both quantitative and qualitative measurements, and readability indices were used as one of the quantitative measurements.

The second quantitative measurement of text complexity is word frequency, which is 'a potential indicator of the internal lexical levels of complexity' and a powerful tool for predicting the amount of cognitive effort that will be spent on a particular word (Jensen, 2009, p. 69). According to Read (2000, p. 160), word frequency correlates with word familiarity. Thus, Jensen (2009) suggested that high-frequency words demand less cognitive effort in text processing than those that appear less frequently, and vice versa. To maintain text comparability at a lexical level, the word frequencies of all three texts were assessed by drawing on the British National Corpus[21], which collects 100 million words from a wide range of sources.

The British National Corpus categorises word frequencies into different levels (K1-K25). K1-words have the highest frequency and K25-words have the lowest. In line with Jensen (2009), in the present study the word frequency levels were grouped into 2 categories: high-frequency words (K1) are among the 1-1,000 most frequently used words; less frequently used words (K2-K10) are among the 1,001-10,000 most frequently used words.
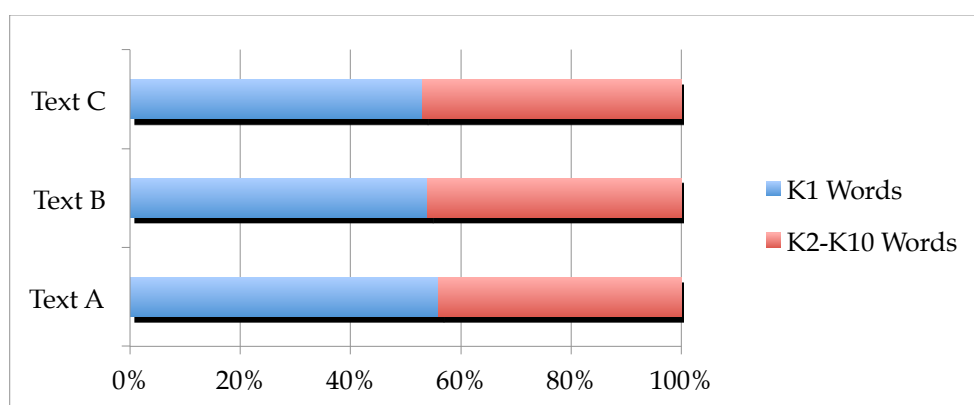
Figure 17: Word Frequency Comparison Bar

Figure 17 above presents the word frequency status for the three texts. It can be observed that high-frequency words in each text accounted for approximately 50-55% of the whole text, which indicates the medium complexity of all texts. Although the word frequency

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[21] Visit http://www.lextutor.ca/vp/bnc/ for more information about the British National Corpus.

distributions in the three texts are not completely identical, they were considered comparable in this research because they apparently fall into the same category, and the word frequency measurement itself is not 100% accurate. As mentioned above, word frequency is related to word familiarity (Read, 2000, p. 160). However, among translators, familiarity with a particular word varies from person to person. In addition, not all less frequently used words can be considered as harder to translate or revise than high-frequency words (Jensen, 2009). The word frequency measurement can be used to predict the complexity trend of the texts, but other measurements are also needed as complementary methods.

Non-literalness was the third quantitative measurement used to indicate the text complexity. Idioms, metaphors and metonyms are used as the indicators, because the meaning of these types of non-literal expression is normally interpreted in context, rather than literally (Black, 1981; Glucksberg, 2001). Thus, a text with a higher number of non-literal expressions is considered to be more difficult than a text with a lower number of non-literal expressions (Jensen, 2009). Since the three texts selected were all introductory texts written in a plain descriptive style, no idioms, metaphors or metonyms were found in the texts to be compared.

4.2.2.2 Qualitative Measures

To complement the quantitative measures, two qualitative measures were also used in this study to assess and compare the complexity of the three texts.

A panel of three reviewers, who were native English speakers (British English), were invited to read and evaluate the three texts according to the text complexity analysis criteria (Table 16). This text complexity analysis criterion was referenced from the *Arizona Department of Education – High Academic Standards for Students[22]*, which was adapted from the PARCC (Partnership for Assessment of Readiness for College and Careers) *Text Complexity Analysis Worksheet*. This worksheet evaluated the complexity of the texts from four perspectives: meaning/purpose, knowledge demands (i.e., domain-specific knowledge and references or allusions), text structure (i.e., coherence, organisation and text features) and language features (i.e., semantic clarity, literalness, word familiarity and sentence structure). The complexity of the texts was ranked according to three scales: readily accessible, moderately complex and very complex. In order to present the results in a neat format, these scales were numbered from 1 to 3 (from readily accessible to very complex).

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[22] Visit http://www.azed.gov/search-results/?q=text%20complexity%20analysis%20worksheet for more details about the text complexity analysis criterion set by the *Arizona Department of Education – High Academic Standards for Students.*

Complexity \ Criteria	Meaning/Purpose	Knowledge Demands	Text Structure	Language Features
(1) Readily accessible	The primary purpose of the text is clear, concrete, narrowly focused, and explicitly stated; the text has a singular perspective.	The subject matter of the text relies on little or no discipline-specific knowledge; if there are any references or allusions, they are fully explained in the text.	Connections between ideas, processes, and events are explicit and clear; organisation is chronological, sequential, or easy to predict because it is linear; any text features help readers navigate content but are not essential to understanding content.	Language is explicit and literal, with mainly contemporary and familiar vocabulary; text uses mainly simple sentences.
(2) Moderately complex	The primary purpose of the text is not stated explicitly but is easy to infer based upon the context or source; the text may include multiple perspectives.	The subject matter of the text involves some discipline-specific knowledge; the text makes some references or allusions to other texts or external ideas; the meaning of references or allusions may be partially explained in the context.	Connections between some ideas, processes, or events are implicit or subtle; organisation is generally evident and sequential; any text features help facilitate comprehension of content.	Language is often explicit and literal but includes some academic, archaic, or other words with complex meaning; text uses some complex sentences with subordinate phrases or clauses.
(3) Very complex	The text contains multiple purposes, and the primary purpose is subtle, intricate, and/or abstract.	The subject matter of the text relies on specialised, discipline-specific knowledge; the text makes many references or allusions to other texts or external areas; allusion or references have no content and require inference.	Connections among an expanded range of ideas, processes or events are often implicit, subtle or ambiguous; organisation exhibits some discipline-specific traits; any text features are essential to the comprehension of content.	Language is generally complex, with abstract, ironic, and/or figurative language, and archaic and academic vocabulary and domain-specific words that are not otherwise defined; text uses many complex sentences with subordinate phrases and clauses.

Table 16: Text Complexity Analysis Criteria

Texts & Reviewers \ Criteria	Reviewers (R1, R2, R3)	Meaning/ Purpose			Knowledge Demands			Text Structure			Language Features		
		1	2	3	1	2	3	1	2	3	1	2	3
Text A	R1	✔			✔			✔				✔	
	R2		✔		✔			✔				✔	
	R3												
Text B	R1	✔			✔			✔				✔	
	R2		✔		✔			✔				✔	
	R3												
Text C	R1	✔			✔			✔				✔	
	R2		✔		✔			✔				✔	
	R3	✔			✔			✔				✔	

Table 17: Text Complexity Analysis Results

From Table 17 it can be seen that R1 and R3 were in complete agreement in their evaluation of the three texts. They both considered that the clarity of meaning/purpose, knowledge demands and structure of all texts were readily accessible, and that the language features were in the medium complexity scale. Similarly, R2 agreed with R1 and R3 in evaluating the knowledge demands, text structure and language features of the three texts, but deemed that the clarity of meaning/purpose of the texts belonged to the medium complexity category. In this study, however, as long as the three reviewers were consistent in their own assessment of the three texts, texts A, B and C would be considered comparable.

Participants' feedback from the pilot studies was also used as one of the qualitative measures because, English being a second language, the participants might comprehend the texts differently. In the pilot studies, the participants were asked to fill in a post-experiment questionnaire after completion of the experiments. In the section on text and task comparison, they were directed to rate the complexity of the three source texts from 1 to 5 (from easiest to hardest), based on their experience of the experiments.

Texts	Participants' Scales	PP5	PP6	PP7	PP8	PP9	PP10
Text A	1						
	2	✔					
	3		✔	✔	✔	✔	✔
	4						
	5						
Text B	1						
	2	✔					
	3		✔	✔	✔	✔	✔
	4						
	5						
Text C	1						
	2	✔					
	3		✔	✔	✔	✔	✔
	4						
	5						

Table 18: Participant Feedback on Text Complexity in Pilot Studies[23]

It can be seen from Table 18 that, apart from PP1 (abbreviation for participant 1 in the pilot study), who rated the complexity of all three texts as scale 2, all participants ranked the texts as scale 3, which can be considered as medium complexity. Despite the fact that not all the participants assessed the text complexity in exactly the same way, the

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[23] Only the feedback of participants in the second round of the pilot study was analysed, as they were considered to have the same language competence as the participants in the formal experiment (see section 4.4).

complexity scores for the three texts were consistent in each of the participant's evaluations. For this reason, texts A, B and C were considered to be comparable.

In summary, in order to speculate on the similarities and differences among the patterns of self-revision, other-revision and post-editing, the researcher selected three comparable texts as research stimuli. Two measurements, quantitative and qualitative measures, were used to complement each other in order to assess the complexity of the texts, using readability indices, word frequency, non-literalness, professional assessment and participants' feedback in the pilot study as indicators. After evaluation and comparison of the text complexity, it was concluded that these three texts were comparable.

4.3 Tasks and Procedures

This section describes how task time was calculated and task randomisation, and presents the instructions for the experiments and the task brief and debriefing procedures.

4.3.1 Task Time

In this experiment, participants were asked to perform in four tasks: translation, self-revision, other-revision and post-editing. The participants in the pilot study were not given time constraints in any of the tasks. The purpose of this was to enable the researcher to calculate the average time taken on each task, and thus to work out the total time that would be needed for the experiment in the main study. Task time measurement is very important, as a tight time schedule might affect participants' performance in revising the texts. For instance, a participant who normally revises a text three times in a normal working routine might just revise the text once or twice if a time constraint is imposed. Besides, in a lab environment, a time limit is likely to cause nervousness or stress, which means the participants are not enacting their natural working routine in ordinary conditions. Therefore, the researcher had to make sure that each of the participants was given enough time to complete every task.

Participant	Translation	Self-revision	Other-revision	Post-editing
PP5	870.173	366.493	574.224	842.499
PP6	826.477	330.098	642.412	745.903
PP7	1197.463	241.521	569.684	683.066
PP8	1464.381	448.737	1168.057	1385.429
PP9	1252.283	508.532	801.548	1450.185
PP10	950.467	634.706	788.803	1237.384
Average time (s)	1093.54067	421.681167	757.4546667	1057.411
Average time (min)	≐18 minutes	≐7 minutes	≐13 minutes	≐18 minutes
longest duration (min)	≐25 minutes	≐11 minutes	≐20 minutes	≐24 minutes

Figure 18: Task Time in Pilot Studies[24]

Figure 18 records the time (in seconds) spent by each participant on all tasks. As can be seen, it took on average approximately 18 minutes to complete the translation task. The longest duration was about 25 minutes. Participants spent an average of approximately 7 minutes on revising their own translations, 13 minutes on other-revision and 18 minutes on post-editing the machine translation. The longest durations for these three tasks were approximately 11 minutes, 20 minutes and 24 minutes respectively. In order to work out how much time to allow for a task, the time taken by the participant who spent the longest time on it was used, in order to ensure that all participants had adequate time to finish the tasks.

The total time taken on the experiment was worked out using the formula below:

***Total Experiment Time** = Introduction and warm-up (30 min) + preparation time[25] (5 min) + task 1 (25 min) + break (10 min) + preparation (5 min) + task 2 (11 min) + cue-based retrospection (20 min) + preparation (5 min) + task 3 (20 min) + break (10 min) + preparation (5 min) + task 4 (24 min) + cue-based retrospection (20 min) + debriefing (10 min) + uncontrollable time[26] (30 min) = 230 min ≈ 4 hours*

The total experiment time was approximately four hours, during which participants were expected to complete four tasks, aside from the warm-ups. The weakness of this design is obvious: fatigue and learning effects were likely to affect the participants' performance

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[24] Only participants in the second round of the pilot study are considered here.

[25] The preparation time here represents the time needed for the researcher to start the eye-tracking and keylogging software, and guide the participants to do successful calibration.

[26] Uncontrollable time here is considered as the time spent on unexpected situations, such as participants arriving late owing to emergencies, or checking which vision aid, frame glasses or contact lenses produced better quality calibration.

and data validity. To cope with these potential confounding variables, two measures were adopted: (1) arranging the experiment over two consecutive days, two tasks each day, and (2) randomising the task order to diminish the order and demand effects.

4.3.2 Task Randomisation

Task randomisation is often used in the within-subjects design to minimise order effects and demand effects (Holmqvist, 2011, pp. 83-85). As can be seen from Table 19 below, in this study, 18 participants were divided into six groups, among which the task orders were randomised. However, the translation session and the self-revision session were not arranged on the same day because 10 minutes' break time was not enough for the participants to refresh their minds. In addition, most of the participants in the pre-experiment questionnaire confirmed that, if time had allowed, they would have shelved the translation overnight and self-revised it on the second day. Hence, the translation session was always arranged for the first day.

Normally, after the experiments on day 1, the participants would ask what tasks they would be expected to do on day 2. Considering the potential demand effects, the researcher had to give them a vague answer such as 'it will be something different' or 'you will find out when you come tomorrow'.

	Day 1			Day 2	
Participants	**Translation**	**Post-editing**		**Self-revision**	**Other-revision**
P1	Text A	Text C		Text A	Text B
P2	Text A	Text C		Text A	Text B
P3	Text A	Text C		Text A	Text B
	Post-editing	**Translation**		**Other-revision**	**Self-revision**
P4	Text C	Text A		Text B	Text A
P5	Text C	Text A		Text B	Text A
P6	Text C	Text A		Text B	Text A
	Translation	**Other-revision**		**Post-editing**	**Self-revision**
P7	Text A	Text B		Text C	Text A
P8	Text A	Text B		Text C	Text A
P9	Text A	Text B		Text C	Text A
	Other-revision	**Translation**		**Self-revision**	**Post-editing**
P10	Text B	Text A		Text A	Text C
P11	Text B	Text A		Text A	Text C
P12	Text B	Text A		Text A	Text C
	Translation	**Post-editing**		**Other-revision**	**Self-revision**
P13	Text A	Text C		Text B	Text A
P14	Text A	Text C		Text B	Text A
P15	Text A	Text C		Text B	Text A
	Other-revision	**Translation**		**Post-editing**	**Self-revision**
P16	Text B	Text A		Text C	Text A
P17	Text B	Text A		Text C	Text A
P18	Text B	Text A		Text C	Text A

Table 19: Task Randomisation

4.3.3 Experiment Instructions and Task Brief

A day before the experiment, the participants were sent a text message (permission obtained) reminding them of the time and venue of the experiment. They were also advised to avoid any alcoholic drinks on the experiment day, not to wear false lashes or mascara, and to remember to bring their glasses and/or contact lenses to the lab on time.

Day 1

Prior to the execution of the experiments, participants were shown the 'participant information sheet' (see Appendix 4) in which only the tasks of the first day were presented. They were informed that the experiment would take approximately two hours, and during these two hours, they would be guided to complete four formal tasks: a copy test, translation, post-editing and cue-based retrospection. There were no time constraints for these tasks. The task brief (Appendix 7) was printed out for their reference. It stated the purposes of the translation and the revised texts: (1) the target texts are to be published in line with the source texts on a website accessible to the public; (2) the target audience are to be educated adults (both male and female); (3) the target text should be written in a formal style, and (4) the readers expect the target texts in natural Chinese. The guidelines for full post-editing (Appendix 8) were explained to the participants. They were given the opportunity to ask questions.

Before the formal experiment, the participants were taught how to use Translog-II and make successful calibrations with the eye tracker, and then guided to do a warm-up test. The warm-up test was informal. They were asked to translate a 50-word piece of English text into Chinese, using Sogou as the input method. This gave them an opportunity to adjust to the lab environment; to familiarise themselves with the research facilities, i.e., the use of keyboard and mouse, and the adjustment of the height of chairs; and to test the working conditions of keylogging and eye-tracking software. During this period, they could ask questions at any time. For the copy test, participants were asked to type a Chinese text of 100 words into the target text area. The purpose was to assess their typing speed by using Sogou. The copy test was considered as part of the experiment, as it served as one of the participant in-experiment screening methods: (1) participants who had a very slow typing speed (below the average), or who had constantly to switch their gaze between the screen and the keyboard, or who had to stare at the keyboard while typing, were screened out; (2) participants who had problems in conducting satisfactory calibrations were also screened out. In order to conform with ethical requirements, the participants who were filtered out in this phase were not told why they had been filtered out.

During all the experiment sessions, the researcher observed the participants' translation and revision process on a second monitor in a place unseen by the participants. After the two experiment sessions, cue-based retrospection was conducted. Participants were first of all asked to review and comment on their working processes during the experiment (e.g., self-revision process) by using gaze replay as cues. Then a retrospective interview was conducted based on the post-experiment questionnaire (Appendix 9) by the researcher.

Day 2

On arrival, participants were shown the 'participant information sheet' again and informed of the three tasks to be completed on that day, i.e., self-revision, other-revision and cue-based retrospection. They were also told that the experiment on the second day would probably also take two hours, and that there would be no time constraints on any of the tasks. Before the start of the experiment, the warm-up test was conducted again to make sure the participants were well adjusted to the research environment, as was the case on the first day, and to check the eye-tracking and keylogging systems. The task brief was also provided.

The procedures for the cue-based retrospection on the second day were the same as that on the first day. Apart from the retrospection, participants were asked to compare the text complexity and task differences and to evaluate the experiment itself (e.g., the researcher's professionalism in guiding them to do the experiment; the lab environment; the validity of the data).

4.3.4 Post-task Debriefing

Although the experiment was not likely to cause the participants post-traumatic stress disorder, to prevent any potential psychological problems, such as stress or anxiety, they were reminded of the aims of this study and the confidentiality of the data they produced. They were also given the opportunity to ask questions. This procedure was also used to detect whether there was any participant whose behaviour was affected by the experiment settings (see 'post-task debriefing' in Saldanha and O'Brien, 2013, p. 32).

4.4 Pilot Studies

This study took as a reference point the eye-tracking experiment guidelines presented in Duchowski (2007) and Holmqvist *et al*. (2011). Prior to the formal experiment, two rounds of exploratory pilot study were conducted to test the experiment environment and to examine the research design.

4.4.1 Pilot Study Round 1

The first round of pilot study was informal. The aim was to test the appropriateness of the lab environment, such as the setup of the eye tracker, the lighting and the chair, as well as to formulate appropriate experiment guiding instructions. In order to retain the maximum number of participants who were eligible for the formal experiment,[27] four PhD students (mother tongue: Chinese, second language: English) who were not specialising in translation studies were invited to take part in this pilot study. Their tasks included: (1) translating the 100-word source text A from English into Chinese; (2) self-revising their translation; (3) other-revising text B which was translated by another student translator from outside the formal experiment participant group; and (4) post-editing text C which was a piece of Google translation. All tasks were conducted in Translog-II, with no time constraints. Tobii Studio was running in the background. Cue-based retrospection was carried out after that in the questionnaire session. The vocals were recorded on a digital voice recorder.

Feedback regarding the experiment environment obtained from pilot study round 1 was reviewed on: lighting control (section 4.4.1.1), eye-camera angulation (section 4.4.1.2), software compatibility (section 4.4.1.3), codes of conduct (section 4.4.1.4) and exoteric interferences (section 4.4.1.5).

4.4.1.1 Lighting Control

The lighting used in the lab was artificial. As there was no window in the lab, natural light would not be a confounding factor. Since Tobii TX300 is very sensitive to luminosity, lighting which has very high surrounding NIR-light[28] levels (e.g., focused halogen spotlights) or very low luminosity needed to be avoided. The lighting used in the lab was a fluorescent lamp. It produces constant luminosity and does not have the problem of flickering. Tobii TX300 worked well with it.

4.4.1.2 Eye-camera Angulation

The eye tracker was installed on a fixed table in order to avoid any swaying. To reduce physical movements by the participants, a fixed chair with a height adjustable function was chosen for the pilots. All participants were asked to sit comfortably but at the same time to make sure they were in the optimal tracking position, i.e., eyes in the centre of the black square area, and the distance indicator somewhere in the middle of the green interval (approximately 60-65cm, optimal 65cm). After conducting the first couple of

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[27] Participants in the formal experiment had to be MA translation students.

[28] NIR-light here is short for Near Infrared Light.

experiments, it was observed that, as the participants gradually began to concentrate more on the tasks, they would unconsciously lean their body and head forward towards the computer screen and physically attain their normal working position. This might cause two problems: data loss (gaze data on the corners of the screen/stimulus cannot be tracked) and data inaccuracy. As can be seen from Figure 19, the participant under study was advised to remain at a constant distance of 65cm from the eye tracker, as the optimal eye-camera angulation is 35° maximum, to ensure data accuracy (Tobii Studio User Manual, p. 18). Anywhere closer than that would increase the eye-camera angulation and lead to data inaccuracy.
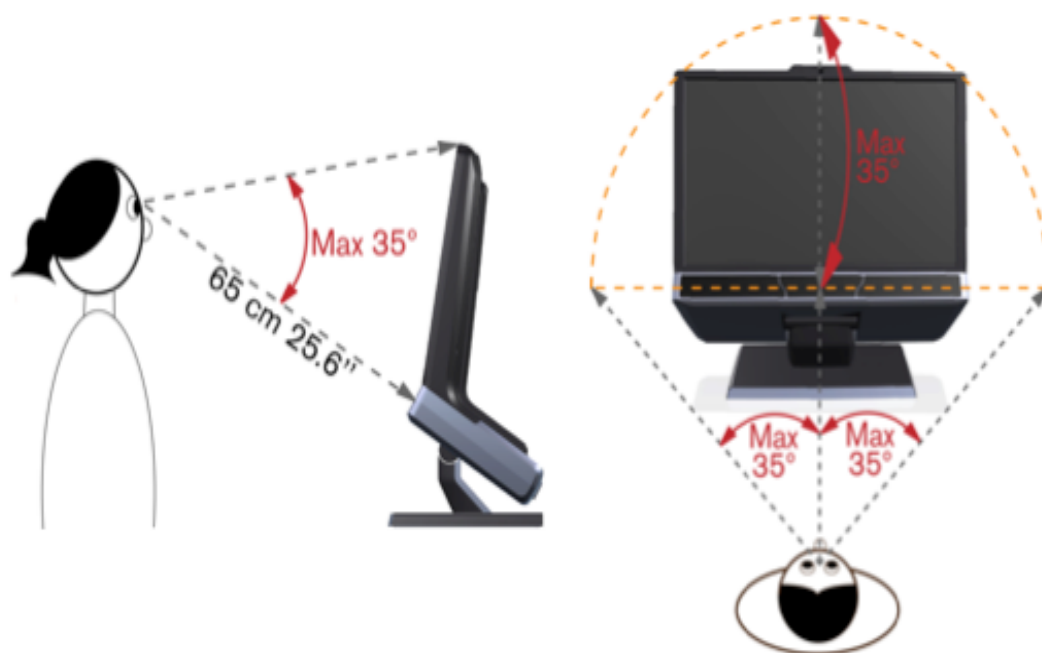
Figure 19: Optimal Eye-camera Angulation

Figure 20 contains a sample of inaccurate data that had to be filtered out. As can be seen in the Translog-II interface, the source text is presented in the upper window and the target text is in the lower window. The green and red dots represent the loci of the right eye and left eye. These dots should have fallen onto the words being fixated, but there were severe drifting problems, namely, the eye movement loci fell one line above the actual loci of the eyes. For this reason, the eye movement data for the first line of the source text (and target text) could not be calculated, and the eye movement data for the second line were incorrectly calculated as the data for the first line.

Figure 20: Inaccurate Data Sample

To tackle this problem, before calibration, participants were asked to move back and forth to find their most comfortable and relaxed posture, and to make sure they were within the optimal tracking zone, even if they moved slightly backwards or forwards. They were then informed of the range of space within which they could lean slightly backwards or forwards, although the ideal status would have been to sit still. However, the participants were not forced to stay completely still in front of the computer because this may have distracted them from performing the tasks. An example of an accurate data sample can be found in Figure 15 in section 3.2.3.

4.4.1.3 Software Compatibility

Since Translog-II collects both eye-tracking and keylogging data, to have Tobii Studio running in the background simultaneously might have increased the risk of software incompatibility, for instance, system breakdown. This possibility was checked in the pilot studies and it was found that no abnormality occurred during the experiment, though all participants had to do the calibration twice in each task.

4.4.1.4 Participants' Code of Conduct

As discussed in section 4.3.3, one day prior to the experiment, the participants were notified of the dos and don'ts for their pre-experiment preparation. Since, in the experiment, some improper behaviour that could have led to the failure of the experiment was observed, the participants' code of conduct was established in the form of *In-*

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experiment Dos and Don'ts (Appendix 6). All items were explained to the participants at the beginning of the experiment.

4.4.1.5 Exoteric Interferences

The experiments were conducted in the School of Modern Languages and Cultures at Durham University, UK. To ensure that no exoteric factors interfered with the experiment, the cleaning staff at the school were asked in advance not to make any noise during the experiment period. A reminder saying 'Experiment in process, please be quiet' was put up on the door.

4.4.2 Pilot Study Round 2

The second round of the pilot study recruited six MA translation students at Durham University. Since this round served as the trial experiment prior to the formal experiment, the researcher endeavoured to conduct all sessions in a formal way. These six MA translation students also passed the pre-experiment screening procedure and were considered as eligible for the formal experiment. The participants were asked to do the same tasks as the participants in round 1. The aim was to test the proposed research design, i.e., experiment time, task arrangement, source text comparability, ecological validity of the experiment, and to check the eye-tracking and keylogging data visually in ProgGraph, a graph produced by a software tool. In order to avoid learning effects, the six students who took part in the pilot study were not invited to participate in the main study.

The feedback on the second round of the pilot study is discussed in the following sub-sections: experiment time and task arrangement (section 4.4.2.1) and the feedback questionnaire (section 4.4.2.2).

4.4.2.1 Experiment Time and Task Arrangement

The start and end times of each experiment session were recorded by the researcher. The purpose was to determine the time needed for each task so as to work out an appropriate total experiment duration (see section 4.3.1). Since conducting all experiment sessions on the same day would cause order effects and demand effects, task randomisation was used as the solution (section 4.3.2). The task arrangement had been tested in the pilot study, and none of the participants reported tiredness after the experiment. All the participants requested feedback on their tasks the day after the first experiment. In order to avoid potential learning effects (demand effects), they were not given any specific details on the tasks for experiment day 2.

4.4.2.2 The Post-experiment Questionnaire

The post-experiment questionnaire in this study was designed to collect qualitative data from four perspectives: (1) revision and post-editing product data; (2) revision and post-editing process data (by using cue-based retrospection); (3) text and task comparison, and (4) experiment validity.

Table 20 summarises the participants' revision and post-editing experience, their views on the necessity of revision and post-editing on the research texts, and the problems of the original translations. The data presented below justified the research design in two ways. The first involved the appropriateness of delaying the self-revision task until the second day of the experiment. As can be seen from Table 20, all participants reported that they did normally revise their own translation text after some 'drawer time' (i.e., the time that the translation has been put away from the translator). Some of them would self-revise overnight, and others would self-revise in one day if they were given a short deadline. The second justification concerned the rationality of the present research, corresponding with the doubts concerning what would happen if student translators did not revise and/or post-edit. All the participants in this pilot study acknowledged the necessity for self-revision, other-revision and post-editing, although they were not necessarily representative of a larger body of participants.

Tasks / Participants	Self-revision	Other-revision	Post-editing
PP5	**Immediate self-revision:** no	**Other-revision experience:** yes	**Post-editing experience:** no
	Drawer time: overnight	**Being revised by others:** yes	**Light or full Post-editing:** latter
	Necessity to self-revise: yes	**Necessity to other-revise:** yes	**Necessity to post-edit:** yes
	Translation problems: lexical choice; accuracy; fluency	**Translation problems:** omission; accuracy; naturalness	**MT output problems:** grammatical errors; sentence order; naturalness; word for word translation
PP6	**Immediate self-revision:** yes	**Other-revision experience:** yes	**Post-editing experience:** no
	Drawer time: 1 day	**Being revised by others:** no	**Light or full Post-editing:** latter
	Necessity to self-revise: yes	**Necessity to other-revise:** no	**Necessity to post-edit:** yes
	Translation problems: sentence segmentation	**Translation problems:** lexical choice; consistency; style	**MT output problems:** word for word translation; illogical; sentence structure
PP7	**Immediate self-revision:** yes	**Other-revision experience:** yes	**Post-editing experience:** no
	Drawer time: 1 day	**Being revised by others:** no	**Light or full Post-editing:** latter
	Necessity to self-revise: yes	**Necessity to other-revise:** yes	**Necessity to post-edit:** yes
	Translation problems: lexical choice; omission; collocation	**Translation problems:** omission; cohesion; lexical choice	**MT output problems:** lexical choice; sentence order; naturalness; coherence; mistranslation
PP8	**Immediate self-revision:** yes	**Other-revision experience:** yes	**Post-editing experience:** no
	Drawer time: overnight	**Being revised by others:** no	**Light or full Post-editing:** latter
	Necessity to self-revise: yes	**Necessity to other-revise:** yes	**Necessity to post-edit:** yes
	Translation problems: typos; omission; naturalness	**Translation problems:** lexical choice	**MT output problems:** sentence structure; coherence
PP9	**Immediate self-revision:** yes	**Other-revision experience:** yes	**Post-editing experience:** no
	Drawer time: 1 day	**Being revised by others:** yes	**Light or full Post-editing:** latter
	Necessity to self-revise: yes	**Necessity to other-revise:** yes	**Necessity to post-edit:** yes
	Translation problems: lexical choice; sentence structure	**Translation problems:** omission; accuracy	**MT output problems:** sentence structure; semantic problems
PP10	**Immediate self-revision:** yes	**Other-revision experience:** yes	**Post-editing experience:** no
	Drawer time: overnight	**Being revised by others:** yes	**Light or full Post-editing:** latter
	Necessity to self-revise: yes	**Necessity to other-revise:** yes	**Necessity to post-edit:** yes
	Translation problems: lexical choice	**Translation problems:** redundancy; genre	**MT output problems:** grammatical problems; sentence order

<div align="center">Table 20: Revision and Post-editing Product Data</div>

Table 21, below, presents the process data for revision and post-editing, based on the participants' cue-based retrospection, taking PP5 as an example. Participants were asked to confirm the reliability of the following summarised data after transcription. It should be noted that these qualitative data, such as revision phases, revision activities, main revision activities, sequences of activities, revision criteria, and motivations behind different revision phases and activities, were primarily based on the participants' retrospection. There might be some inconsistencies between these subjective data and the objective eye movement and keylogging data. These subjective and conscious data were complemented by the objective user activity data, e.g., revision and post-editing progression graphs (see section 5.2.2), to infer the cognitive activities during the revision and post-editing processes.

Tasks / Participants	Self-revision	Other-revision	Post-editing
PP5	**Revision phases:** 2	**Revision phases:** 3	**Revision phases:** 2
	Revision activities: ST reading; TT reading; TT reading and TT typing	**Revision activities:** ST reading; TT reading; TT reading and TT typing	**Revision activities:** ST reading; TT reading; TT reading and TT typing
	Main activities: ST reading	**Main activities:** TT reading	**Main activities:** TT reading and TT typing
	Sequences of activities: (1) ST reading – TT reading - … - TT typing - …(S-B-S[29]) (2) TT reading – ST reading - … -TT typing - …(S-B-S)	**Sequences of activities:** (1) ST reading (whole text) (2) TT reading – ST reading - … - TT typing - …(S-B-S) (3) TT reading – ST reading - … - TT typing - …(TT-focused)	**Sequences of activities:** (1) ST reading – TT reading - … - TT typing - … (S-B-S) (2) TT reading
	Revision criteria: (1) Naturalness (2) Naturalness; accuracy; style	**Revision criteria:** (1) Correct ST comprehension (2) Accuracy (lexical choice; omission) (3) Naturalness	**Revision criteria:** (1) Sentence order; accuracy; fluency; lexical choice; register (2) Naturalness; fluency
	Motivations behind revision: (1) Checking errors (2) Confirmation	**Motivations behind revision:** (1) ST comprehension (2) Problem detection and solving (3) Problem solving and confirmation (TT-independent)	**Motivations behind post-editing:** (1) Checking errors and re-translation (2) Confirmation
	Motivations behind activities: (1) ST reading: re-comprehension; re-translation; comparison; confirmation (2) TT reading: comprehension; spot-detection; re-translation; comparison; confirmation (3) TT reading and TT typing: revision (Problem-solving)	**Motivations behind activities:** (1) ST reading: comprehension; checking; comparison; decision-making (translation formation); confirmation (2) TT reading: comprehension; spot-detection; decision-making (translation formation); comparison; confirmation (3) TT reading and TT typing: revision (Problem-solving)	**Motivations behind activities:** (1) ST reading: comprehension; decision-making (translation formation); comparison; confirmation (2) TT reading: comprehension; spot-detection; re-translation; comparison; confirmation (3) TT reading and TT typing: revision (Problem-solving)

Table 21: Revision and Post-editing Process Data

Table 22 below shows the participants' evaluation of the complexity of the source texts and of the tasks. This evaluation was carried out to make sure the source texts were comparable (section 4.2.2.2) and that the different task complexity was not caused by source text incomparability. As can be seen, although the participants ranked the task complexity into different scales, they shared the opinion that the task difficulties were owing to the different qualities of the target texts.

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[29] 'S-B-S' here is short for sentence by sentence.

Tasks \ Participants	Self-revision	Other-revision	Post-editing
PP5	Text A complexity (1<5): 2	Text B complexity (1<5): 2	Text C complexity (1<5): 2
	Task complexity (1<5): 4	Task complexity (1<5): 2	Task complexity (1<5): 3
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
PP6	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 4	Task complexity (1<5): 2	Task complexity (1<5): 3
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
PP7	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 4	Task complexity (1<5): 3	Task complexity (1<5): 2
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
PP8	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 3	Task complexity (1<5): 3	Task complexity (1<5): 4
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
PP9	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 2	Task complexity (1<5): 3	Task complexity (1<5): 4
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
PP10	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 4	Task complexity (1<5): 3	Task complexity (1<5): 2
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		

Table 22: Text and Task Complexity

To ensure the validity of the entire experiment, and to detect any potential interferences that might affect the quality of the data, participants were asked, at the end of the experiment, to evaluate the lab environment, including experiment devices: computer screen, keyboard, mouse, eye-tracking and keylogging software, Chinese input method, chair and desk, light and humidity etc.; their satisfaction with the researcher's performance in leading the experiment; the naturalness of their performance; interferential factors, and the reliability of the data. As can be seen from Table 23, although the research environment had been tested in the first round of the pilot study, the first two participants still reported that the chair was uncomfortably hard. As a result of this, the rest of the participants were given chairs with soft seat cushions, and this worked well. PP7 reported that s/he did not feel very natural doing the translation task because s/he normally listened to music while doing translation assignments at home. However, s/he still considered that there was an element of authenticity in the performance, as these experiment sessions were similar to examinations, and s/he was concentrating very hard.

	Lab Environment Satisfaction (1<5)	Researcher's preparation and guidance satisfaction (1<5)	Naturalness of performance in the experiment	Interferential factors affecting performance in the experiment	Reliability of the data
PP5	4 (Uncomfortable chair)	5	Very natural	No	Reliable (I suggest using my data for research analysis)
PP6	4 (Uncomfortable chair)	5	Very natural	No	Reliable (I suggest using my data for research analysis)
PP7	5	5	Natural (Lab environment)	No	Reliable (I suggest using my data for research analysis)
PP8	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
PP9	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
PP10	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)

Table 23: Experiment Validity

Appendices 10 and 11 show the text and task complexity data and experiment validity data for all participants in the formal experiment, respectively.

4.5 Summary

This chapter has described the research design for the present study. This includes the considerations related to participants (participant recruitment and selection methods, ethical issues, and solutions to participant variation); research texts (text type and length and text comparability measures); tasks and experiment procedures (task time, task randomisation, experiment instructions, task brief and post-task debriefing), and two rounds of pilot studies (checking lighting control, eye-camera angulation, software compatibility, participants' code of conduct in the experiment, exoteric interferences, experiment time and task arrangement, and the post-experiment questionnaire). Data quality and validity insurance methods were also discussed in each section.

Chapter 5 introduces the data compilation process and the data analysis methods used in this study, as well as data quality control.

Chapter 5

Data Compilation and Analysis

This chapter describes the process of compiling the data that were used for the qualitative and quantitative analyses. Section 5.1 describes the raw logging data compilation process, which includes data annotation preparation, process data annotation and product data annotation. The focus is on the process of compiling data containing Chinese characters. Section 5.2 gives an overview of the different types of User Activity Data (UAD) that can be used for statistical analysis, and of the progression graphs that can be used for qualitative analysis. Section 5.3 presents the post-experiment data quality control methods used in this study. Section 5.4 discusses the method for conducting the statistical analysis.

5.1 Data Compilation Process

As discussed in section 3.2.3, the raw logging data recorded by Translog-II (with plug-in eye sampler activated) contained both product and process data. To analyse the UAD, the TPR-DB compilation process was followed to manipulate the raw data obtained (see Carl and Schaeffer, 2014).
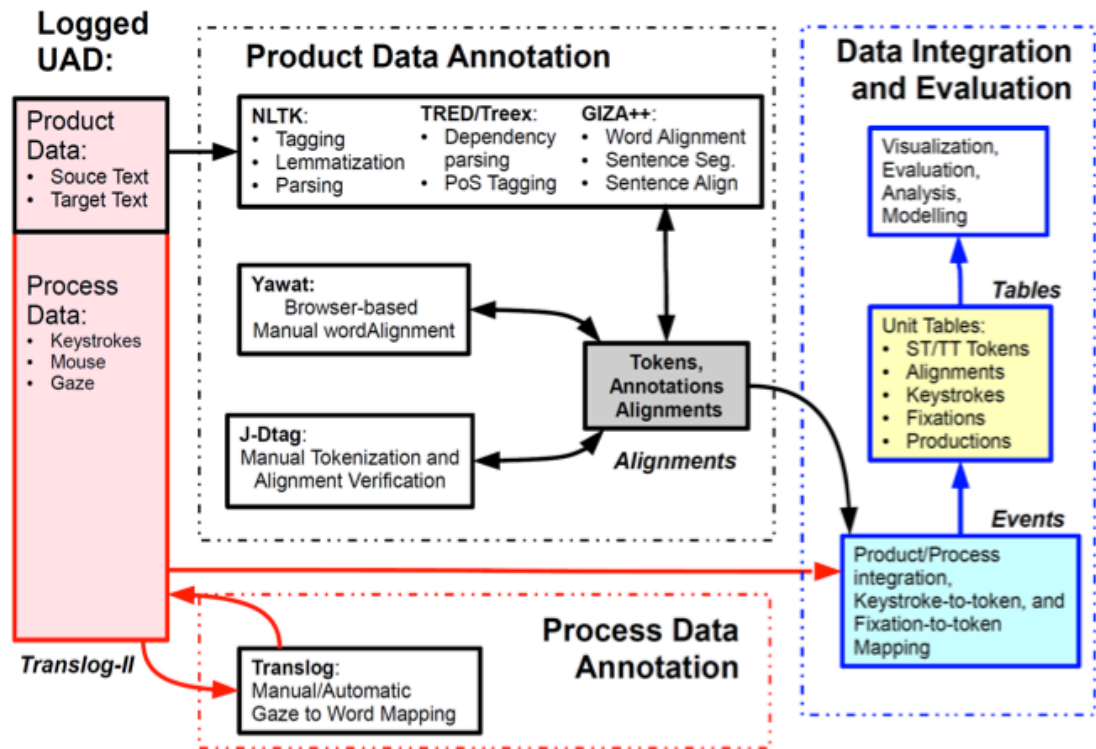
Figure 21: Diagram for the CRITT TPR-DB Compilation Process

In the framework designed by Carl and Schaeffer (2014), the TPR-DB compilation process contains three major steps: product data annotation, process data annotation, and data integration and evaluation (Figure 21). The process data annotation includes automatic and manual correction of fixation-to-word mapping (see section 5.1.2). The product data were extracted from the Translog-II raw logfiles and processed linguistically in six steps: '(1) Tokenisation; (2) Sentence segmentation; (3) Sentence alignment; (4) Word alignment; (5) POS tagging and Lemmatisation[30], and (6) Dependency annotation' (Carl, 2012b, no page). The annotated product data were incorporated with the process data by mapping the fixations and the keystrokes onto the produced TT tokens, and by aligning the TT tokens with the corresponding ST tokens (ibid.). The algorithms used can be found in Carl and Jakobsen (2009).

In translation, reading or writing-related research, in order to analyse the UAD and obtain both quantitative and qualitative data for further analysis, the StudyAnalysis Script provided in CRITT TPR-DB (which can be downloaded from the CRITT website[31]) has to be run. The procedures for Roman-alphabet language UAD compilation can also be found on the CRITT website.

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[30] According to Carl (2012b), POS tagging and lemmatisation are automatically accomplished by using NLTK (Bird, 2009), a Python platform used to process human language data.

[31] Visit https://sites.google.com/site/centretranslationinnovation/ for CRITT homepage.

Compared with Roman-alphabet languages, the UAD compilation procedures for non-Roman-alphabet languages, such as Chinese, are more complex. All the steps shown in Figure 22 have to be run. The steps highlighted in red are the ones that need to be run for data containing Chinese characters. The following sections explain these steps in detail.
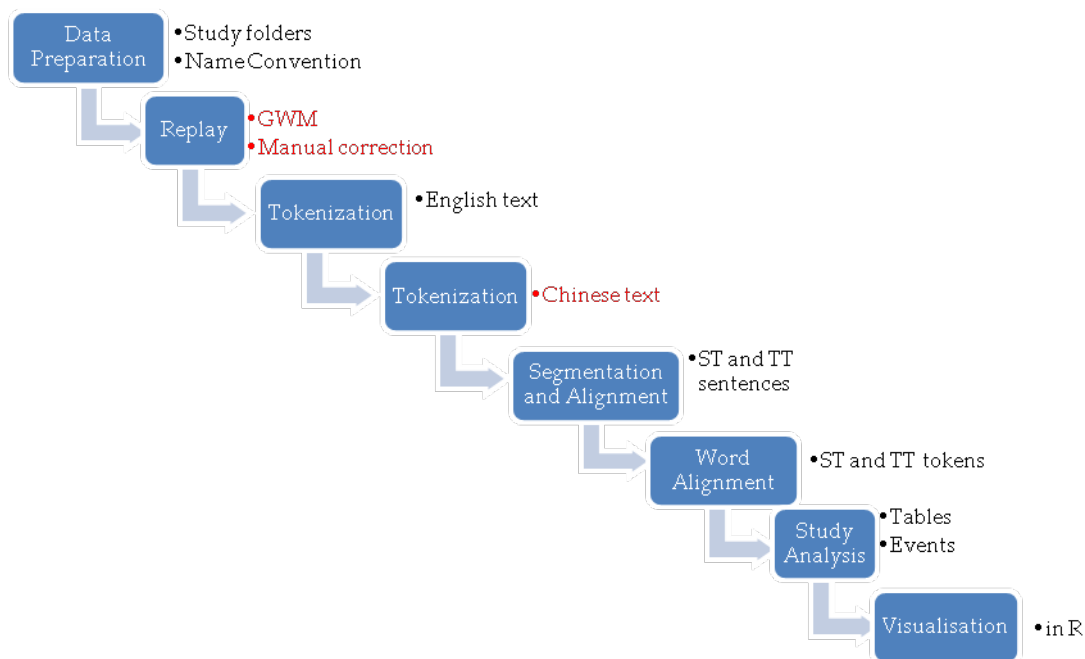
Figure 22: UAD Compilation Procedure for Any Language-into-Chinese Translation-related Tasks

5.1.1 Data Annotation Preparation

The data annotation preparation process includes the creation and organisation of working folders and the use of name conventions.

5.1.1.1 Working Folders

Before the annotation of the product and process data, the working folders should be created. Figure 23 explains the construction of these working folders. The TPR-DB folder is the head folder[32], which consists of two sub-folders: the bin folder and the study folder. Translog-II is equipped with 'Study Analysis' scripts, enabling statistical analysis of the raw data stored in the xml output. All scripts are saved in the bin folder. The study folder keeps all raw logfiles (in folder Translog-II), and subsequently keeps the generated 'Tables' and 'Events' data.

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[32] The TPR-DB folder can be downloaded from
https://sites.google.com/site/centretranslationinnovation/translog-ii.
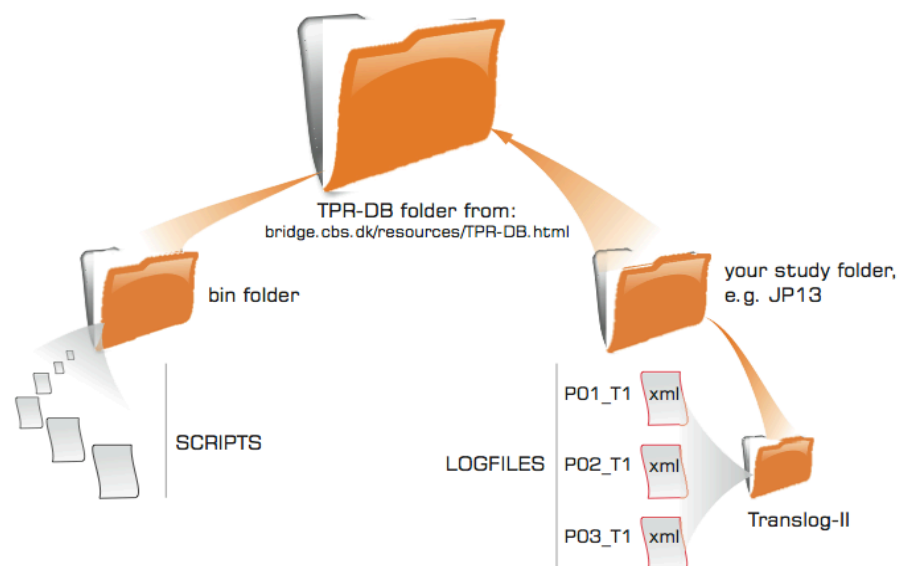
Figure 23: CRITT TPR-DB Data Annotation and Integration Working Folders[33]

5.1.1.2 Name Convention

The names of the study folder and the logfiles should follow a certain convention. According to the *Translog-II Manual*, the study folder should be named using *two or more characters + two or more digits*. In this study, the initials of the participants were taken and the number 13 was chosen to create the folder name (e.g., LX13, ZCH13). The number 13 stands for 2013, the year in which all the experiments were conducted.

In the Translog-II folder, the raw logfiles have to be named using *P + two or more digits_character + one or more digits*. For example, in P01_S1.xml., P09_P2.xml., and P16_R3.xml., P is short for participant; the digit following P stands for the number of the participant (from 01 to 18); the character following the underscore reveals the type of task (T for translation, S for self-revision, P for post-editing, R for other-revision), and the last digit indicates the number of the text used (Text 1 = Text A, for translation and self-revision, Text 2 = Text B, for post-editing, Text 3 = Text C, for other-revision).

Table 24 lists the names of the study folders and logfiles used in this study.

Participant	Study Folder	Tasks	Texts	Logfiles
P01	LX13			
P02	MQ13			
P03	ZC13			
P04	ZQ13			
P05	ZCH13			P01_S1.xml
P06	DJ13	T: Translation	Text 1 (Text A) =	P01_P2.xml
P07	KX13		Translation + Self-revision;	P01_R3.xml
P08	YL13	S: Self-revision		.
P09	WL13		Text 2 (Text B) =	.
P10	QW13	P: Post-editing	Post-editing;	.
P11	XY13			P18_S1.xml
P12	LIX13	R: Other-revision	Text 3 (Text C) =	P18_P2.xml
P13	YY13		Other-revision	P18_R3.xml
P14	ZH13			
P15	SY13			
P16	MX13			
P17	SS13			
P18	SH13			

Table 24: Data Annotation Preparation

5.1.2 Process Data Annotation

In this section, automatic and manual gaze-to-word mappings are discussed.

5.1.2.1 Automatic Fixation-to-Word Mapping

Process data include any keystrokes that have been inserted or deleted, together with the modification time, gaze information, and the position of mouse clicks. For most of the European languages, the fixation-to-word mapping is done online automatically. Re-fixation is only needed for manual correction of the fixations. However, since the Chinese typing tool, Sogou, is a window-based external software program, and online mapping interferes with the window focus[34], therefore fixation-to-word mapping has to be done offline for English-into-Chinese translation or revision tasks. To do this, one only needs to replay the whole session after the experiment has been conducted (see Figure 15 in section 3.2.3).

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[34] Cf. *Translog-II Manual 1* (https://sites.google.com/site/centretranslationinnovation/translog-ii).

The replay function can be found in Translog-II Supervisor. To obtain better quality data, ideally the whole session should be replayed on the monitor that was used for the data collection. If that is not available, it is necessary to select a monitor which has the same screen size and resolution as the one used for the data collection. Options for the velocity of the replay vary from 1% to 10000%. In this study, a speed of 200% was used.

5.1.2.2 Manual Fixation-to-Word Mapping

With offline gaze mapping, the fixations and fixation-to-word mapping is sometimes noisy and inaccurate. Manual fixation-to-word mapping correction is needed in research, especially when dealing with linguistic analysis from a cognitive perspective. In Translog-II, manual fixation-to-word correction can be accomplished by using 'Fix Map', a function which allows the researcher manually to attribute a fixation or several fixations to a certain word. The procedure can be found in the *Translog-II Manual*[35]. It should be noted that manual correction of fixation-to-word mapping is very time-consuming. It is thus important to record good quality data during the experiment.

5.1.3 Product Data Annotation

Product data include both source text and target text information. Product data annotation in the process of TPR-DB compilation falls into the category of natural language processing (NLP). The process goes through several steps, such as sentence segmentation, tokenisation, part-of-speech tagging (PoS tagging), dependency parsing etc.[36] Since NLP is the focus of this study, the following sub-sections shed light on the tools and guidelines used for word segmentation (tokenisation) and word alignment for data containing Chinese characters.

5.1.3.1 Tokenisation

According to Palmer (2000, p. 11), 'tokenisation is also known as word segmentation'. It is a process of breaking down a text into independent units (tokens) by locating word boundaries. The end point of a word and the beginning of the next word are normally considered as a word boundary. A unit can be a word, a number, or a punctuation mark, depending on the structure of a language. Many European languages are space-delimited, such as English, French and Spanish. Space is usually taken as the word boundary for

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[35] Cf. *Translog-II Manual 3* (https://sites.google.com/site/centretranslationinnovation/translog-ii) for reference.

[36] For further details, see Kok and Brouwer (2011) *Natural Language Processing for the Working Programmer*, available online at http://www.nlpwp.org/nlpwp.pdf (Accessed: 12 March 2014).

these languages. However, for languages that are unsegmented, the tokenisation process is slightly different. It requires additional lexical and morphological information. It is also affected by the writing system and the typographical structure of the words (Olive *et al.*, 2011, pp. 135-163). For example, Chinese and Thai are both unsegmented languages. There is no space between Chinese characters or Thai words. Word boundaries in these languages are not clear. In addition, Chinese is an isolating language, which means the characters cannot be divided into smaller units. Therefore, the tokenisers (i.e., the tokenisation tools) used for these languages are different. There are some integrated suites of natural language processing tools for languages of different natures, such as Stanford CoreNLP[37]. In this study, the PTBTokenizer[38] was used to tokenise the English text (the ST) and the ChiSegmentor[39] was used to segment the Chinese text (the TT).

English tokenisation follows the guidelines used in the Penn English Treebank.[40] It is done automatically, without human corrections. Since there were no double inverted commas, hyphens or brackets in the texts used in the current study, the tokenisation guidelines were fairly simple and straightforward, i.e., using white spaces as word boundaries; separating most punctuation marks from adjoining words, and treating apostrophe S ('s) as a separate token: e.g., Oxford's → Oxford 's. The passage below is an example of an English text tokenisation sample used in this study.

English Text Tokenisation in This Study (ST Text C):
Oxford leads and actively supports a wide range of regional , national and international initiatives designed to showcase the value of research and its intellectual , social , cultural , industrial and economic impacts . Research carried out by Oxford 's staff , students and alumni has made an enormous impact on the world of ideas . Our ambitions are influenced by more than eight centuries of learning , scholarship , research and public engagement . We will continue to provide a supportive research environment in which scholars , at every stage of their career , can flourish and develop . We will also keep attracting the very best research students nationally and internationally .

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[37] Stanford CoreNLP can be downloaded from http://nlp.stanford.edu/software/corenlp.shtml.

[38] PTBTokenizer is a word segmentation tool for English texts, developed by the Stanford Natural Languages Processing Group. It can be downloaded from http://nlp.stanford.edu/software/tokenizer.shtml.

[39] ChiSegmentor is a word segmentation tool for Chinese texts, developed by the Natural Language Processing & Portuguese-Chinese Machine Translation Laboratory (NLP2CT) at the University of Macau. Visit http://www.fst.umac.mo/en/lab/nlp2ct/ for more information.

[40] Visit http://www.cis.upenn.edu/~treebank/ for a detailed introduction to the Penn Treebank Project conducted by the LINC Laboratory of the Computer and Information Science Department at the University of Pennsylvania.

The Chinese tokenisation tool, ChiSegmentor, is a rule-based tokeniser, since Chinese is not space-delimited and is an isolating language. It uses the *Modern Standard Chinese Dictionary* as its linguistic data consortium, and segments the text into words and phrases. Punctuation marks are separated from the preceding and following characters. In Chinese, the border between a word and a phrase is not always clear. For example, there are two different ways of tokenising the sentence 南京市长江大桥很美 (back translation: Nanking Yangtse River Bridge is very beautiful. To give two examples, this sentence can be segmented as: (1) 南京市 (Nanking city)、长江 (Yangtse River)、大桥 (bridge)、很美 (very beautiful)；and (2) 南京 (Nanking)、市长 (mayor)、江 (river)、大桥 (bridge)、很美 (very beautiful). The first sentence means 'Yangtse River Bridge in Nanking is very beautiful', whereas the second means 'Jiang Daqiao, the mayor of Nanking, is beautiful'. Thus, in consideration of the potential problems in locating the word boundaries in the Chinese text, the Tokenizer.exe software allows manual correction of the word segmentations. The following examples present a comparison of the tokenisation of Chinese text C (produced by P01) before and after manual manipulation. The corrections are underlined.

Chinese Text Tokenisation by ChiSegmentor *(Translation of ST Text C):*

牛津 大学 以 领导 并 积极 支持 地区 范围 、 全国 范围 以及 国际 范围内 的 各方面 研究 ， 来 彰显 这些 研究 的价值 及其 在 知识 、 社会 、 文化 、 工业 和 经济 等 方面 的 影响 。 牛津 大学 的 学 者 、 学生 及 校友 所 取得 的 研究 成果 ， 在 全球 思想 领域 也 产生 了 巨大 的 影响。 我们 的 目标 基于 本校 八 个 多 世纪 以来 所 做出 的 学习 、 研究 及 在 公共 事务 方面 的 参与 。我们 将 继续 为 各方 学者 提供 良好 的 研究 氛围 ， 帮助 他们 无论 在 哪个 阶段 都 可以 取得 成就 ， 并进 一 步 发 展 。 我们 也 将 对 国内外 最 优秀 的 研究型 学生 保持 吸引 和 吸纳 。

Chinese Text Tokenisation after Manual Manipulation (Translation of ST Text C):

牛津 大学 以 领导 并 积极 支持 地区 范围 、 全国 范围 以及 国际 范围 内 的 各 方面 研究 ， 来 彰显 这些 研究 的 价值 及 其 在 知识 、 社会 、 文化 、 工业 和 经济 等 方面 的 影响 。 牛津 大学 的 学 者 、 学生 及 校友 所 取得 的 研究 成果 ， 在 全球 思想 领域 也 产生 了 巨大的 影响。 我们的 目标 基 于 本校 八个 多 世纪 以来 所 做 出 的 学习 、 研究 及 在 公共 事务 方面 的 参与 。我们 将 继续 为 各方 学者 提供 良好的 研究 氛围 ， 帮助 他们 无论 在 哪个 阶段 都 可以 取得 成就 ， 并 进一步 发展 。 我们 也 将 对 国内外 最优秀的 研究型 学生 保持 吸引 和 吸纳 。

This study included three comparable English texts, and 54 different Chinese text outputs. The researcher conducted manipulation of the tokenisation of all texts in order to achieve consistency in word segmentation.

The Chinese tokenisation produced by ChiSegmentor is in fact acceptable, but several word boundaries needed to be corrected. Manual corrections are mainly focused on the incorrect segmentation of noun phrases (e.g., 的价[41] 值 → 的 价值, back translation: the value of), the segmentation of possessive pronouns (e.g., 我们 的 → 我们的, back translation: our or ours), verb complements (e.g., 做出 → 做 出, back translation: has made), adjectives (e.g. 良好 的 →良好的, back translation: favourable), measure words (e.g., 八 个 → 八个, back translation: eight) and superlative adjectives (e.g., 最 优秀 的 → 最优秀的, back translation: the best). In the manual manipulation of these segmentations, two facets were taken into consideration: grammatical differences between Chinese and English, and word alignment. For instance, in Chinese, a measure word has to be used before a noun and after a number to indicate the number of objects. However, since English is a synthetic language, and the plural form of a noun can simply be expressed by adding the suffix –s or –es, the Chinese characters '八 个' ('八' means eight, '个' is a measure word) have to be merged into one segmentation to match the English word 'eight'. The processes of tokenisation and word alignment are tightly connected, as they are both combined into the annotation process of the texts.

5.1.3.2 Word Alignment

The task of word alignment is to align the source text tokens with the corresponding target text tokens in a set of parallel texts. The word alignment tool used in this study was program J-Dtag. It displays the tokenised ST words and TT words in two columns (Figure 24). By manually aligning all ST tokens with the corresponding TT tokens (red lines occur if the alignments are successful; blue lines occur when the annotator wants to change the alignment threads), the ST and the TT are aligned. Another option to align the ST tokens with the TT tokens is, first of all, to use the auto-alignment function embedded in the software to produce an automatic alignment version, and then, if necessary, perform manual corrections using an annotator. Since English and Chinese have very different structures, the auto-alignments are normally problematic. It takes a long time to correct the alignments manually. Therefore, for English-into-Chinese or Chinese-into-English translation-related tasks, it is not recommended to use the auto-alignment function.

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[41] '的价' is not a noun phrase and does not mean anything. The character '价' should be put together with the character '值' to mean 'value'.
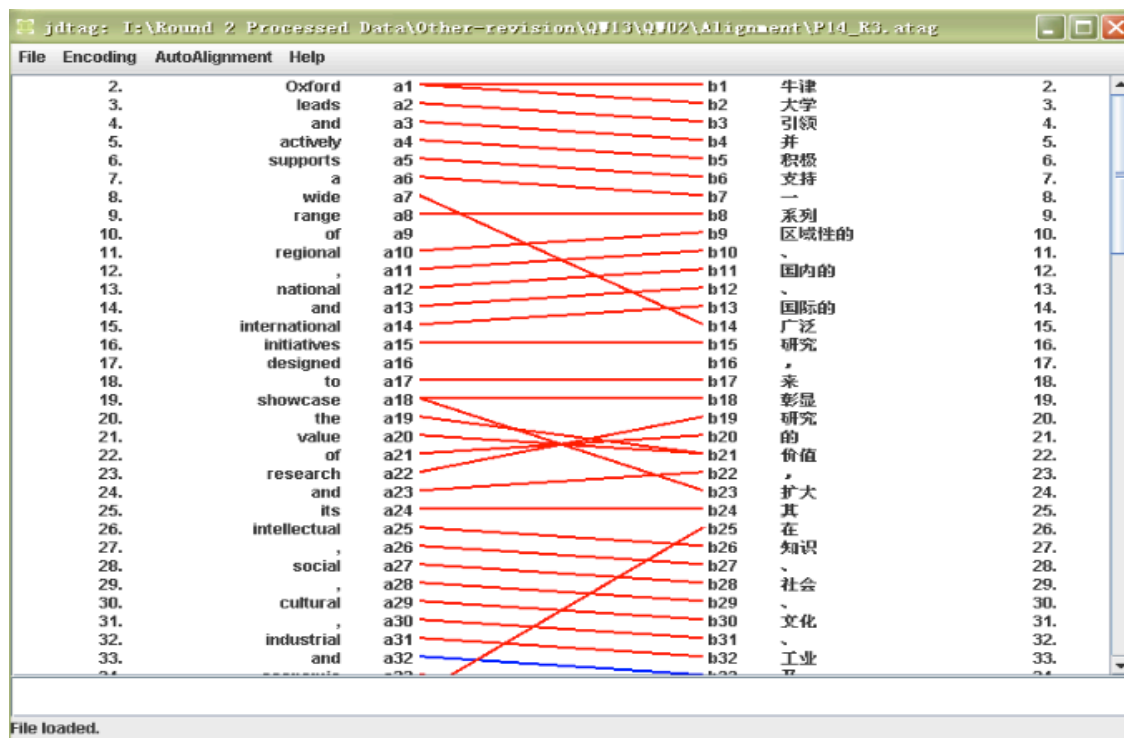
Figure 24: Screenshot of the Word Alignment Tool J-Dtag

In order to standardise the word alignment task in this study, *Guidelines for Chinese-English Word Alignment Version 4.0*[42] (Li *et al.*, 2009) were used as the key reference.

Prior to the actual alignment, it is suggested that the annotator read both the ST and the TT thoroughly to get a good understanding of the texts. The alignment starts with the ST sentence, i.e., the ST tokens are taken as the source words to match the corresponding TT words. All content words (nouns, most verbs, adjectives and adverbs) should be linked first and then the annotator should move on to function words (articles, conjunctions, auxiliary verbs, interjections, particles etc.). It is expected that all the ST tokens and TT tokens will be aligned. This is because, on the one hand, from the technical perspective, if there are too many unaligned ST and TT tokens, then in the revision progression graphs (see section 5.2.2) all these unaligned tokens will fall to the bottom of the graph, which will cause inaccuracies in the qualitative analysis. On the other hand, it is normal for translators, especially student translators, to produce errors in their translations. As long as the error is not a serious translation omission (see Example 23 in Rules of attachment 14), the mistranslated TT token(s) will be aligned with the related ST token(s). Since this study focused on the cognitive process of translation revision and post-editing, and did not touch on the linguistic analysis, the alignment of the ST with the

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wrongly translated TT tokens did not affect the accuracy and validity of the findings. The following sections specify the general word alignment rules and strategies used in this study, giving examples.

This study employed three basic rules set out in the *Guidelines for Chinese-English Word Alignment Version 4.0* as the word alignment principles.

I. Rule of Minimum Match

Minimum match refers to the word-for-word linkage between the ST token and the TT token, preferably taking the smallest unit of the words or characters. This rule is mainly used in literal translations. For example, in Example 1 below, the Chinese equivalent of 'and its' is '及其'. Instead of aligning 'and its' with '及其' (in version A), the rule of minimum match is applied to split '及' from '其' and align 'and' with '及', and 'its' with '其' (in version B).

Example 1:

…the value of research and its[43] intellectual, social… (ST)

Version A:　研 究 的 价值 及其 在 知识 、 社会… (TT)

　…the value of research and its intellectual, social…(ST)

Version B:　研 究 的 价值 及 其 在 知识 、 社会… (TT)

II. Rule of Maximum Match

The rule of maximum match is mainly used for non-literal translations, such as idioms, proverbs or un-detachable phrases and expressions. It refers to the alignment of ST token(s) and TT token(s) that are in one-to-many or many-to-one or many-to-many relationships.

Example 2:

…where the most motivated students and leading researchers choose to work. (ST)

　…成为 拥有 鸿鹄之志的 学子 和 独占鳌头的 研究者 所 选择 工作… (TT)

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[43] In this section, the alignment of the ST and TT tokens is presented using the same types of borders and colours. Since both the ST and the corresponding TT segments are presented, no back translation is provided.

Example 3:

…help to shape national and international agendas… (ST)

…得益 于 国内外的 研究 计划… (TT)

In Example 2, the ST tokens 'the most motivated' are translated into '鸿鹄之志的', and 'leading' into '独占鳌头的'. Leaving aside the appropriateness of the translations (which are discussed in part III), the Chinese idioms '鸿鹄之志' and '独占鳌头' cannot be detached into any smaller units. In this case, the word alignment complied with the rule of maximum match, i.e., linking the ST token(s) with the corresponding TT token(s), regardless of the word-for-word linkage. Example 3 is another word alignment example conforming to the rule of maximum match.

III. Rules of Attachment

Rules of attachment deal with various situations where the rules of minimum and maximum matches cannot be applied to achieve accurate word alignments. This section discusses the attachment rules of 13 different cases, with examples.

(1) Proper Noun

Proper nouns usually begin with capital letter(s), and refer to specific and unique entities, such as 'Beijing', 'Durham University' and 'Mars'. Proper nouns are distinguished from common nouns, which describe a class of entities, e.g., 'city', 'university' and 'planet'. For the alignment of proper nouns, the rule of minimum match (in Example 4) and, if necessary, the rule of maximum match is followed (in Example 5).

Example 4:
Cambridge University is recognised internationally for creative thought… (ST)
剑桥 大学 因 其 创造性 思维 和… (TT)

Example 5:
Oxford leads and actively supports a wide range of regional, national and international initiatives … (ST)
牛津 大学 领导 并 积极 支持 地区 范围 、 全国 范围 以及 国际 范围 内 的 各 方面 研究 …
(TT)

(2) Auxiliary Verb

Auxiliary verbs are typically used together with main verbs to help express the tense, mood, aspect and voice of sentences: for instance, 'be (am, is, are, was, were, being, been)', 'do (does, doing, did, done)', 'can', 'could', 'shall', 'should', 'will', 'must' are all examples of auxiliary verbs. The alignment of auxiliary verbs complies with the rule of minimum match (Example 6).

Example 6:
In future, we will continue to foster interdisciplinary and multidisciplinary ideas and create collaborative research environments. (ST)
在 未来 ，我们 将 继续 加强 跨学科 和 多学科的 理念 ，并 创造 合作性的 实验 环境。(TT)

(3) Verb Particles

A verb particle is also called a phrasal verb. It refers to the semantic unit which consists of a verb and a preposition, and/or a participle, such as 'look after', 'think over' and 'look down upon'. The alignment of verb particles in this study followed the rule of minimum match (see Example 7).

Example 7:
We concentrate on the positive impacts of Warwick research on society at large, particularly in areas of knowledge transfer. (ST)
我们 专注 于 对 社会 研究 带来 的 积极 影响 ，特别 是 在 知识 传递 方面。(TT)

(4) Infinitive 'To'

Infinitive phrases are verb phrases constructed with the verbs in infinitive forms, such as 'to solve the problem' and 'to tell you the truth'. What follow the verb are its object(s), complement(s) and/or modifiers. In Example 8, there are two infinitive phrases: '**to generate** outcomes' and '**to do** so'. The first infinitive phrase 'to generate' serves as the second complement of the verb 'expect', and comes after its direct object 'our research'. In such cases, the infinitive 'to' is attached to the verb as one ST token. The aligned TT token for 'to generate' in this text is '产生'. The second infinitive phrase '**to do** so' is the modifier of the noun 'potential'. The reason the infinitive 'to' is separated from the verb 'do' and

aligned with the TT token '以' is because 'to' here expresses purpose and intent, and the character '以' in Chinese has the same meaning and function.

Example 8:

We expect our research to generate outcomes which enhance social and human well-being, or have the potential to do so through shaping academic disciplines. (ST)

我们 希望 我们的 试验 产生 良好的 结果 以 造福 社会 和 全人类 ， 或 通过 形成 学术性 学科 以 发展 此 潜能。 （mistranslation (TT))

(5) Possessive Determiners

Possessive determiners are typically used to modify a noun by attributing possession, as in '**my** dog' and '**their** contributions'. Possessive forms of the personal pronouns - my, your, his, her, its and our - are also called possessive adjectives. The alignment of possessive adjectives is very straightforward. For example, in Example 9, the ST token 'our' corresponds to the TT token '我校的'. However, in the second half of the TT, '我校' is repeatedly mentioned to complete the grammatical sentence structure. In such cases, the repetition was aligned with its referent.

Example 9:

Our research and scholarship benefit from and help to shape national and international agendas. (ST)

我校的 研究 项目 和 学者 得益 于 国内外的 研究 计划 ， 与此同时 我校 又 推动 了这些 研究 计划。 (TT)

Possessive determiners can also be used to modify a following noun, pronoun or noun phrase; for example: 'Tim**'s** girlfriend' and 'mum**'s** apple tree'. The equivalent token corresponding to the possessive determiner '**'s**' is '的' in Chinese (Example 10).

Example 10:

Research carried out by Oxford 's staff, students and alumni has made an enormous impact on the world of ideas. (ST)

牛津 大学 的 学者 、 学生 及 校友 所 取得 的 研究 成果 ， 在 全球 思想 领域 也 产生 了 巨大 的 影响。 (TT)

(6) Measure Words

As discussed in section 5.1.3.1, there are no measure words in English. Therefore, the measure words in Chinese are usually attached to the number as a unit (Example 11).

Example 11:
Our ambitions are influenced by more than eight centuries of learning, scholarship, research and public engagement. (ST)

我们的 目标 基 于 本校 八个 多 世纪 以来 所 做 出 的 学习、研究 及 在 公共 事务 方面 的 参与。(TT)

(7) Definite and Indefinite Articles

The definite article 'the' specifies the identity of a noun or pronoun to a reader or a listener. Usually, this noun or pronoun has already been mentioned, e.g., '**the** girl I talked about yesterday'. The Chinese equivalents of 'the' can vary, depending on the context: for instance, '那个', '这个', '那些' and '这些'. In Example 12, the ST token 'the' is aligned with the TT token '这些 (back translation: these)'.

Example 12:
Oxford leads and actively supports a wide range of regional, national and international initiatives designed to showcase the value of research… (ST)

牛津 大学 以 领导 并 积极 支持 地区 范围 、全国 范围 以及 国际 范围内 的 各 方面 研究，来 彰显 这些 研究 的 价值 …(TT)

The indefinite articles, 'a' and 'an', are usually used to indicate something or someone that is not particularly identifiable to a person (e.g., **an** eight-year-old girl), or to make a general statement about someone or something (e.g., you educate a man, you educate a man; you educate a woman, you educate a generation).[44] In Example 13, the indefinite article 'an' does not have a corresponding element in the TT. In such cases, the articles are put together with the noun or pronoun they modify as a unit.

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[44] 'You educate a man, you educate a man; you educate a woman, you educate a generation.' – Quoted from Brigham Young. Visit http://www.goodreads.com/author/show/575321.Brigham_Young (accessed on 16 June 2014) for Brigham Young's books and quotes.

Example 13:

Research carried out by Oxford's staff, students and alumni has made an enormous impact on the world of ideas. (ST)

牛津 大学 的 学者 、 学生 及 校友 所 取得 的 研究 成果 ， 在 全球 思想 领域 也 产生 了 巨大 的 影响 。 (TT)

(8) Conjunction 'and'

In some cases in Chinese, it is grammatically correct to omit the conjunction 'and' to simplify the sentence structure. For example, in Example 14, 'nationally and internationally' can be translated as '国内外' without mentioning the conjunction '和 (back translation: and)'. By contrast, the ST token 'attracting' was translated into a conjunctive phrase '吸引和吸纳'.

Example 14:

We will also keep attracting the very best research students nationally and internationally. (ST)

我们 也 将 对 国内外 最优秀的 研究型 学生 保持 吸引 和 吸纳 。 (TT)

The alignment of the conjunction 'and' sometimes involves punctuation. For example, in Example 15, 'and' was translated into a comma, denoting the parataxis relationship of the two sub-sentences. In Example 16, the ST token 'and' was translated into a comma with the conjunction '并' and '与此同时'.

Example 15:

We expect our research to generate outcomes which enhance social and human well-being, or have the potential to do so through shaping academic disciplines. (ST)

我们 期望 我们的 研究 成果 不仅 有利于 社会 发展， 有利于 人类 进步 ， 还 能 在 完善 学 术 体系 上 出一份力。 (TT)

Example 16:

Our research and scholarship benefit from and help to shape national and international agendas. (ST)

我们的 实验 和 奖学金 自 国内外 机构 获得 ， 并 为 国内外 机构 的 建立 提供 帮助 。(TT)
我校的 研究 项目 和 学者 得益 于 国内外的 研究 计划 ， 与此同时 我校 又 推动 了这些 研究 计划。(TT)

(9) Prepositions

Prepositions, such as 'in', 'on', 'under' and 'with', are usually used before nouns or pronouns to indicate the relationship between the nouns (or pronouns) and other words. The alignment of the prepositions follows the rule of minimum match, and the rule of maximum match when necessary. In Example 17, the ST token 'with' is aligned with the TT token '与'. The literal translation of the ST token 'throughout' in Chinese is '遍及'. However, in this sentence, the student translator rendered it semantically as '各地的', based on the context and the completeness of the Chinese sentence structure. Since the translation '各地的' semantically comes from the ST token 'throughout', translations like this are acceptable in word alignment (see entry number 12). The translation of 'through' is similar. The literal translation in Chinese should be '通过', but considering the completeness and naturalness of the Chinese sentence structure, '建立 (back translation: establish)' is attached to '通过 (back translation: through)' as a TT token.

Example 17:

We share resources and knowledge with academic communities throughout the world through collaborative partnerships. (ST)
通过 建立 合作 伙伴 关系 ， 我们 与 世界 各地的 学术 团体 共享 资源 与 知识 。(TT)

(10) Passive Voice

Sentences in the passive voice can be easily recognised in both English (indicator: 'be + Verb in past participle + by') and Chinese (indicators: '被' and '给'). The English passive voice indicators can easily be aligned with those of Chinese, following the rule of minimum match, if both the ST and the TT are in the passive voice. However, if the ST is in the passive voice but the TT is in the active voice, or vice versa, it is difficult to separate the passive voice indicators. Therefore, the rule of maximum match is adopted for such

cases. In Example 18, the ST is in the passive voice and the TT is in the active voice. Thus, the ST tokens 'are influenced by' are taken as 1 unit, aligned with the TT tokens '基于'.

Example 18:
Our ambitions are influenced by more than eight centuries of learning, scholarship, research and public engagement. (ST)
本校的 目标 基于 八个 多 世纪 的 学习、交流，研究 及 在 公共 事务 方面 的 参与。(TT)

(11) Subordinate Clauses

A subordinate clause is an independent clause in a sentence that supplies additional information, but cannot stand alone as a sentence. Both Example 19 and Example 20 are relative clauses. In Example 19, 'where' is the relative adverb. The 'where' clause further explains the noun 'place'. In Chinese, the corresponding equivalent of the relative adverb 'where' is usually '的'. In Example 20, 'which' is the relative pronoun. Together with the preposition 'in', the 'in which-'clause augments the information regarding 'research environment'. The ST tokens 'in which' were translated here into '使', meaning 'to make, to enable'.

Example 19:
We aim to be a place where the most motivated students and leading researchers choose to work and visit. (ST)
我们的 目标 是 成为 最有学术热情的 学生 和 学科 领军人 工作 和 到访 的 首选 地。(TT)

Example 20:
We will continue to provide a supportive research environment in which scholars, at every stage of their career, can flourish and develop. (ST)
我们 将 继续 为 所有 学者 提供 良好的 研究 氛围 ，使 他们 无论 在 哪个 阶段 都 可以 进步 并 发展 。(TT)

(12) Contextually Attached Words

In translation, contextual words are sometimes needed to give a better understanding, or for the naturalness or grammatical correctness of the sentence. For example, in Example 21, the ST token 'for' is aligned with the TT tokens '因其…而 (literal translation: because…so…) '. The word 'across' is aligned with '对包括…在内 (literal translation:

include…)'. In Example 22, the ST tokens 'is recognised' are aligned with '倍受认可'. '倍' in Chinese literally means 'times', i.e., double, triple etc. In the TT, it is an extra contextual word which originates from the ST tokens 'is recognised'. In such cases, the extra contextual words are usually aligned with the ST word(s) with which they are associated or related.

Example 21:
Cambridge University is recognised internationally for creative thought and transformative research of the highest calibre across a broad subject base of sciences, social sciences and the humanities. (ST)
剑桥 大学 因 其 创造性 思维 和 对 包括 科学 、 社会学 和 人文学 在内 的 各 学科 最高等的 转移性 实验 而 享誉 全球 。 (TT)

Example 22:
Cambridge University is recognised internationally for creative thought and transformative research of the highest calibre across a broad subject base of sciences, social sciences and the humanities. (ST)
剑桥 大学 因 其 创新 思维 及 其 在 自然 科学 、 社会 科学 ， 以及 社科 领域 多学科 ， 高成效的 转换 研究 ， 而 倍受 世界 认可 。 (TT)

(13) Unmatched Words

Despite efforts to align all the ST tokens with the TT tokens, in this study there were some tokens that did not have corresponding matches, especially when part of the ST text had not been translated into the TT. For example, in Example 23, only the first part of the ST sentence has been translated, while the part in the column has been completely omitted. In such cases, the participants were screened out so as to ensure the quality of the data collected. Only one participant in this study was filtered out owing to translation omission.

Example 23:
We expect our research to generate outcomes which enhance social and human-being, or have the potential to do so through shaping academic disciplines.
期待 我们的 研究 能够 取得 对 社会 与 人类 生存 福祉 做出 贡献 的 成果。

5.1.3.2.2 Examples of Full Sentence Word Alignment

ST and TT sentences can be categorised into four different types, depending on the completeness and the semantic accuracy of the translations: (1) ST translated and TT correct; (2) ST translated but TT incorrect; (3) ST not-translated but TT correct; and (4) ST not-translated and TT incorrect.

ST Translated and TT Correct:

This category describes ST sentences that have been correctly translated into the TT. Each of the TT tokens in the sentence has its equivalent in the ST and can be aligned with the ST token(s).

Example 24:

We present our major areas of research strength around key global priorities . (ST)

我们 主要的 科研 强 项 围绕 全球 首要 重点 问题 展开 。 (TT)

ST Translated but TT Incorrect:

This category describes ST sentences that have been incorrectly translated into the TT, including typos. As can be seen in Example 25, the semantic meaning of the translated TT is different from the original ST sentence (c.f. literal back translation of the TT). For ST translated but TT incorrect sentences, the TT tokens are aligned with the related ST tokens. For example, the TT token '优势 (back translation: strength)' is aligned with the ST tokens 'areas of research strength'; and the ST token 'priorities' is aligned with the TT tokens '领先地位 (back translation: leading status)'.

Example 25:

We present our major areas of research strength around key global priorities . (ST)

华威 大学 的 主要 优势 在 于 占据 着 国际 领先 地位 。 (TT)

Warwick University's major strength lies in the occupation of the global leading status. (literal back translation of the TT)

ST Not-translated but TT Correct:

This category describes words, phrases or sentences in which the ST token(s) are not translated into TT token(s) but are semantically and grammatically correct. Examples in this category are limited, with most problems relating to the translation omission of the ST token 'and'. In Example 26, the ST tokens 'nationally and internationally' are translated into and aligned with the TT token '国内外'.

Example 26:
We will also keep attracting the very best research students nationally and internationally . (ST)
我们 也 将 对 国内外 最优秀的 研究型 学生 保持 吸引 和 吸纳 。 (TT)

ST Not-translated and TT Incorrect:

This category describes ST sentences that have not been fully translated into the TT, which leads to TT incompleteness or inaccuracy. As discussed in rules of attachment 13 (unmatched words), sentences in this category are not accepted.

Example 27:
We expect our research to generate outcomes which enhance social and human-being, or have the potential to do so through shaping academic disciplines .
期待 我们的 研究 能够 取得 对 社会 与 人类 生存 福祉 做出 贡献 的 成果 。
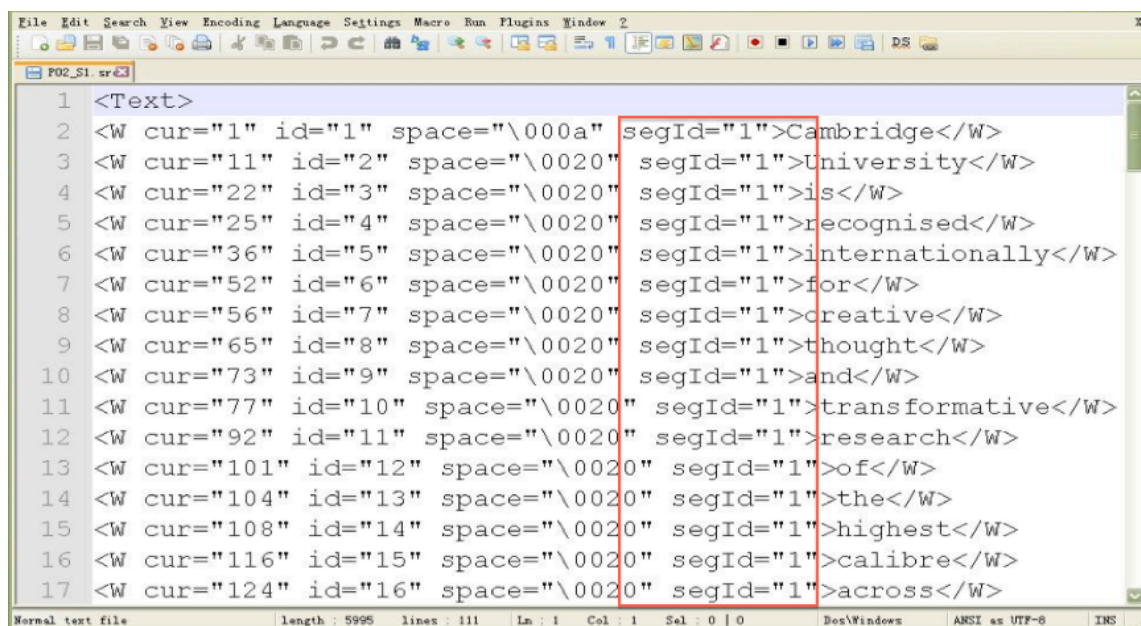
5.1.3.3 Sentence Segmentation and Alignment

Sentence segmentation and alignment are somewhat easier than word segmentation and alignment. In this study, sentences in both ST and TT texts were manually segmented and aligned in Notepad++ by inserting scripts into the segmentation files and the alignment files.

For example, in the ST sentence segmentation file (Figure 25), segId='1' was inserted in front of each ST token (e.g., 'Cambridge'). This indicates that the ST token belongs to the first ST sentence. Similarly, segId='2' was added in front of all ST tokens which belonged to the second ST sentence.

In the ST and TT sentence alignment files (Figure 26), scripts such as '<salign src='1' tgt='1'/>', were inserted at the end of the alignment session. In this way, the first ST sentence was aligned with the first TT sentence. With the rest of the scripts, the ST

sentences were aligned with the corresponding TT sentences in the same way. Full stops were considered as sentence boundaries.

Figure 25: Screenshot of the ST Sentence Segmentation

Figure 26: Screenshot of the ST and the TT Sentence Alignment

5.2 Data Analysis Methods

5.2.1 Process Data Units

The running of the study analysis script, '…StudyAnalysis.pl tables LX13[45]', in the terminal (the cmd in a Windows system) is the last step in the integration of the product and process data. Once the script has been successfully run, two different subfolders – 'Events' and 'Tables' – are automatically generated in the study folder. In the 'Tables' folder, there are 10 types of product and process units, which interpret the UAD from different perspectives. They include: basic product unit tables (Source tokens and Target tokens), composed product unit tables (Session, Segments and Alignment units), basic process unit tables (Keystroke data and Fixation data), and composed process unit tables (Production units, Fixation units and Activity units). Since the present study was mainly process-oriented, the basic and composed process unit tables are presented below. A detailed introduction to all tables can be found in Carl *et al*. (2015b).

1. Keystroke Data (KD)

Table 25 shows a sample of 10 basic text modification operations in order (KEYid), i.e., insertions (ins) or deletions (del). It shows the starting time (Time) of the keystroke, the actual character which the keystroke contributes to (Char), the corresponding number of the ST word (STid), the TT word (TTid) and the sentence (Seg), as well as the position of the cursor. KD can be used to calculate and compare the numbers of insertions and deletions recorded during the typing process.

KEYid	Time	Type	Cursor	Char	Seg	STid	TTid
0	168731	del	14	域	1	5	6
1	168934	del	13	区	1	5	6
2	169137	del	12	在	1	5	6
3	183068	ins	12	范	1	5	6
4	183069	ins	13	围	1	5	6
5	184971	ins	14	广	1	5	6
6	184972	ins	15	阔	1	5	6
7	185423	ins	16	的	1	6+7+8+9	7
8	187857	ins	17	区	1	10	8
9	187858	ins	18	域	1	10	8
10	187859	ins	19	性	1	10	8

Table 25: KD Sample

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[45] LX13 is just an example of the names of the study folders.

2. Fixation Data (FD)

Table 26 demonstrates the fixation information in order (FDid). It shows the starting time (Time) of the fixation, its duration (Dur), its location in Translog-II (Win[46]), the character offset for which fixation was recorded (Cursor), the word or character the fixation is aimed at (STid or TTid), the edit information (Edit and EditID), as well as the parallel activities: fixation and keystrokes (FixK and ParalK). According to Carl and Schaeffer (2014), a density-driven fixation computation algorithm is currently used in Translog-II: gaze samples within a distance of 60 pixels are clustered into a fixation, and the threshold for the fixation is set at 40 ms; the centre of the fixation is mapped onto the closest character. FD can be used to calculate the number and duration of fixations.

FIXid	Time	Dur	Win	Cursor	FixK	ParalK	Edit	EditID	Seg	STid	TTid
0	77	416	1	300	0	0	---	---	2	50	52
1	483	163	1	637	0	0	---	---	5	110	114
2	670	306	2	0	0	0	---	---	1	1	1
3	998	243	2	0	0	0	---	---	1	1	1
4	1232	213	2	0	0	0	---	---	1	1	1
5	1481	1113	1	376	0	0	---	---	3	65	60
6	2589	170	1	0	0	0	---	---	1	1	1+2
7	2761	513	1	19	0	0	---	---	1	4	5
8	3275	250	1	139	0	0	---	---	1	22	19
9	3541	807	1	10	0	0	---	---	1	2	3
10	4336	390	1	18	0	0	---	---	1	4	5

Table 26: FD Sample

3. Production Units (PU)

Table 27 presents coherent typing activities in sequences (see Carl and Kay, 2011). The boundary of PUs (Pauses) is set at 1000 ms (Carl *et al.*, 2015b). It is assumed that 'coherent typing is interrupted beyond this delay of time, with a likely shift of attention towards another set of segment' (ibid., p. 35). Each PU has a starting time (Time) and a duration (Dur). In translation tasks, usually every PU unit covers more than one activity (Ins + Del), but in revision or post-editing tasks, the number and the size of the PUs depend on the number and the size of the revisions made by the revisers.

　　For example, in Table 27, PUid 3 includes three insertions: '区域性 (back translation: regional)'. The duration of this PU unit was about 984 ms. However, with

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[46] Win=1 means the fixation is in the source text window; Win=2 means the fixation is in the target text window.

PUid 4, the duration was 0. This is because the typing activity was a deletion of the Chinese full stop, '。', which takes no time. 'FixS' and 'FixT' show the number of fixations on the ST and the TT respectively, and 'ParalS' and 'ParalT' present the duration of the fixations on the ST and the TT. The actual typing activities are recorded in 'Edit'. 'STid' and 'TTid' demonstrate the corresponding aligned number of ST and TT word(s) in the text. By working out the number and duration of PUs, the productivity of student translators can be compared.

PUid	Time	Dur	Pause	FixS	ParalS	FixT	ParalT	Ins	Del	STid	TTid	Edit
0	27156	116	27156	1	48	1	329	0	3	5	6	[域区在]
1	33969	225	5797	0	0	1	1	2	0	5	6	范围
2	102062	1875	68093	2	332	1	103	3	0	5+6+7+8+9	6+7	广阔的
3	105000	984	1063	1	2	0	0	3	0	10	8	区域性
4	126234	0	20250	0	0	0	0	1	0	10	8	。
5	131375	112	2125	0	0	0	0	1	1	10+11	8+9	[。]、
6	181265	2516	48578	0	0	1	2	3	0	12	10	全国性
7	186375	1344	2594	1	1	0	0	2	0	13	11	以及
8	191578	2141	3859	0	0	1	1	2	0	14	12	国际
9	203875	231	10156	0	0	0	0	1	0	14	12	性
10	207844	625	1938	0	0	0	0	1	0	14	12	的

Table 27: PU Sample

4. Fixation Units (FU)

As with the PUs, Table 28 presents the student translators' reading behaviour in sequences (FUid). The boundary of the FUs was set at 400 ms, based on the experimental evidence found by Carl and Kay (2011). 'If the stream of the gaze samples indicates the gaze directs away from the screen for more than 400 ms, thus interrupting coherent reading activity, we assume a boundary of a fixation unit and the beginning of the next fixation' (Carl *et al.*, 2015b, p. 36). The time and duration of FUs were recorded along with the time stamp. The path of each FU was logged as well. By working out the number and duration of FUs, the number of attentional shifts and the length of the reading activities of the student translators could be compared.

Time	FUid	Dur	Pause	FixK	ParalK	Path
77	0	108191	770	0	0	1:50+1:110+2:1+2:1+2:1+1:65+1:1+1:4+1:22+1:2+1:4 +1:5+1:7+…
108748	1	59109	480	0	0	1:20+1:22+1:1+1:22+1:3+1:5+1:2+1:84+2:1+2:1+2:1+ 2:1+1:12+1:8+1:1+1:65+1:1+…
168309	2	12117	452	1	406	1:7+1:5+2:1+1:5+1:4+1:6+1:1+1:8+1:5+1:1+1:5+1:5…
181023	3	8915	597	4	455	1:7+2:39+2:6+2:40+1:25+1:6+1:8+1:10+2:40+1:8+1:10 +2:6+2:1+
191350	4	3801	1412	0	0	2:7+2:1+1:8+1:10+1:10+2:1+2:39+1:10+
196764	5	7078	1613	4	4	2:40+2:39+1:12+1:12+1:13+1:14+2:39+2:1+2:39+1:33 +1:14+1:14+2:10+2:12+
205593	6	20368	1751	3	3089	1:14+1:14+1:14+1:12+1:7+1:1+1:43+1:8+1:14+1:14+1: 8+1:14+1:14+2:1+2:1+2:1+2:1+2:1+2:1+2:1+1:114+2: 1+2:1+2:1+2:1+2:1+2:1+2:1+1:1+1:1+…
229290	7	35844	3329	4	1484	1:15+2:51+2:14+2:1+2:13+2:1+2:51+2:51+2:14+2:1+2: 51+2:1+1:16+1:1+1:20+1:20+1:21+2:1+2:1+2:1+1:12+ 1:1+2:1+2:1+2:1+1:20+1:22+1:23+…
265560	8	57664	426	4	3511	2:1+2:1+2:1+2:1+2:1+2:1+2:1+1:16+1:1+1:20+1:23+1: 25+1:23+1:25+1:27+1:29+1:108+2:1+1:27+1:29+2:1+2 :1+1:29+1:29+1:32+1:33+2:3+2:1+2:1+1:28+1:29+1:34 +…

Table 28: FU Sample

5. Activity Units (CU)

As discussed in section 2.5.2, activity units (CUs) segment the entire recorded session into sequences of activities that belong to the same category. According to Carl and Schaeffer (2014, pp. 39-40), these types of activity are:

- Type 1: source text reading.

- Type 2: target text reading.

- Type 4[47]: translation typing.

- Type 5: translation typing while reading the source text.

- Type 6: translation typing while reading the target text.

- Type 7: translation typing while reading the source and the target text.

- Type 8: no activity was recorded.

As can be seen in Table 29, below, a CU segment is described by its number (CUid); the session being recorded (Session); the starting time (Time); the duration (Dur); the segment in which it takes place (TTseg); the type of activity (Type), and the label of the activity (Label) which annotates the overall information on a CU segment.

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[47] Type 3 (source text reading and target text reading) was omitted, as this activity was not detected in the translation processes in Carl and Schaeffer (2014).

CUid	Session	Time	Dur	TTseg	Type	Label
0	P06_P2	31	390	2	1	CU0-S:2-T:1-D:390
1	P06_P2	421	1778	1	2	CU1-S:1-T:2-D:1778
2	P06_P2	2199	1825	1	1	CU2-S:1-T:1-D:1825
3	P06_P2	4024	1217	1	2	CU3-S:1-T:2-D:1217
4	P06_P2	5241	1529	1	1	CU4-S:1-T:1-D:1529
5	P06_P2	6770	2028	1	2	CU5-S:1-T:2-D:2028
6	P06_P2	8798	12215	1	1	CU6-S:1-T:1-D:12215
7	P06_P2	21013	2262	1	2	CU7-S:1-T:2-D:2262
8	P06_P2	23275	515	1	1	CU8-S:1-T:1-D:515
9	P06_P2	23790	1654	1	2	CU9-S:1-T:2-D:1654
10	P06_P2	25444	203	1	4	CU10-S:1-T:4-D:203

Table 29: CU sample

For example, the Label for CUid0 (CU0-S:2-T:1-D:390) can be interpreted as follows: this CU0 segment took place in the second TT segment; it belonged to activity Type 1 (ST reading), and its duration was 390 ms. The type of activity changed at 421 ms (Time). By reading the Label for CUid1 (CU1-S:1-T:2-D:1778), it can be seen that this CU1 activity took place in the first TT segment; it belonged to activity Type 2 (TT reading), and it lasted for 1778 ms (duration). At 2199 ms (Time), the type of activity changed back to Type 1 (ST reading), with a duration of 1825 ms (CU2-S:1-T:1-D:1825).

From CUid0 to CUid9, it can be seen that the participant took different amounts of time to read the ST and the TT. CUid10 was a different type of activity (CU10-S:1-T:4-D:203). At 25444 ms (Time), the participant started to type (T:4) in the first TT segment (S:1) with a duration of 203 ms (D:203).

By analysing CUs, different types of reading and typing activity could be identified, and information about the number and duration of each type of activity was also provided. The sequences of the reading and typing activities could also be identified.

Since the aim of the present study was to investigate student translators' physical activities (basic reading and typing activities and the sequences of these activities) during the self-revision, post-editing and post-editing processes, activity units (CUs) were used for the quantitative analysis (see section 6.1).

5.2.2 ProgGraph Visualisation

The concept of a 'progression graph' (ProgGraph) was first introduced by Perrin (2003) as a method of visualising the writing process. Carl and Jakobsen (2009) adapted it for translation studies, using a 'translation progression graph' as a tool to conceptualise and visualise the entire translation process in time, i.e., how the translation evolves over time. The present study borrowed the progression graph concept from Perrin (2003). In order to

present the evolving processes of self-revision (SR), other-revision (OR) and post-editing (PE) in time, it also adapted the following graphs from Carl and Jakobsen (2009): the self-revision progression graph (SR ProgGraph); the other-revision progression graph (OR ProgGraph), and the post-editing progression graph (PE ProgGraph). These ProgGraphs were used as the qualitative analysis method to detect the types of revision and post-editing patterns.

With the UAD, the ProgGraphs can be generated in R[48] with either a micro-view or a bird's-eye view. The micro-view provides a visualisation of part of the task process, while the bird's-eye view presents the entire task process in time.

Figure 27: A Bird's-eye View of the ProgGraph for Other-revision

Figure 27 plots the bird's-eye view of participant P07's other-revision pattern. In this graph, the x-axis represents revision time (task time) in milliseconds; the y-axis on the left lists the corresponding number of tokenised source text words (ST token list), and the y-axis on the right shows the aligned target text words (TT token list). The blue dots and green diamonds represent the participant's gazing activities for ST reading and TT reading respectively, and the black and red symbols represent the typing activities - insertions and deletions - respectively. The larger a symbol is in size, the longer its duration.

Figure 27 tells us that, from 0 ms to about 80000 ms, P07 was reading ST tokens (0-90) initially; and then s/he switched attention to the TT and read the whole text. From

about 80000 ms to 1000000 ms, P07 continuously shifted his/her attention between the ST and the TT (ST reading and TT reading) and made several text modifications (insertions and deletions). From 1000000 ms to 1150000 ms, P07 reviewed the TT, ST and TT in turn, and made a few revisions.

Figure 28 is a micro-view of P07's other-revision process pattern. It reveals the participant's gazing and typing activities between 360000 ms and 460000 ms (X=360000-460000 ms) while s/he was working on the second sentence of Text 3 (Y=36-56).
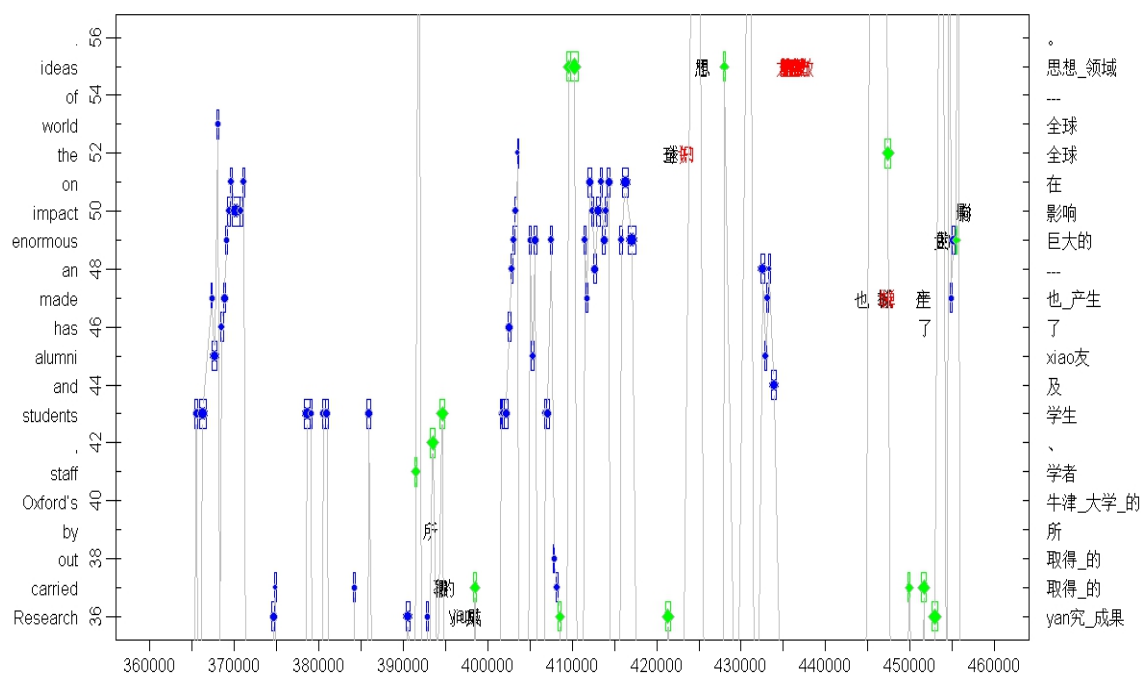
Figure 28: A Micro-view of the Other-revision ProgGraph

On the right hand side of the graph in Figure 28 are two Chinese *pinyin*, words, 'xiao' and 'yan', with the characters. This is because some of the Chinese characters had an encoding conflict with R (even using UTF-8 encoding), which prevented the successful running of the scripts. When such a character was detected by R, an error message, such as 'Error in scan (file, what, nmax, sep, dec, quote, skip, nline, na.strings, line 36 did not have 11 elements)', was reported automatically. In order to solve this problem, manual correction of the unrecognised Chinese characters was required. The manual correction was performed in Notepad++ by first detecting the unrecognised Chinese character (e.g., in line 36), and then replacing it with the *pinyin* word . The characters which could not be recognised in this study were: '研', '校', '标', '习', '无', '传', '造', '奠', '因', '破', '占', '样', '加', '惠' and '树'.

The graph also shows that some of the Chinese characters overlapped. This is a special case that only occurs with Chinese-as-the-typing-language tasks, since Chinese typists are used to typing a string of *pinyin* words in one go (especially for four-character

phrases) and then pressing the enter button to input several Chinese characters at the same time. These characters are shown without time sequence in both Translog-II and the ProgGraphs.

In section 5.1.3.2, it was noted that one of the word alignment principles was to try to align all the ST tokens with the TT tokens. As can be seen in Figure 28, if a ST token is not aligned with a TT token, a hyphen is shown on the TT token list (e.g., Y=48 and Y=54). However, if a TT token is not aligned with any ST token, the TT token falls to the bottom of the graph (e.g., in Figure 28, where X=340000, Y=0). If there are too many unaligned TT tokens, both the quantitative data (tables) and the qualitative data (ProgGraph) will be too noisy to be interpreted accurately.

In summary, in this study CUs were analysed to work out the types of reading and typing activities in self-revision, post-editing and other-revision, and to compare the number and mean durations of these activities both within and across tasks. ProgGraphs were used to determine the working phases and the sequences of the reading and typing activities, and to identify the various working styles. Furthermore, cue-based retrospection data were used to investigate the purposes that lay behind the student translators' conducting of each type of reading and typing activity across tasks.

5.3 Data Quality

As discussed in section 4.1.1, in this study efforts were made to ensure that data quality was maintained in all phases and from all perspectives: for instance, by using a pre-experiment participant screening questionnaire in the pre-experiment phase, and by applying control of calibration and typing speed in the in-experiment phase. In the following section, eye-tracking data quality control in the post-experiment phase is discussed.

5.3.1 Mean Fixation Duration (MFD)

Rayner and Sereno (1994, p. 58) observed that the MFD in reading is normally 200 to 250 ms. Jakobsen and Jensen (2008) found that the MFD in ST reading for normal comprehension was 205 ms, and for translation was 218 ms. On the basis of these findings, and in line with Hvelplund (2011), this study set the minimum mean fixation duration threshold at 175 ms. Any data in which the MFDs were lower than 175 ms were discarded. Table 30 presents the MFDs of the selected participants in all three tasks. Most are actually above 300 ms.

Participants	MFD in SR	MFD in OR	MFD in PE
P1	505.2	513.2	468.0
P2	439.6	447.5	416.9
P3	453.5	393.1	415.9
P4	427.5	335.7	398.4
P5	342.3	360.5	377.8
P6	364.7	372.6	357.8
P7	480.4	471.3	443.9
P8	399.4	408.8	386.5
P9	383.9	407.3	395.1
P10	508.1	478.7	488.8
P11	383.1	421.3	427.3
P12	420.2	400.0	412.7
P13	383.7	364.9	378.2
P14	409.9	454.1	406.6
P15	413.1	421.4	501.5
P16	354.2	361.5	358.2
P17	376.4	312.0	275.6
P18	340.6	327.0	303.6

Table 30: Participant MFD (in ms) in SR, OR and PE

5.3.2 Gaze Percentage on Screen (GPS)

Furthermore, during the experiment, the participants were asked to fix their gaze as much as possible on the screen. Although all participants were good touch typists, it was inevitable that they would occasionally direct their gaze at the keyboard, or other places. Hvelplund (2011) used GTS (gaze time on screen) score, 100/total drafting time * fixation sum, as the eye tracking data screening method, as this indicates the amount of data tracked in the experiment. The present study drew on the gaze percentage on screen (GPS) recorded by Tobii Studio 3.2.3, data recording and analysis software, as the indicator.

GPS can be found under the 'Replay' tab. Tobii Studio automatically calculates the GPS score after each experiment session. In this study, the threshold was set at 85%. Any participant whose GPS was lower than 85% in any session was screened out. These turned out to be two participants whose GPS scores were below 70%. Table 31 lists the GPS of the selected participants in three tasks. Most of participants' GPS were above 90%, which was very satisfying for the study.

Participants	GPS in SR	GPS in OR	GPS in PE
P1	90%	92%	95%
P2	94%	96%	97%
P3	96%	92%	97%
P4	91%	96%	90%
P5	89%	94%	97%
P6	95%	92%	94%
P7	88%	93%	96%
P8	94%	91%	90%
P9	87%	90%	98%
P10	91%	96%	95%
P11	95%	92%	97%
P12	94%	89%	95%
P13	90%	93%	88%
P14	91%	96%	93%
P15	96%	93%	92%
P16	94%	92%	99%
P17	85%	93%	92%
P18	94%	95%	86%

Table 31: Participant GPS in Three Tasks

5.4 Statistical Analysis Tools

'Significance in statistics refers to the probability of our results being a fluke or not; it shows the likelihood that our result is reliable and has not just occurred through the bizarre constellation of individual numbers' (Rasinger, 2008, p. 159). A confidence level is used to indicate 'how confident we are that our result is accurate', and a p-value is used to indicate 'the probability that the results happened by chance' (Saldanha and O'Brien, 2013, pp. 198-199). For instance, many researchers use a confidence level of 95%, which means they are 95% confident that the result is accurate and the probability that the result happened by chance is 5% ($p = 0.05$). The further below 0.05 the p-value is, the more confidently we can report that the result is reliable. Generally speaking, a confidence level of 95% is acceptable in social sciences (e.g., psychology, linguistics and anthropology), although in natural sciences (e.g., physics, astronomy, chemistry and earth science) the confidence level should be higher (ibid.).

Different types of test can be used to calculate statistical significance. According to Saldanha and O'Brien (2013, p. 199), the choice of an appropriate test is generally dependent on two factors: the type of data collected, and whether the data are normally distributed.

According to Rasinger (2008, pp. 25-26), there are four types of data: categorical scale data, also called nominal data: the data can only fall into one category (e.g., self-revision, post-editing or other-revision); ordinal scale data: the labels can be ranked but the differences cannot be compared (e.g., strongly agree or disagree); interval scale data: the categories can be labeled but the differences are fixed (e.g., all students who obtain a mark between 70 and 75 get a distinction, but their marks may be different: one student may have scored 71, while another scored 75), and ratio scale data, which are similar to interval scale data, but 'possess a unique, non-arbitrary zero'. The data collected in the present study fall into the category of nominal data, as there were seven types of reading and typing activity, four types of working style and three task types, the durations of which were compared within groups.

ANOVA (Analysis of Variance) can be used for nominal data. However, another factor that needs to be considered is the distribution of the data. According to Rasinger (2008, p. 130), when data are symmetrically distributed in the mean point of a bell curve, a normal distribution is identified. If the curve has a long tail to the right, the data are positively skewed; if the curve has a long tail to the left, the data are negatively skewed. When the data are skewed, normally tests for non-parametric data, such as the Wilcoxon signed-rank or Mann-Whitney U-tests, are suggested (Saldanha and O'Brien, 2013, p. 200). However, in the present study, multiple pairwise comparisons needed to be carried out to compare the values between groups (e.g., SR was compared with PE, PE was compared with OR, and SR was compared with OR in terms of task time), and the post hoc tests in the one-way ANOVA seemed to be the most efficient. To deal with the problem of skewness, a logarithmic function was used to transform the data (Baayen, 2009, p. 279). This made the distribution of the data more symmetrical (see section 6.1.1 for sample graphs) and reduced the probability of detecting significant effects driven by random outliers (Hvelplund, 2011, p. 120).

Two typical errors may occur in multiple pairwise comparisons (Rasinger, 2008, pp. 160-161): Type I error, a false positive, increases the probability of showing a significant difference when in fact there is none; while Type II error, a false negative, increases the risk of showing a non-significant difference that is in fact significant. According to Montgomery (2013, pp. 99-100), the Fisher Least Significant Difference (LSD) Method tests the least significant difference, but is prone to cause Type I error; the Bonferroni correction is conservative, 'adjusting the p-value by dividing the standard 0.05 p-level by the number of post-hoc comparisons that are to be carried out', and is prone to cause Type II error. However, according to Carmer and Swanson (1973, pp. 73-74), the LSD method is 'a very effective test for detecting true differences in means if it is applied after the F test in the ANOVA shows significance at the 0.05-level'. Therefore, as described

in section <u>7.3.5</u>, an LSD test was run to do post hoc comparisons between the three tasks (SR, PE and OR) in terms of task time. Nonetheless, the LSD test cannot be used to compare the duration of the different types of reading and typing activity, or the task time for different working styles, because it requires equal sample data. According to Montgomery (2013, p. 98), the Tukey-Kramer test for differences between means is usually used for post hoc comparisons of data with unequal sample size. Montgomery (2013, p. 100) also mentions that since the Tukey method does not control the overall error rate, it is a method chosen by many statisticians.

In the present study, all data were checked to ensure symmetrical distributions prior to conducting the statistical analyses. The skewed data were log transformed in R and new data were saved for significance tests. The one-way ANOVA with post hoc tests was run in Statplus.[49] The significance level of the F test in the ANOVA was analysed. Only the tests showing significant difference at/below the 0.05-level (e.g., F = 6.87, p = 0.0010) were further compared in a pairwise fashion. The Tukey-Kramer test was used for the comparison of the reading and typing activities, as well as the working styles in terms of task time. The LSD test was used to compare the total amount of time each participant took on each task. The post hoc test showed a t-value and a p-value (e.g., t = 1.14, p = 0.2545). The t-value is an estimate of the differences in the means between the two compared datasets. The p-value indicates the probability that the null-hypothesis (the tentative hypothesis that there is no effect) is true or false. The further below 0.05 the p-value is, the more likely it is that the null-hypothesis is false and the difference is significant.

5.5 Summary

This chapter has presented the raw logging (eye tracking and keylogging) data compilation process under the CRITT TPR data analysis framework. This includes the data annotation preparation (creation of working folders and use of name convention); process data annotation (automatic and manual fixation-to-word mapping), and product data annotation (tokenisation, word alignment and sentence segmentation and alignment). The different procedures and tools used for Chinese tokenisation, as well as the word alignment rules for English-into-Chinese translation, have been presented. The process units (e.g., CU) that were used for quantitative analysis, and the ProgGraphs which were used for qualitative analysis, were presented. The problems associated with visualising the ProgGraph (which contains Chinese characters) in R were also explained. This chapter

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[49] Statplus is a statistical analysis tool which has similar functions as SPSS but is easier to operate. Visit <u>https://www.analystsoft.com/en/products/statplus/</u> for more details.

also discussed the eye-tracking data quality control in the post-experiment phase and the statistical analysis tools used for the significance tests that are described in Chapters 6 and 8.

Before reporting the findings of this study, the research questions and the relevant data collection and analysis tools are revisited and summarised in Table 32 below.

Research Questions	Data Collection Tools	Data Analysis Tools	Findings and Discussions
RQ1: **What types of reading and typing activity can be identified in the self-revision, other-revision and post-editing processes?**	- Tobii TX 300 Eye tracker - Translog-II	- Activity Units (CU) in UAD - One-way ANOVA with post hoc tests for statistical analysis	Chapter 6
RQ2: **What are the purposes behind these reading and typing activities?**	- Cue-based retrospection	The interview is focused on the questionnaire questions below: - What were your reading and typing activities during your revision and post-editing processes? Which was your main activity? Why?	
RQ3: **What are the working styles of translators in performing self-revision, other-revision and post-editing? And why?**	- Tobii TX 300 Eye tracker - Translog-II - Cue-based retrospection	- ProgGraph The interview is focused on the questionnaire questions below: - Were there any problems with the TT before you revise or post-edit it? - How many times did you revise the TT from start to finish, and why? - What were your focuses and criteria during each run-through? - Can you describe how you read the ST and the TT and revised the TT, and why?	Chapter 7 Sections 7.1, 7.2, 7.3.1, 7.3.2, 7.3.3, 7.3.4
RQ4: **How do the working styles of the student translators vary within and across tasks?**	- Tobii TX 300 Eye tracker - Translog-II	- ProgGraph	Chapter 7 Sections 7.3.5, 7.3.6
RQ5: **To what extent do working styles affect the working efficiency of translators in each task?**	- Tobii TX 300 Eye tracker - Translog-II	- One-way ANOVA with post hoc tests for statistical analysis	Chapter 8

Table 32: Data Collection and Analysis Framework

In the following chapter the types of reading and typing activity that were detected in the processes of SR, OR and PE are reported, as well as the student translators' retrospections on the purposes behind their physical activities.

Chapter 6

Physical Activities and the Underlying Purposes in Self-revision, Other-revision and Post-editing

This chapter examines the first two research questions proposed in the present study: 1) What types of reading and typing activities can be identified in the self-revision, other-revision and post-editing processes, and 2) what are the purposes underlying these reading and typing activities?

The first question was investigated by analysing the activity unit data (see section 5.2.1) in the user activity data (UAD). Statistical analyses were carried out to compare the number and mean duration of each type of reading and typing activity in SR, PE and OR. One-way ANOVA with post hoc tests were run to test the significance level of the F test. For those F tests which showed a significant difference, the Tukey-Kramer test was used to conduct pairwise comparisons.

The second research question, the purposes behind each type of reading and typing activity, was explored primarily by scrutinising student translators' retrospection reports. Krings' (2001) text analysis model and Hvelplund's (2015) findings on cognitive activities and purposes in translation were drawn on as theoretical underpinnings.

Section 6.1 reports the different types of reading and typing activity detected in the activity unit data and compares the number and the mean duration of these activities in self-revision, post-editing and other-revision. Examples of cue-based retrospection data are presented and analysed to infer the potential purposes behind all physical acts. Section 6.2 compares the number and the duration of the reading and typing activities within each task to identify the most frequently performed reading and typing activities in each task. Section 6.3 concludes this chapter.

6.1 Types, Proportions and the Underlying Purposes of Physical Activities

By analysing the activity unit (CU) data, seven types of reading and typing activities were detected in all tasks in the present study. These were the same as the seven types of activity units identified by Carl (2014). Figure 29 presents these activities.
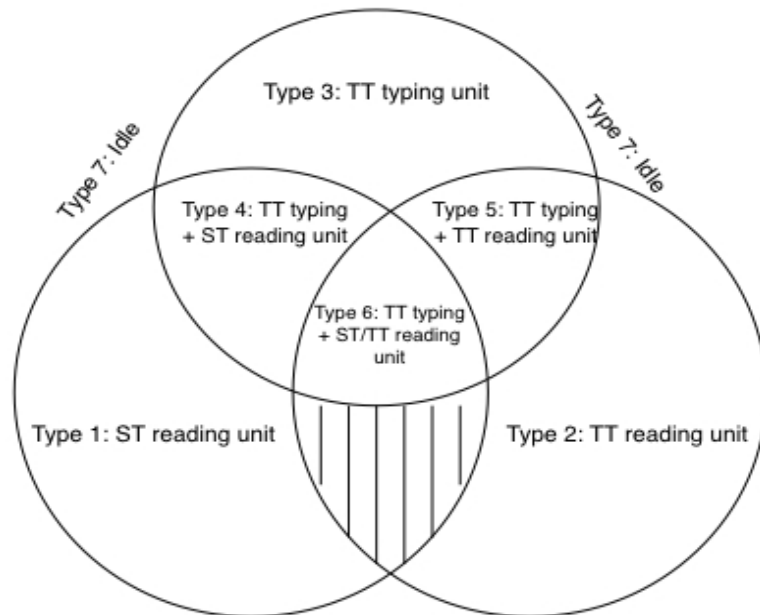
Figure 29: Seven Types of Activity Units in SR, PE and OR

In terms of the number of the activity units, the three main reading and typing activities identified in the SR, PE and OR processes included:

- Type 1: ST reading unit (Source text reading unit).
- Type 2: TT reading unit (Target text reading unit).
- Type 3: TT typing unit (Target text typing unit).

When the co-occurring typing while reading activities were taken into account, three more types of activity units were detected. These are:

- Type 4: TT typing + ST reading unit
  (Target text typing while reading the source text unit).
- Type 5: TT typing + TT reading unit
  (Target text typing while reading the target text unit).
- Type 6: TT typing + ST/TT reading unit
  (Uninterrupted target text typing while quickly shifting the gaze between the source and the target text).

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Physically speaking, since one cannot direct the gaze on the ST and the TT at the same time, no activity was found going on in the shaded area (Figure 29). In the data, there were also some segments in which no data were recorded. In line with Carl (2014), these segments are categorised as Idle.

- Type 7: Idle (no recorded activity, the length of which is longer than one second).

Section 6.1 is divided into seven subsections, each of which focuses on the discussion of one type of physical activity (reading and/or typing activities) and its potential relationship with the mental activities, taking place simultaneously, that underlie it.

6.1.1 Statistical Analysis of Activity Units across Tasks

This section presents the results of the statistical analyses for the activity units. For each type of activity unit, I will use two hypothetical assumptions as a starting point to examine and present the statistical data. Please note that they are not the hypotheses of this study. In each subsection, column charts are used to illustrate the data. As discussed in section 5.4, one-way ANOVA with post hoc tests were run to test the significance level of the F test. Only the tests showing significant differences at/below the 0.05-level were further compared in a pairwise fashion, as the F test itself showed the significance level of the difference within a group, but did not indicate which pair(s) in the group differed significantly. The Tukey-Kramer test was used for pairwise comparisons.

It should be noted that, although the seven types of activity unit were detected in all three tasks, not every participant undertook all activities during the working process. As can be seen from Figure 30, 100% of the participants engaged in ST reading and TT reading (Type 1 and 2) in all the tasks. As Hvelplund (2015) mentions, ST reading and TT reading are two of the fundamental types of reading taking place during the process of translation. This should also be true for SR, PE and OR. As the participants in the current study were asked to revise and to post-edit the translations, the TT typing unit (Type 3) occurred in all tasks.

With regard to the TT typing + ST reading unit (Type 4), it was found that only 22.2% of the participants read the ST while typing the emerging TT in the process of conducting SR, whereas 88.9% and 66.7% of the participants consulted the ST while typing out the TT in the processes of PE and OR respectively. This is probably because the participants had gained a certain degree of familiarity with the ST during the translation phase so that they did not need to re-read the ST to a great extent during the process of SR. With respect to the TT typing + TT reading unit (Type 5), 88.9% and 94.4% of the participants read the emerging TT while typing in the processes of SR and OR

respectively, while all participants coordinated the TT typing activity at some point by fixating their gaze on the TT in PE. It should be noted that the TT typing + ST/TT reading unit (Type 6) consisted of a sequence of reading and typing activities. As noted earlier, it was not possible for the participants to read the ST and the TT simultaneously, but it was possible for them to shift their gaze quickly between the ST and the TT while typing a word or a segment, especially for skilful touch typists. The percentages of participants engaged in this type of activity unit in the process of SR, PE and OR were 33.3%, 83.3% and 38.9%, respectively.

The last type of activity unit was what we call 'Idle' (Type 7). 88.9%, 77.8% and 83.3% of the participants were found to have no recorded gazing or typing activity units in the processes of SR, PE and OR. The possible interpretations for this type of unit are discussed in section 6.1.1.7.
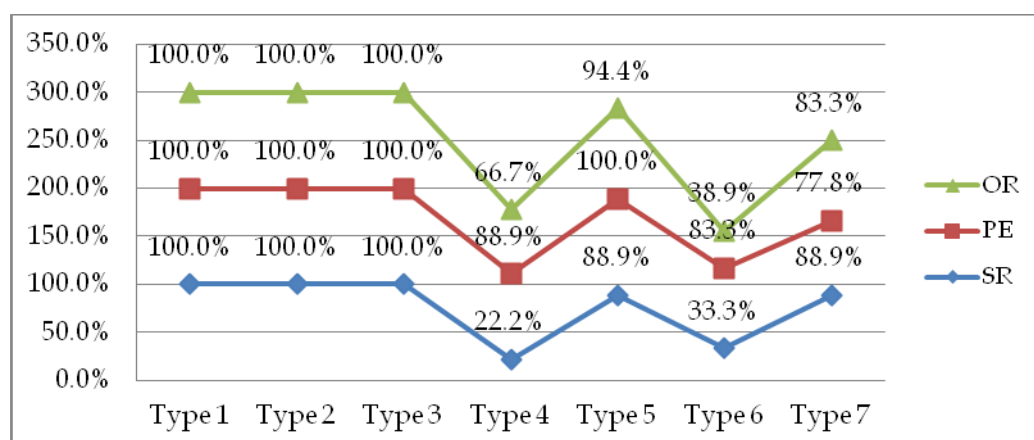
Figure 30: Percentage of Participants Undertaking All Types of Activity Units across Tasks

To reduce the risk of observing significant effects driven by random outliers, the distributions of all data were logarithmically transformed in R and new data sets saved for further analysis (see section 5.4). For instance, as can be seen in Figure 31, the distribution of TT typing + ST/TT reading (the lower left) had a high and a low kurtosis. The post-transformation (the lower right) shows a symmetric distribution.
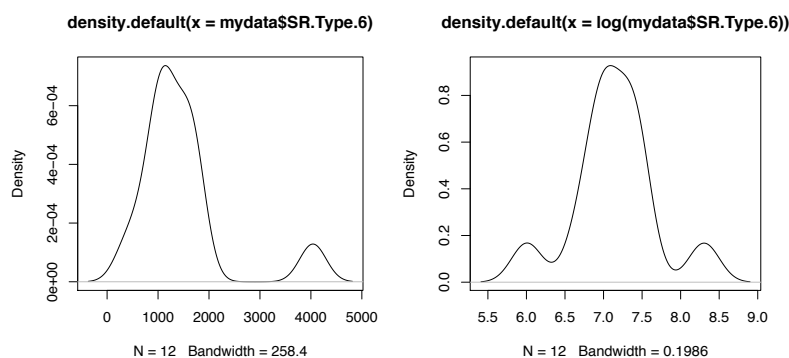
Figure 31: Data Distribution before and after Logarithmic Transformation

6.1.1.1 Type 1: ST Reading Unit

6.1.1.1.1 Statistical Analysis

It was reasonable to assume that the mean duration of ST reading activity unit in SR was shorter than that in PE and OR, on account of the fact that, having the previous day translated the ST, the participants had become familiar with the ST. They should be able to retrieve the ST information from the long-term memory, to utilise their text knowledge and macrostructure of both the ST and the TT to carry out revision. For PE and OR, the processes were more complex. With the new ST and TT, the analysis of both texts started from the bottom of the text comprehension process (see section 2.4), i.e., word identification, morphosyntactic reception, proposition formation, text coherence formation etc. At the same time, the comparison between the ST and the TT (evaluation process) was taking place. All these processes consumed more time.

It was also reasonable to assume that the mean duration of ST reading activity unit in PE would be longer than that in OR, because the quality of the TT in OR was higher than that of the raw machine output, and more time was needed for ST comprehension in PE.

However, as can be seen from Figures 32 and 33, the statistical analysis showed that the number of ST reading units for PE (n = 2,795) was the highest, followed by OR (n = 2,180) and SR (n = 1,597), but the mean duration of ST reading units for SR (2,257.2 ms) was longer than that of PE (2,201.0 ms) and OR (2091.7 ms). The one-way ANOVA showed a non-significant difference for the duration of ST reading in all three tasks (F = 1.28, p = 0.2791). In section 6.1.1.1.2 the retrospection data are presented and interpreted.
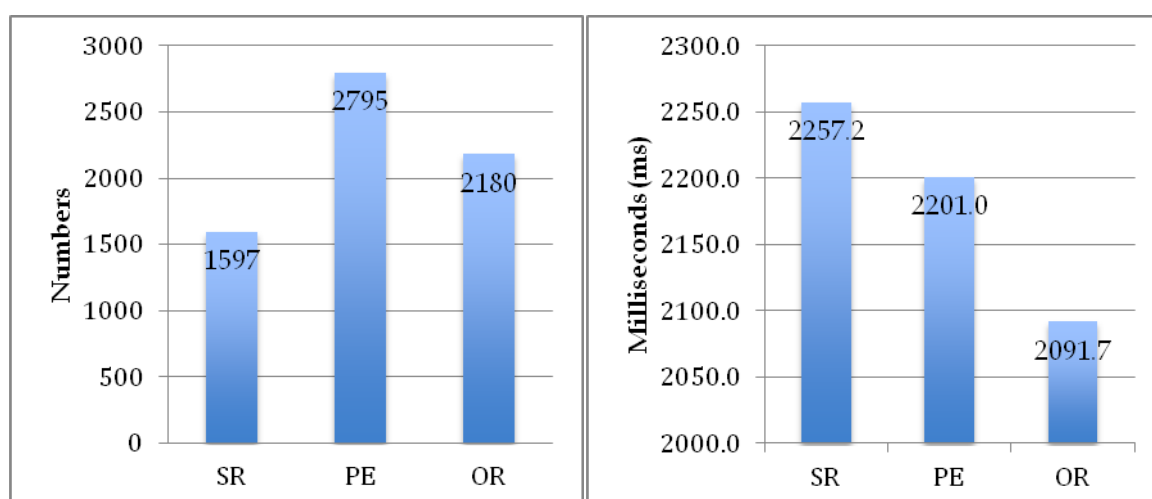
Figures 32 and 33 (left to right): Number of ST Reading Units; Mean Duration of ST Reading Units

6.1.1.1.2 Subjective and Conscious Reflections on the Underlying Purposes

The participants' retrospection data were analysed to infer the purposes behind their ST reading activities in the three tasks. After the experiment session, the participants were asked to describe their revision and post-editing processes with the replay of their eye movements in Tobii Studio. After their retrospection, the researcher asked the student translators questions related to the research questions of this study based on the post-experiment questionnaire (Appendix 9), such as: 'Did you read the ST while conducting SR, PE and OR?' and 'Why or why not?' Some representative answers to these questions in all three tasks are presented in Table 33. The column on the right hand side summarises the purposes behind the student translators' ST reading activities based on the analysis of their retrospection data.

Retrospection Data (Chinese)	English Translation	Purposes of ST Reading Activities
P06: (SR)就是再看看我之前翻译的时候对原文理解的是否有误，确认一下。	P06: (SR) I just wanted to check whether my previous understanding of the ST was correct or not. Just to confirm.	- To comprehend and analyse the ST - To confirm accurate understanding of the ST
P09: (OR and PE)原文跟译文会上下比对着看，确定译文跟原文在意思上是对等的。	P09: (OR and PE) I compared the TT with the ST to make sure that the TT was equivalent to the ST in meaning.	- To confirm accurate meaning transfer of the ST
P12: (SR) 我当时翻译的时候不知道到底这个 'transformative research'该怎么翻，当时没想出来就放在那儿了，所以我刚刚又看了很久，想摆脱译文的干扰，再组织组织语言。	P12: (SR) Since I did not know how to translate 'transformative research' yesterday, I just left them there. I reread the ST just now for a while to reorganise the 'language' (TL) without interference of the TT.	- To propose a solution to previously unsolved or newly identified translation problems - To reformulate the ST with intentional avoidance of TT reading (to extract meaning, generate, test, reject or accept plausible meaning hypotheses)
P15： (SR) 我第一句话翻译的特别别扭，就想不看译文，自己再翻译一下。	P15: (SR) I found my translation of the first sentence awkward. Then I tried to avoid reading the TT; instead, I read the ST to retranslate (that sentence).	
P18: (SR, PE and OR)自己翻译过的大概还有印象，但是修改别人的以及机器翻译肯定需要再去读原文理解大意，然后对照译文，该改改，该重新翻译重新翻译。	P18: (SR, PE and OR) My memory of the ST in SR was more or less intact, but I did need to read and comprehend the (new) source texts in order to revise others' translation (OR) and the raw machine output (PE). I changed whatever needed to be changed and retranslated the parts which needed to be retranslated.	- To comprehend and analyse the ST - To prepare for positive or negative evaluation of the TT - To prepare for retranslation (to extract meaning, generate, test, reject or accept plausible meaning hypotheses)

Table 33: Retrospection Data for ST Reading Activities

Based on Krings' (2001) text analysis model and Hvelplund's (2015) model, it can be seen that in all three tasks the purposes behind the ST reading included:

- ST comprehension and analysis
    - to extract ST meaning
    - to confirm accurate understanding of the ST
    - to confirm accurate meaning transfer of the ST
    - to generate, test, reject or accept plausible meaning hypotheses of the ST
- Preparation for other processes
    - to prepare for positive or negative evaluation of the TT
    - to propose solutions to the previously unsolved or newly identified problems
    - to retranslate the ST.

One possible interpretation of the lower number and longer duration of ST reading activity units in SR is that, during the self-revision process, the participants focused more on the previously unsolved translation problems. With the retrieved information of the ST and the TT from the long-term memory, they were able to allocate more cognitive resources to specific problematic areas to propose solutions and make final decisions. However, for PE and OR, the new ST and the TT require text comprehension and analysis. The limited capacity of an individual's working memory explains the higher number of attentional shifts (number of activity units) and shorter duration of the ST reading activities in PE and OR than in SR.

Another possible interpretation of the lower number and longer duration of ST reading activity units in SR than in PE and OR is that 'two heads are better than one'. In PE and OR, the participants were either working with a 'technical' brain (machine) or a human brain, which provided plausible translations. In other words, when dealing with a translation problem, they had options from their own brain and from the other 'brain' (the computer). Therefore, the duration of the ST reading activity units was slightly shorter. However, in SR, the participants were only working by themselves with a slightly fresher view of the ST and the TT. It took more time to solve a problem which had been previously left unsolved, and reading the ST was part of the problem-solving process.

6.1.1.2 Type 2: TT Reading Unit

6.1.1.2.1 Statistical Analysis

It was assumed that the mean duration of the TT reading activity units would be shortest in PE and longest in SR. This is because the raw machine translation was lower in quality, thus the processing of the TT would be frequently interrupted by the translation problems

and the need for ST reading. For OR, the quality of the TT was somewhat higher than that of the machine translation, but it is often the case that it is harder to detect one's own problems than those of others. Therefore, the mean duration of the TT reading activity units was expected to be longer in SR than in OR.

The statistical analysis confirmed the above assumption. It was interesting to find that the number of TT reading units for SR (n = 1,991) was the lowest across all tasks (PE: n = 4,048; OR: n = 2,902), but its mean duration was the longest (2,960.7 ms) (cf. Figures 34 and 35). According to the one-way ANOVA, the mean durations of the TT reading units in the three tasks were significantly different (F = 6.87, p < 0.01). The Tukey-Kramer test was run to do pairwise comparisons. The results (Table 34) showed that the mean duration of the TT reading units in SR was significantly longer than in PE (2,594.7 ms) (t = 3.70, p < 0.05) and OR (2,694.9) (t = 2.53, p < 0.05). The mean duration of the task of PE, which had the highest number of units but the shortest mean duration, was not significantly shorter than that of OR (t = 1.14, p > 0.05). Section 6.1.1.2.2 presents the retrospection data and analyses the potential purposes underlying the TT reading units in all tasks.
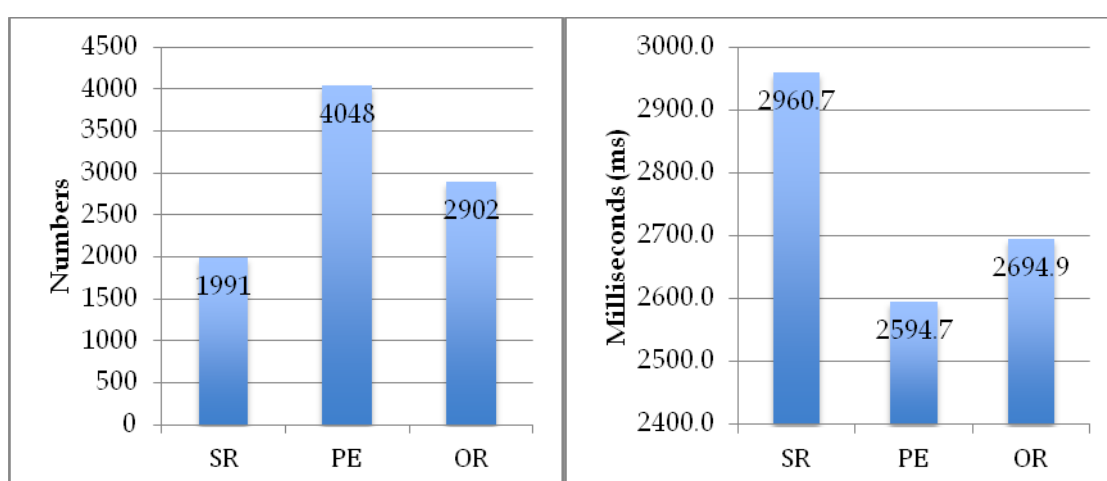
Figures 34 and 35 (left to right): Number of TT Reading Units; Mean Duration of TT Reading Units.

Tukey-Kramer Test for Differences Between Means			
Group vs. Group (Contrast)	Difference	Test Statistics	p-level
OR Type 2 vs. PE Type 2	100.19	1.14	0.2545
OR Type 2 vs. SR Type 2	-265.76	2.53	0.0115
PE Type 2 vs. SR Type 2	-365.95	3.70	0.0002

Table 34: Pairwise Comparison of the Duration of TT Reading Activity Units

6.1.1.2.2 Subjective and Conscious Reflections on the Underlying Purposes

The participants' retrospection data were analysed to discover the purposes of the TT reading activities in the three tasks. Table 35 presents representative answers to the questions: 'Did you read the TT in doing SR, PE and OR?' and 'Why or why not?' in all three tasks. The column on the right hand side summarises the purposes of the student translators' in the TT reading activities based on the analysis of their retrospection data.

Retrospection Data (Chinese)	English Translation	Purposes of TT Reading Activities
P07：(SR, PE and OR) 修改我自己的话主要就是读读看通顺不通顺，有没有什么语言上语法上逻辑上的问题，不过也会再对照原文看看语意上是不是有翻译失误的地方。不过翻译过一遍以后，对语意还是基本上有把握的。 修改机器翻译我觉得特虐，因为基本上译文就是废的，但是也还会去读，看看有没有我能用上的词组啊什么的，有时我不认识的词也能给我提供一个翻译参考，不过基本上就是自己重新翻译了。 修改人工翻译我觉得还好，因为也是译者翻译的，所以我觉得应该在语意上，比如错译漏译这些方面应该不会有大的问题。所以就是主要检查语言、语法、流畅度，也会再看译文的准确性。	P07: (SR, PE and OR) For SR, I primarily read the TT to check fluency, language use, grammar and logics. I also compared it with the ST to confirm there was no mistranslation. But basically speaking, I am confident about the ST meaning transfer after translation. For PE, I felt screwed as, basically, the TT was useless. But I did read it to see whether there was anything I could use, such as phrases. It also provided me with some ideas for the words that I did not understand. For OR, I felt all right. Since it was translated by a human translator, I felt there should not be many problems such as mistranslation and omission. I mainly checked language use, grammar and fluency. I also checked accuracy.	SR: - To evaluate the TT positively or negatively, checking its fluency, language use, grammar, logics and accuracy PE: - To help with the proposal of a new translation segment OR: - To evaluate the TT positively or negatively, checking its language use, grammar, fluency and accuracy.
P03: (SR, PE and OR) 这三个任务其实都是找错。我觉得性质上是一样的，读译文无非就是检查 accuracy, consistency, fluency, register, equivalence, structure 等等。	P03: (SR, PE and OR) The nature of these three tasks in fact was the same: that is, to find mistakes. The purpose of reading the TT was to check accuracy, consistency, fluency, register, equivalence, structure etc.	- To evaluate the TT positively or negatively, checking its accuracy, consistency, fluency, register, equivalence, structure etc.
P11: (PE and OR) 我觉得要分两个情况看耶。读机器翻译和别人的译文的主要目的是发现错误然后修改，一般改完之后至少会再读一遍自己修改的，看看整体译文是否通顺、达意。	P11: (PE and OR) I think there are two different cases here. Reading the raw machine output and other's translation was to detect problems and to revise. After that I would reread the revised sentences to ensure that the TT was fluent and accurate on the whole.	PE and OR: - To detect problems and to revise - To confirm the solutions previously found - To evaluate the revised translation from a holistic

		perspective
P09：(OR)就比如 ambition 这个词，他的翻译是目标，我就在想是不是翻译成志向更为准确一些，然后就会不停读整个句子，看究竟哪个词在句子中更合适。读完之后还是觉得志向更好。	P09: (OR) For example, the translation for the word 'ambition' was '目标' (back translation: aim/target). I was thinking whether the phrase '志向' (back translation: ambition) was more accurate. Then I kept rereading the TT to check which phrase fitted better in the context. After rereading the TT, I decided to use '志向'.	- To propose a solution to the identified problems - To analyse the TT (to extract meaning, generate, test, reject or accept plausible meaning hypotheses) - To determine the final solution
P15：(PE)尤其是机器翻译，我改完之后会不停的重读，确定我翻译的是 ok 的。遇到不太确定的地方会读原文，但也会不停的读译文，我觉得翻译符合中国人语言习惯很重要。	P15: (PE) Especially for PE, I kept rereading the TT after performing revision on it, just to check that my translation or revision was OK. I would reread the ST when I was uncertain about the translation of particular areas (e.g., words or sentences), but I also kept rereading the TT. I think naturalness is very important.	- To comprehend and analyse the TT - To evaluate the TT positively or negatively - To compare the TT with the ST - To confirm the final translation (naturalness as criteria)

Table 35: Retrospection Data for TT Reading Activities

Similar to Kring's (2001) findings regarding TT reading units, MT reading (reading of the existing TT) and PETT (reading of the post-edited TT) were also detected in the post-editing process in the present study. However, in addition to these two types of TT reading, the participants reported a third type of reading. This was the reading of the entire TT, a mixture of the existing TT and the revised or the post-edited TT.

In summary, from the participants' conscious retrospection data above, three types of TT reading were identified: reading of the existing TT (pre-translated TT for revision and post-editing purposes), reading of the newly produced TT (the revised or the post-edited parts), and reading of the entire TT (a mixture of the existing TT and the revised or the post-edited TT).

The purposes of reading the existing TT included:

- TT comprehension and analysis
  - to extract TT meaning
  - to evaluate the translation positively or negatively (problem detection), checking accuracy, fluency, consistency, structure, grammar, equivalence etc.
  - to propose solutions to the identified problems (decision making)

The purposes of reading the newly produced TT included:

- Verification of the revision

  - to compare the newly produced TT with the original (existing) TT

  - to confirm accurate meaning transfer of the ST

  - to evaluate the solutions (the changes having been made)

The purposes of reading the entire TT included:

- Evaluation and verification of the translation

  - to avoid translation problems (e.g., mistranslation, omission)

  - to read the TT from a macro-view and to check naturalness etc.

It was also found that the purposes of TT reading in SR, PE and OR were very similar, as these three tasks shared the same nature, which was to detect problems, to make changes and to improve the translation quality. However, according to the retrospection data, for many of the participants, the task of PE (full post-editing) included some degree of retranslation. Therefore, the number of TT reading units in PE was the highest and the mean duration of these units was the shortest.

6.1.1.3 Type 3: TT Typing Unit

6.1.1.3.1 Statistical Analysis

TT typing units are those typing activities without simultaneous registration of eye movement data. Given the fact that many participants retranslated some parts of the ST in PE, it was assumed that PE would have the highest number of TT typing units, whereas SR would have the fewest TT typing units. It was also assumed that the mean duration of TT typing would be the shortest in PE and the longest in SR.

As can be seen in Figures 36 and 37 below, the above assumptions were verified. The highest number of TT typing units was found in PE (n = 1,083), followed by OR (593) and SR (431). The mean duration of the TT typing units for SR was 314.8 ms, which was longer than that for OR (283.6 ms) and PE (274.2 ms). The differences were not significant (F = 2.08, p = 0.1257). Section 6.1.1.3.2 presents the retrospection data and analyses the potential purposes underlying the TT typing units in all tasks.
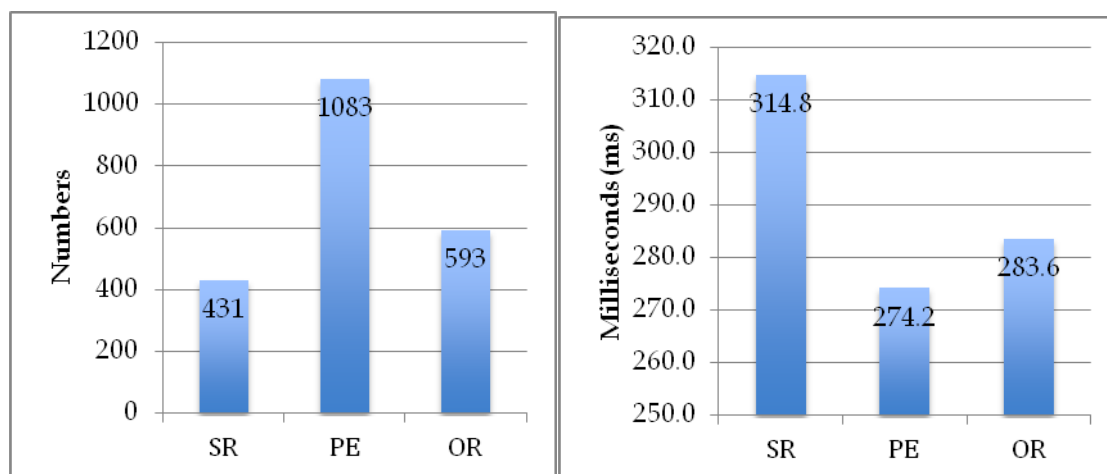
Figures 36 and 37 (left to right): Number of TT Typing Units; Mean Duration of TT Typing Units

6.1.1.3.2 Subjective and Conscious Reflections on the Underlying Purposes

The participants' retrospection data were analysed to infer the potential purposes behind the TT typing activities in the three tasks. Table 36 presents representative answers to the questions: 'Did you make any typing in doing SR, PE and OR?' and 'Why or why not?' in all three tasks. The column on the right hand side summarises the purposes behind the student translators' TT typing activities based on the analysis of their retrospection data.

Retrospection Data (Chinese)	English Translation	Purposes of TT Typing Activities
P01: (SR, PE and OR) 确定了要改的内容就改了，不合适的地方删掉，需要添加的部分就添加，这个很简单。	P01: (SR, PE and OR) Just to type out the revisions when decisions have been made. That includes deletion of inappropriate parts and insertion of necessary content. It is simple.	- To make changes - To delete - To insert
P18: (SR, PE and OR) 有，就是修改不是吗？改得还挺多的我觉得，尤其是那个机器翻译。一般是有了改的想法之后，可能就会付诸于行动，因为写下来更好判断自己的决定是不是正确的，或者说合理的。也就是说分两个方面我觉得。一种是很确定要怎么改，尤其对于错别字或者标点符号什么的，这种修改比较快；另一种就是比如选词啊或者句式需要调整，或者错译，这种修改我个人习惯是要把心里想的打出来，然后再通读译文的句子，这样比较清楚，也可能有人是一定要想好之后才打字。	P18: (SR, PE and OR) Yes, I did. That is making changes, right? I think I did make a lot of changes, especially in doing PE. Normally, I would write down whatever ideas in my mind, because by doing so it is easier to evaluate my decision (i.e., whether it is correct or appropriate or not). I think there are two cases. The first is when you are quite sure about how to make the changes. For example, the revision of typos or punctuations is much quicker (than that of other types of error). The other case is about the revision of lexical choices, the sentence pattern, or the mistranslated parts. For these types of error, I usually type out whatever is in my mind, and then reread the TT to check. That is much more clear (than just thinking), I think. Other people may be used to making actual changes only when they have a definite idea in mind.	- To produce new segments - To generate, test, reject or accept the solutions to the problems detected

Table 36: Retrospection Data for TT Typing Activities

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By analysing the above representative retrospection data, it can be seen that the purposes of TT typing included:

- Production of new TT segment(s)

  - to insert

  - to delete

  - to generate, test, reject or accept the solutions to the problems detected.

Participant P18 mentioned two types of purpose underlying the TT typing activities. These two purposes were related to the participants' certainty in the decision-making process. When they were confident about the revision of certain errors, such as typing errors, they executed insertions and/or deletions to make actual changes. However, when they had to become involved with the revision of lexis, sentence structures or ST meaning transfer which they were not quite certain about, some participants tended to use typing as a problem-solving method, during which the solutions were generated, tested, rejected or accepted; other people might tend to do inner revisions (proposing, testing, rejecting or accepting the solutions in mind only) before they typed out the actual changes.

6.1.1.4 Type 4: TT Typing + ST Reading Unit

6.1.1.4.1 Statistical Analysis

TT typing + ST reading is considered as a type of parallel activity (Carl and Schaeffer, 2014; Hvelplund, 2011; 2015). It was assumed that the mean duration of TT typing + ST reading activity would be the shortest in SR and longest in PE, since participants were more familiar with the ST in SR and hence did not need to focus on the ST for long. For PE, where more revisions were required, the proportion of this activity would be relatively higher.

However, as can be seen from Figures 38 and 39, the statistical analysis showed that the mean duration of TT typing + ST reading unit was the longest for SR (521.7 ms) and the shortest for OR (351.6 ms). The mean duration of TT typing + ST reading unit for SR was longer than for PE (420.5 ms). The difference was not significant, however (F = 1.38, p = 0.2542). PE had the highest number of activity units (n = 82) compared with OR (n = 34) and SR (n = 16). Section 6.1.1.4.2 presents the retrospection data and analyses the potential purposes underlying the TT typing + ST reading units in all tasks.
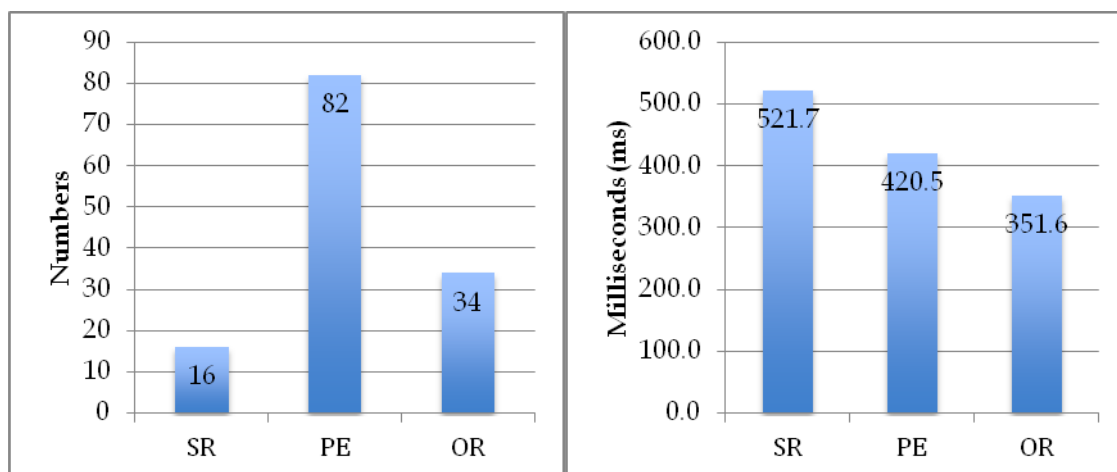
Figures 38 and 39 (left to right): Number of TT Typing + ST Reading Units; Mean Duration of TT Typing + ST Reading Units

6.1.1.4.2 Subjective and Conscious Reflections on the Underlying Purposes

The participants' retrospection data were analysed to infer the possible purposes behind the TT typing + ST reading activities in the three tasks. Representative answers to the questions: 'Did you read the ST whilst typing the TT in SR, PE and OR?' and 'Why or why not?' in all three tasks are presented in Table 37. The column on the right hand side summarises the purposes behind the student translators' TT typing and ST reading activities based on the analysis of their retrospection data.

Retrospection Data (Chinese)	English Translation	Purposes of TT typing + ST Reading Activities
P13: (SR, PE and OR) 我不觉得我有边看原文边打字，看着译文打字是有的。	P13: (SR, PE and OR) I do not think I read the ST while typing the TT, but I did read the TT while typing.	- No such activities
P17: (SR, PE and OR) 不是很多我觉得。其实盯着原文的时候还是在想译文应该怎么说，也不是完全就在想原文是什么意思。	P17: (SR, PE and OR) Not many cases I think. In fact I was thinking how to formulate the TT while reading the ST. It is not that I was completely focusing on the meaning extraction of the ST.	- To reformulate the TT
P16: (SR, PE and OR) 我会，在比较难的地方或者不太确定的地方可能打字的时候会看着原文，因为心里其实不是非常确定我想的是不是正确的，会考虑有没有更好的说法。但也不是说一直盯着原文，否则容易打错别字。	P16: (SR, PE and OR) Yes, I did. I read the ST while typing the translation of those difficult or uncertain parts. I was not sure whether my translation was correct or not and was considering better options while reading the ST. But I could not fix my eyes on the ST for long; otherwise there would be typos.	- To analyse the ST and confirm meaning transfer of the uncertain or difficult parts

P15：(SR, PE and OR) 会的，更多的我觉得还是在解码原文吧，可能对自己的理解还不是很确定。不过即使看（原文）也看不了很多，盯着几个字而已，中文输入法不是还得选字呢么，应该是原文译文原文译文来回切换，有时还得看键盘。	P15: (SR, PE and OR) Yes, I did. Mostly I was still decoding the ST I think, probably because I was not quite sure about my understanding of the ST. But since I have to choose the right characters (using the Chinese input method Sogou), I could not focus on the ST for long. I think I shifted between the ST and the TT. Sometimes I had to look at the keyboard as well.	- To generate, test, reject or accept better translation options - Conscious ST processing and automatic TT typing - Quick attentional shifts between the ST and the TT, as possibly the keyboard

Table 37: Retrospection Data for TT Typing + ST Reading Activities

From the analysis of the retrospection data shown in Table 37, it can be inferred that the purposes underlying the TT typing + ST reading activities included:

- ST analysis
   - to confirm the ST meaning transfer of obscure or difficult parts
   - to generate, test, reject or accept better translation options
- TT reformulation
   - to produce TT segments.

According to Hvelplund (2011; 2015), since an individual's attention can only be allocated to one place at a time, interpretations of this type of activity include either quick attentional shifts between the ST and the TT, or conscious processing of ST information while typing the TT automatically.

In the present study, although not all the participants read the ST while typing the TT (see statistics in section 6.1.1), both of Hvelplund's (2011; 2015) interpretations were found to be valid in the participants' accounts. Most of the participants who engaged in this parallel activity confirmed that they were processing the ST while typing, especially when dealing with difficult or obscure parts. However, since additional attention needed to be focused on Sogou, they could not concentrate on the ST for long when producing TT segments. This probably explains why they had to coordinate the ST processing and TT production at the same time, as the typing activities needed to be monitored.

One possible explanation is that the different durations of TT typing + ST reading in the three tasks are linked to certainty. As discussed in section 6.1.1.1, in SR, the participants focused more on previously unsolved translation problems. In other words, they mainly focused on the parts they were uncertain about, reprocessing the ST while typing the TT. Therefore, the mean duration of TT typing + ST reading was longer. However, for OR, the participants were working with a different human brain (translator), so it is possible that they were less uncertain about the meaning of the ST and could concentrate more on TT production. For PE, since many of the participants chose to retranslate the ST, the number of parallel activities was the highest.

6.1.1.5 Type 5: TT typing + TT Reading Unit

6.1.1.5.1 Statistical Analysis

TT typing while reading the emerging text is considered, by Hvelplund (2015), as constructing a pre-verbal version of an ST item in the TL. As noted above, the participants in the current study could be more certain about the ST encoding in OR than in SR, as the text had been previously translated by another human translator. Therefore, it was assumed that the mean duration of the TT production and monitoring activities in OR was longer than that in SR. Since there were more typing activities in PE than in SR and OR, it was also assumed that the largest number and longest mean duration of TT typing + TT reading activities would be found in PE.

As can be seen in Figures 40 and 41 below, the above assumptions were confirmed. The number of TT typing + TT reading units in PE was the highest (n = 327), followed by OR (n = 166) and SR (n = 94). With regard to the mean duration of TT typing + TT reading units, the one-way ANOVA showed a non-significant difference (F = 3.25, p = 0.0597). The duration in PE was longer than in OR (1,021.9 ms) and SR (949.0 ms) (cf. Figures 40 and 41). Section 6.1.1.5.2 presents the retrospection data and analyses the potential purposes underlying the TT typing + TT reading units in all tasks.
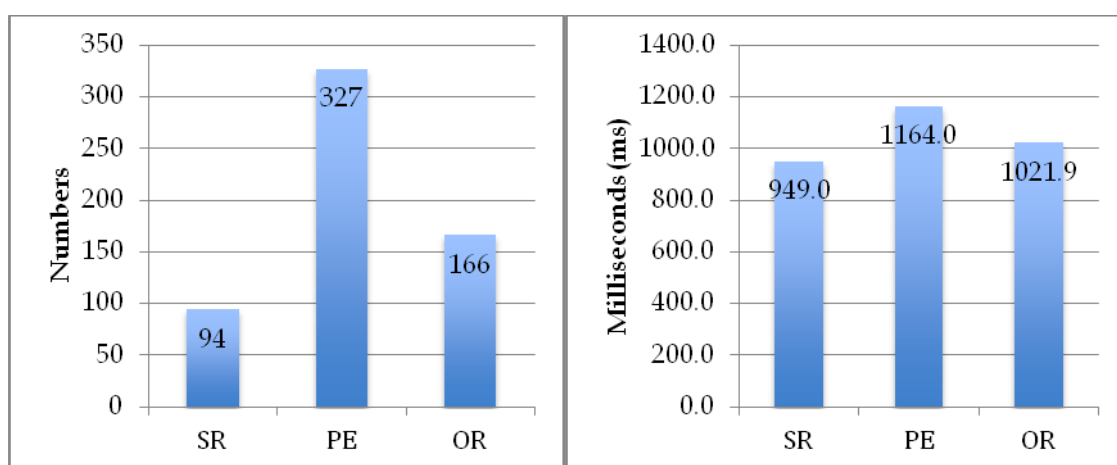
Figures 40 and 41 (left to right): Number of TT Typing + TT Reading Units; Mean Duration of TT Typing + TT Reading Units

6.1.1.5.2 Subjective and Conscious Reflections on the Underlying Purposes

The participants' retrospection data were analysed to infer the potential purposes behind the TT typing + ST reading activities in the three tasks. Table 38 presents representative answers to the questions: 'Did you read the TT while typing the TT in SR, PE and OR?' and 'Why or why not?' in all three tasks. The column on the right hand side summarises the purposes of the student translators' TT typing and TT reading activities based on the analysis of their retrospection data.

Retrospection Data (Chinese)	English Translation	Purposes of TT typing + TT Reading Activities
P08: (SR, PE and OR) 边打字肯定边看了，不然就打错了。其实我觉得打字是个思考的过程，打字本身不是问题，但心里想的只有写出来才更清楚，才能更好地进行判断。	P08: (SR, PE and OR) I definitely read the TT while typing it, otherwise there would be typos. In fact I think the process of typing was a process of thinking. To type is not a problem for me. It only became clearer when I put my thoughts down into words so that it was easier for me to judge (the translation).	- To test TT hypothesis in a real context - To execute TT - To formulate TT
P09: (SR, PE and OR) 写的时候会看译文，一方面确保没有打错字的情况，也会考虑我写的跟我想的是不是一致，另一方面也会思考接下来写什么，以及译文是否与原文一致。	P17: (SR, PE and OR) I did fix my eyes on the TT while typing. On the one hand, I could make sure that there were no typos, and would also consider whether what I put down was what I thought. On the other hand, I would think what I should write next, and whether that was equivalent to the corresponding ST.	- To monitor the generated TT (including typos and the translation) - To evaluate the TT (by evaluating the TL itself and by comparing the TT with the ST to confirm meaning transfer)
P10: (SR, PE and OR) 一般都会的吧，主要是考虑译文的结构组织、用词、以及句子是否通顺、流畅、自然，当然前提是能够准确地表达原文的意思。	P16: (SR, PE and OR) I think that was common. I mainly focused on the structure of the TT, lexical choice, as well as the fluency and naturalness of the TT sentence. Of course, the premise is that the meaning of the ST was accurately transferred.	

Table 38: Retrospection Data for TT Typing + TT reading Activities

From the representative retrospection data shown in Table 38 above, it can be seen that the main purposes of TT typing + TT reading included:

- TT formulation
  - to formulate the subsequent TT segments
  - to test the TT hypothesis by typing and then evaluating
- TT execution
  - to type out the TT segments
- TT monitoring
  - to avoid typing errors
  - to avoid incorrect ST meaning transfer
- TT evaluation
  - to evaluate the structure, lexical choice, fluency, accuracy and naturalness of the TT.

The higher number of TT typing + TT reading activities in PE might be an indication of a more intense TT production process. Although there were significantly higher numbers of TT typing + TT reading units in PE than in OR and SR, the mean durations of this type of activity in the three tasks were not significantly different. This indicates that it took approximately the same amount of time for the participants to execute actual changes in all the tasks.

6.1.1.6 Type 6: TT Typing + ST/TT Reading Unit

6.1.1.6.1 Statistical Analysis

Another type of activity unit detected in this study concerns the shift of attention between the ST and the TT whilst typing. It was assumed that the number of this type of activity in all three tasks would be low, as it was not very likely that the participants could coordinate attention between the processing of the ST, the processing of the existing TT and the production of new TT segments.

As can be seen in Figures 42 and 43, the number of TT typing + ST/TT reading units in all tasks (SR: n = 12; PE: n = 31; OR: n = 11) was much lower than in other activity units. The one-way ANOVA indicated a non-significant difference in the mean duration of TT typing + ST/TT reading units across tasks (F = 0.96, p = 0.3891). The mean duration of TT typing + ST/TT typing units for SR, PE and OR was 1,449.0 ms, 1,788.4 ms and 1,356.1 ms respectively. Section 6.1.1.6.2 presents the retrospection data and analyses the potential purposes underlying the TT typing + ST/TT reading units in all tasks.
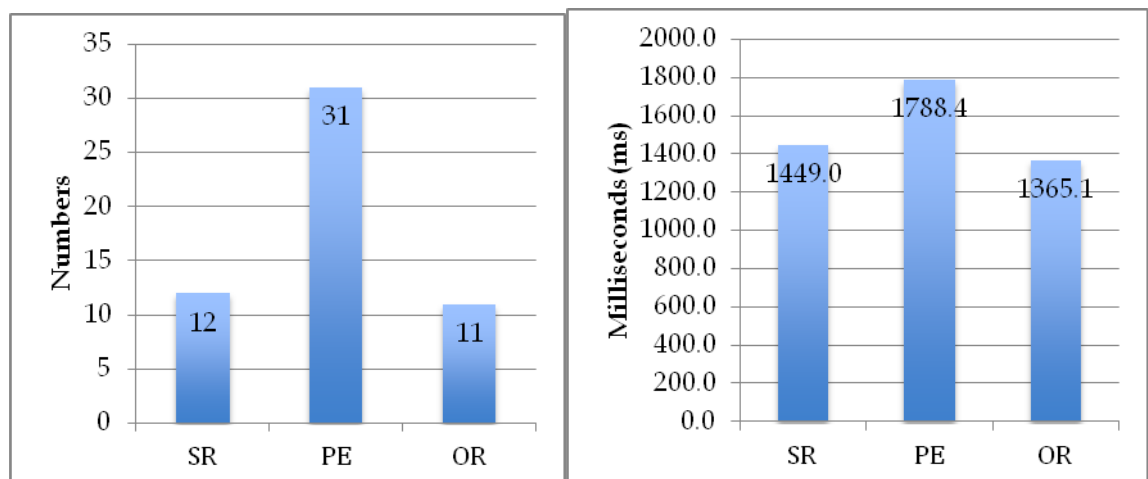
Figures 42 and 43 (left to right): Number of TT Typing + ST/TT Reading Units; Mean Duration of TT Typing + ST/TT Reading Units

6.1.1.6.2 Subjective and Conscious Reflections on the Underlying Purposes

The participants' retrospection data were analysed to infer the possible purposes of the TT typing + ST reading activities in the three tasks. Representative answers to the questions: 'Did you read the ST and the TT while typing the TT in SR, PE and OR?' and 'Why or why not?' in SR, PE and OR are presented in Table 39. The column on the right hand side summarises the purposes of the student translators' TT typing and ST/TT reading activities based on the analysis of their retrospection data.

Retrospection Data (Chinese)	English Translation	Purposes of TT typing + ST/TT Reading Activities
P15: (SR, PE and OR)没有，那么忙能顾的过来么？	P15: (SR, PE and OR) No, I did not. Was it possible to manage it during that hectic time?	- No such activities
P08: (SR, PE and OR) 或许有可能吧，比如修改机器翻译的时候，很多我是又重新翻译的，可能眼睛会很快地扫视原文和译文。看原文可能还是因为想要快速地确定一下自己的理解是无误的，或者也有可能我突然间忘记原文在讲什么了，但更多时候肯定是在看译文。	P08: (SR, PE and OR) Yes, probably. For instance, I retranslated many parts of the ST in PE, so it was possible to type the TT while quickly shifting my gaze between the ST and the TT. The purpose of reading the ST, I think, perhaps was because I would like to quickly confirm that my understanding was correct, or because I suddenly forgot what the ST was talking about. But most of the time I was definitely reading the TT (while typing).	- To confirm the meaning transfer of the ST while typing - To retrieve the ST information while typing
P18: (SR, PE and OR) 应该会，我打字算是比较熟练的，盲打没问题，所以心思主要放在原文的解码和译文的编码上，这样的话就有可能边打字边看原文和译文，但肯定有个先后顺序，谁也不可能左眼看原文右眼看译文对吧？	P18: (SR, PE and OR) Yes, I think I did. I am skilful at typing. I have no problem with touch typing. So I think my attention was mainly focused on the decoding of the ST and the encoding of the TT. In that case, it was possible to type the TT while shifting my gaze between the ST and the TT. But there was definitely an order (in reading the ST and the TT). Nobody could fix their left eye on the ST and the right eye on the TT, right?	- To decode the ST and encode the TT while typing - To shift attention quickly between the ST and the TT while typing - Conscious ST and TT processing in order while typing the TT automatically

Table 39: Retrospection Data for TT Typing + ST/TT Reading Activities

Although the statistics show that 33.3% of the participants in SR, 83.3% of the participants in PE, and 38.9% of the participants in OR carried out TT typing + ST/TT reading activities (see section 6.1.1), only two (P08, P18) stated that they did shift their gaze

between the ST and the TT while typing. From the retrospection data shown in Table 39, it can be seen that the purposes of TT typing + ST/TT reading included:

- Confirmation of the ST meaning transfer while typing and monitoring the emerging TT, which included frequent attentional shifts
- ST information retrieval while typing
  - to remind themselves of the already decoded ST information while typing (owing to the limited capacity of an individual's working memory)
- Simultaneous ST decoding, TT decoding and typing.

Some proficient touch typists are able to multitask while typing. As with the TT typing + ST reading activities, the participants might shift their attention to the ST while typing automatically. With respect to the TT typing + ST/TT reading activities, from the retrospection data shown in Table 39, it could be inferred that the participants shifted their attention to the ST while typing in order to: (1) quickly confirm the ST meaning transfer, and then shifted attention back to the TT to monitor the production process; or (2) retrieve the ST information while producing the new TT segments, owing to the limited capacity of their working memory. The number of this type of parallel activity was very low in all three tasks. It is assumed that professional translators may produce a higher number of parallel activities during the process of revision and post-editing. This needs to be further tested in future research.

6.1.1.7 Type 7: Idle

6.1.1.7.1 Statistical Analysis

As defined by Dragsted (2010), idle units are considered as pauses during which there is no registered activity. If the occurrence of the idle periods was largely owing to the overload on cognitive effort during either ST or TT processing, it would be reasonable to assume that the number of idles would be the highest in PE, and its mean duration would also be the longest. It was hard to predict whether it would be SR or the OR that attracted more and longer idle units because, on the one hand, the number of typing units in OR might be higher than in SR; and on the other hand, the cognitive effort in performing SR might be more intense than in carrying out OR.

As can be seen in Figures 44 and 45 below, the assumption that PE would attract the highest number of idles (n = 135) was confirmed. The mean duration of the idle units (2,461.9 ms) was also the longest compared with SR (n = 71, mean duration: 1,750 ms) and OR (n = 60, mean duration: 1,545.9 ms). According to the one-way ANOVA, the pairwise comparison did not show any significant differences in the mean duration of the three

tasks (F = 2.21, p = 0.1122). Section 6.1.1.7.2 presents the retrospection data and analyses the potential purposes underlying the idle units in all tasks.
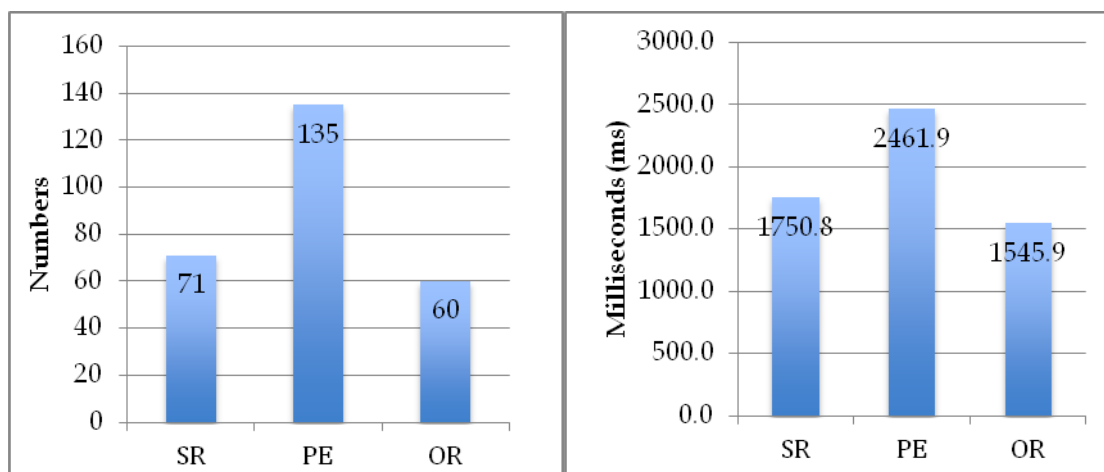
Figures 44 and 45 (left to right): Number of Idle Units; Mean Duration of Idle Units

6.1.1.7.2 Subjective and Conscious Reflections on the Underlying Purposes

The participants' retrospection data were analysed to infer the possible purposes behind their idle activities in three tasks. Table 40 shows the representative answers to the questions: 'Did you focus on anywhere other than the computer screen in SR, PE and OR, during which there was no typing activity going on?' and 'Why or why not?' in all three tasks. The column on the right hand side summarises the purposes of the student translators' idle activities based on the analysis of their retrospection data.

Retrospection Data (Chinese)	English Translation	Purposes of Idle Activities
P02: (SR, PE and OR) 不觉得有，不是说尽量要看着屏幕吗？除非我低头找键盘的时候。	P02: (SR, PE and OR) I do not think so. You told me to try to focus on the screen, didn't you? Unless I had to look at the keyboard (to find certain keys).	- To find keys on the keyboard
P05: (SR, PE and OR) 可能我找具体某一个按键的时候会低头看键盘。	P05: (SR, PE and OR) Perhaps (my eyes were not on the screen) while I was finding a key on the keyboard.	
P04: (SR, PE and OR) 其实从心理学上讲，人思考的时候目光是游离的，有可能眼睛会盯着别处看，我有时可能也会，但实验前你说了要尽可能看屏幕，我也尽量注意了，不过不排除习惯性行为。如果有的话，我觉得更多是在考虑原文怎么翻译，不是自己翻译的译文其实还挺干扰的。	P04: (SR, PE and OR) Psychologically speaking, the eyes are usually drifting when there is something going on in the mind. Probably I would do so sometimes. I tried to focus on the screen as much as possible since you asked me to do so prior to the experiment, but that does not exclude my habitual behaviours. If I did move away my eyes from the screen, it was more likely to happen while I was thinking how to retranslate the ST. The TT is actually quite interferential, especially others' translation.	- To avoid the distraction of the TT - To propose a new translation of the ST segment(s)

P06：(SR, PE and OR) 如果私下里的话，我思考的时候可能会看着别处，或者闭上眼睛去揣摩一下，就是一种习惯，平时也没有太注意这个问题，也觉得不是个问题。实验的时候我比较专注，所以我不太清楚我到底有没有看别处，看了多久。	P06: (SR, PE and OR) If I were not doing an experiment, I would probably look somewhere else or even close my eyes while thinking. That is a habit. I did not pay much attention to this problem in the past. Well, it is not a problem actually. I was concentrating very hard during the experiment, so I was not quite sure whether I moved my eyes away from the screen or not, and if I did, for how long.	

Table 40: Retrospection Data for Idle Units

According to Schilperoord (1996, p. 47), pauses are considered as an indication of a participant searching for the required information in the long-term memory to produce the TT. This was done with the eyes closed in order to avoid the distraction of the ST or the TT. The same explanation was also found in studies on simultaneous interpreting (e.g., Lambert, 2004, p. 304). In translation and post-editing process studies, pauses are considered as an indicator of cognitive processing (e.g., Jakobsen, 2002; Krings, 2001; Alves, 2006; O'Brien, 2006b). Based on this literature, Dragsted (2010, pp. 56-58) proposed two assumptions for the interpretation of pauses: (1) shifting the attention to the keyboard to find the right key; and (2) looking away from the screen or even closing the eyes to avoid the distraction of words on the screen when formulating the translation or decoding the meaning of the ST.

According to the statistics presented in section 6.1.1 of this thesis, 88.9% of the participants in SR, 77.8% of the participants in PE and 83.3% of the participants in OR produced idle units (pauses) during the working process. From the retrospection data above it can be seen that idles tended to occur when the participants had to:

- Find certain keys on the keyboard
- Decode ST information to propose new TT segment(s) while avoiding the distraction of the existing TT.

It can be seen that, in the present study, the participants' self-explanations of their purposes for the pauses are in line with Dragsted's (2010, pp. 56-58) proposals. Since this is the case, the longer duration of idles in SR than in OR can be explained by the fact that SR was more cognitively demanding than OR.

6.2 Reading and Typing Activities within Tasks

In this section, the number and mean duration of all types of activity unit are compared within tasks. Section 6.2.1 presents the statistical analysis. Section 6.2.2 provides a discussion of the findings.

6.2.1 Statistical Analysis

As illustrated in Figure 46, the trend lines for the number of each type of activity unit in all tasks are similar. TT reading attracted the largest number of units, followed by ST reading units, TT typing units, TT typing + TT reading units, idle units, TT typing + ST reading units, as well as TT typing + ST/TT reading units, going from the highest to the lowest (Type 2 > Type 1 > Type 3 > Type 5 > Type 7 > Type 4 > Type 6). The numbers of parallel activities (Types 4 and 6) were much lower than those of other activity units.

	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7
SR	1597	1991	431	16	94	12	71
PE	2795	4048	1083	82	327	31	135
OR	2180	2902	593	34	166	11	60
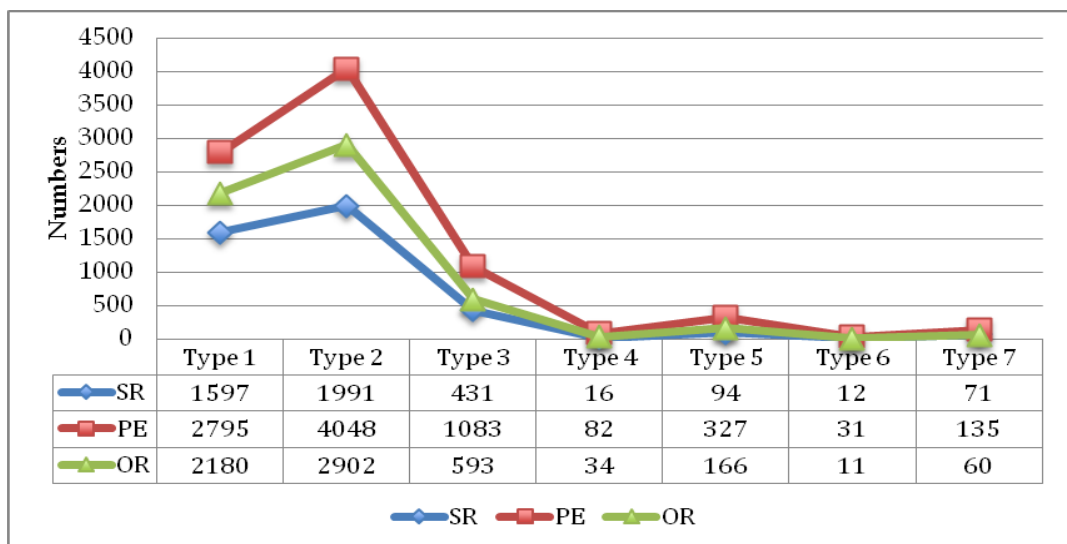
Figure 46: Number of Activity Units in Three Tasks

	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7
SR	2257.2	2960.7	314.8	521.7	949.0	1449.0	1750.8
PE	2201.0	2594.7	274.2	420.5	1164.0	1788.4	2461.9
OR	2091.7	2694.9	283.6	351.6	1021.9	1365.1	1545.9
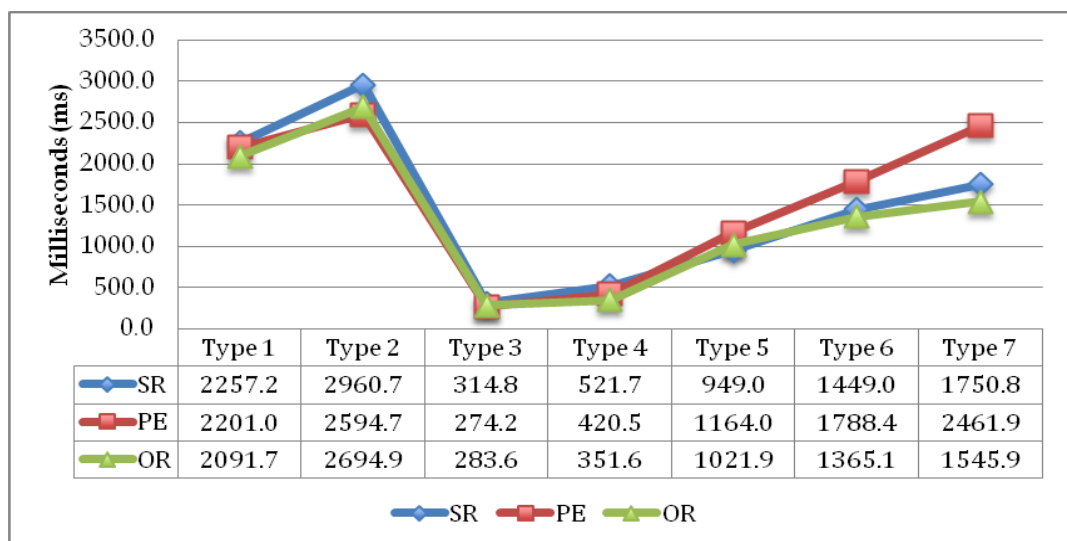
Figure 47: Mean Duration of Activity Units in Three Tasks

With regard to the mean duration of the different types of activity units, the trend lines for all tasks also look similar (Figure 47). The mean duration of the TT reading units was found to be the longest, followed by ST reading units, idle units, TT typing + ST/TT reading units, TT typing + TT reading units, TT typing + ST reading units and TT typing units (Type 2 > Type 1 > Type 7 > Type 6 > Type 5 > Type 4 > Type 3).

In SR, the differences between the mean durations of the seven types of activity were significant (F = 38.19, p < 0.0001). The Tukey-Kramer post hoc tests (Table 41) showed that the mean duration of Type 1 (ST reading) was significantly shorter than that of Type 2 (TT reading), and was significantly longer than that of Type 3 (TT typing), Type 4 (TT typing + ST reading) and Type 5 (TT typing + TT reading): for Types 1 and 2 (t = 5.98, p < 0.0001), for Types 1 and 3 (t = 10.21, p < 0.0001), for Types 1 and 4 (t = 1.97, p < 0.05) and for Types 1 and 5 (t = 3.52, p < 0.001). The mean duration of Type 2 (TT reading) was significantly longer than that of Type 3 (TT typing), Type 4 (TT typing + ST reading), Type 5 (TT typing + TT reading), Type 6 (TT typing + ST/TT reading) and Type 7 (Idle): for Types 2 and 3 (t = 14.21, p < 0.0001), for Types 2 and 4 (t = 2.77, p < 0.05), for Types 2 and 5 (t = 5.44, p < 0.0001), for Types 2 and 6 (t = 1.49, p < 0.05) and for Types 2 and 7 (t = 2.86, p < 0.05). The mean duration of Type 3 (TT typing) was significantly shorter than that of Type 7 (t = 3.2, p < 0.05). For the rest of the comparisons, the differences were not significant.

Tukey-Kramer Test for Differences Between Means			
Group vs. Group (Contrast)	Difference	Test Statistics	p-level
Type 1 Dur vs. Type 2 Dur	-703.51	5.98	**0.0000**
Type 1 Dur vs. Type 3 Dur	1,942.36	10.21	**0.0000**
Type 1 Dur vs. Type 4 Dur	1,735.48	1.97	**0.0488**
Type 1 Dur vs. Type 5 Dur	1,308.14	3.52	**0.0004**
Type 1 Dur vs. Type 6 Dur	808.17	0.8	0.4262
Type 1 Dur vs. Type 7 Dur	506.36	1.19	0.2337
Type 2 Dur vs. Type 3 Dur	2,645.88	14.21	**0.0000**
Type 2 Dur vs. Type 4 Dur	2,438.99	2.77	**0.0056**
Type 2 Dur vs. Type 5 Dur	2,011.65	5.44	**0.0000**
Type 2 Dur vs. Type 6 Dur	1,511.68	1.49	**0.0064**
Type 2 Dur vs. Type 7 Dur	1,209.87	2.86	**0.0043**
Type 3 Dur vs. Type 4 Dur	-206.89	0.23	0.8167
Type 3 Dur vs. Type 5 Dur	-634.22	1.59	0.112
Type 3 Dur vs. Type 6 Dur	-1,134.2	1.11	0.2689
Type 3 Dur vs. Type 7 Dur	-1,436.	3.2	**0.0014**
Type 4 Dur vs. Type 5 Dur	-427.33	0.45	0.6521
Type 4 Dur vs. Type 6 Dur	-927.31	0.69	0.4885
Type 4 Dur vs. Type 7 Dur	-1,229.12	1.27	0.2051
Type 5 Dur vs. Type 6 Dur	-499.98	0.47	0.6417
Type 5 Dur vs. Type 7 Dur	-801.78	1.45	0.1458
Type 6 Dur vs. Type 7 Dur	-301.8	0.28	0.7826

Table 41: Mean Duration Comparison of Seven Types of Activity in SR

With regard to the PE task, the one-way ANOVA also showed a significant difference between the duration of the seven types of activity (F = 93.68, p < 0.0001). The Tukey-Kramer post hoc tests (Table 42) showed that the mean duration of Type 1 (ST reading) was significantly shorter than that of Type 2 (TT reading), and was significantly longer than that of Type 3 (TT typing), Type 4 (TT typing + ST reading) and Type 5 (TT typing + TT reading): for Types 1 and 2 (t = 5.28, p < 0.0001), for Types 1 and 3 (t = 17.76, p < 0.0001), for Types 1 and 4 (t = 5.24, p < 0.0001) and for Types 1 and 5 (t = 5.85, p < 0.0001). The mean duration of Type 2 (TT reading) was significantly longer than that of Type 3 (TT typing), Type 4 (TT typing + ST reading), Type 5 (TT typing + TT reading), Type 6 (TT typing + ST/TT reading) and Type 7 (Idle): for Types 2 and 3 (t = 22.37, p < 0.0001), for Types 2 and 4 (t = 6.43, p < 0.05), for Types 2 and 5 (t = 8.21, p < 0.0001), for Types 2 and 6 (t = 1.48, p < 0.05) and for Types 2 and 7 (t = 0.50, p < 0.05). The mean durations of both Type 3 (TT typing) and Type 4 (TT typing + ST reading) were significantly shorter than those of Type 5 (TT typing + TT reading), Type 6 (TT typing + ST/TT reading) and Type 7 (Idle): for Types 3 and 5 (t = 4.65, p < 0.0001), for Types 3 and 6 (t = 2.74, p < 0.05), for Types 3 and 7 (t = 7.91, p < 0.0001), for Types 4 and 5 (t = 1.99, p < 0.0001), for Types 4 and 6 (t = 2.14, p < 0.05), for Types 4 and 7 (t = 4.81, p < 0.0001). The mean duration of Type 5 (TT typing + TT reading) was significantly shorter than that of Type 7 (t = 4.18, p < 0.0001). For the rest of the comparisons, the differences were not significant.

Tukey-Kramer Test for Differences Between Means			
Group vs. Group (Contrast)	Difference	Test Statistics	p-level
Type 1 Dur vs. Type 2 Dur	-393.73	5.28	**0.0000**
Type 1 Dur vs. Type 3 Dur	1926.75	17.76	**0.0000**
Type 1 Dur vs. Type 4 Dur	1780.52	5.24	**0.0000**
Type 1 Dur vs. Type 5 Dur	1036.94	5.85	**0.0000**
Type 1 Dur vs. Type 6 Dur	412.64	0.75	0.4511
Type 1 Dur vs. Type 7 Dur	-260.86	0.98	0.3289
Type 2 Dur vs. Type 3 Dur	2320.48	22.37	**0.0000**
Type 2 Dur vs. Type 4 Dur	2174.25	6.43	**0.0000**
Type 2 Dur vs. Type 5 Dur	1430.68	8.21	**0.0000**
Type 2 Dur vs. Type 6 Dur	806.37	1.48	**0.0002**
Type 2 Dur vs. Type 7 Dur	132.87	0.50	**0.0064**
Type 3 Dur vs. Type 4 Dur	-146.23	0.42	0.6737
Type 3 Dur vs. Type 5 Dur	-889.81	4.65	**0.0000**
Type 3 Dur vs. Type 6 Dur	-1514.11	2.74	**0.0061**
Type 3 Dur vs. Type 7 Dur	-2187.61	7.91	**0.0000**
Type 4 Dur vs. Type 5 Dur	-743.57	1.99	**0.0471**
Type 4 Dur vs. Type 6 Dur	-1367.88	2.14	**0.0324**
Type 4 Dur vs. Type 7 Dur	-2041.38	4.81	**0.0000**
Type 5 Dur vs. Type 6 Dur	-624.31	1.10	0.2732
Type 5 Dur vs. Type 7 Dur	-1297.80	4.18	**0.0000**
Type 6 Dur vs. Type 7 Dur	-673.50	1.12	0.2647

Table 42: Mean Duration Comparison of Seven Types of Activity in PE

For the task of OR, the one-way ANOVA also showed a significant difference between the duration of the seven types of activity (F = 52.62, p < 0.0001). The Tukey-Kramer post hoc tests (Table 43) showed that the mean duration of Type 1 (ST reading) was significantly shorter than that of Type 2 (TT reading), and was significantly longer than that of Type 3 (TT typing), Type 4 (TT typing + ST reading) and Type 5 (TT typing + TT reading): for Types 1 and 2 (t = 6.60, p < 0.0001), for Types 1 and 3 (t = 12.10, p < 0.0001), for Types 1 and 4 (t = 3.12, p < 0.0001) and for Types 1 and 5 (t = 4.12, p < 0.0001). The mean duration of Type 2 (TT reading) was significantly longer than that of Type 3 (TT typing), Type 4 (TT typing + ST reading), Type 5 (TT typing + TT reading), Type 6 (TT typing + ST/TT reading) and Type 7 (Idle): for Types 2 and 3 (t = 16.59, p < 0.0001), for Types 2 and 4 (t = 4.21, p < 0.05), for Types 2 and 5 (t = 6.50, p < 0.0001), for Types 2 and 6 (t = 1.36, p < 0.05) and Types 2 and 7 (t = 2.73, p < 0.05). The mean duration of Type 3 (TT typing) was significantly shorter than that of Type 5 (TT typing + TT reading) and Type 7 (Idle): for Types 3 and 5 (t = 2.61, p < 0.05) and for Types 3 and 7 (t = 2.89, p < 0.05). For the rest of the comparisons, the differences were not significant.

Tukey-Kramer Test for Differences Between Means			
Group vs. Group (Contrast)	Difference	Test Statistics	p-level
Type 1 Dur vs. Type 2 Dur	-603.23	6.60	**0.0000**
Type 1 Dur vs. Type 3 Dur	1808.09	12.10	**0.0000**
Type 1 Dur vs. Type 4 Dur	1740.10	3.12	**0.0018**
Type 1 Dur vs. Type 5 Dur	1069.80	4.12	**0.0000**
Type 1 Dur vs. Type 6 Dur	726.59	0.75	0.4561
Type 1 Dur vs. Type 7 Dur	545.77	1.29	0.1960
Type 2 Dur vs. Type 3 Dur	2411.31	16.59	**0.0000**
Type 2 Dur vs. Type 4 Dur	2343.32	4.21	**0.0000**
Type 2 Dur vs. Type 5 Dur	1673.03	6.50	**0.0000**
Type 2 Dur vs. Type 6 Dur	1329.82	1.36	**0.0023**
Type 2 Dur vs. Type 7 Dur	1149.00	2.73	**0.0063**
Type 3 Dur vs. Type 4 Dur	-67.99	0.12	0.9048
Type 3 Dur vs. Type 5 Dur	-738.28	2.61	**0.0092**
Type 3 Dur vs. Type 6 Dur	-1081.49	1.10	0.2705
Type 3 Dur vs. Type 7 Dur	-1262.32	2.89	**0.0039**
Type 4 Dur vs. Type 5 Dur	-670.29	1.10	0.2696
Type 4 Dur vs. Type 6 Dur	-1013.50	0.91	0.3650
Type 4 Dur vs. Type 7 Dur	-1194.33	1.73	0.0846
Type 5 Dur vs. Type 6 Dur	-343.21	0.34	0.7325
Type 5 Dur vs. Type 7 Dur	-524.04	1.08	0.2808
Type 6 Dur vs. Type 7 Dur	-180.83	0.17	0.8643

Table 43: Mean Duration Comparison of Seven Types of Activity in OR

6.2.2 Discussion

From the above statistics, we can conclude that:

- Regardless of the task type, all participants spent significantly more time in reading the TT (Type 2) and the ST (Type 1). This is reasonable, as the task

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requirements were to revise or post-edit the texts, and all participants chose to consult the ST during the revision and post-editing process.

- Although in number terms the TT typing activities (Type 3) ranked third amongst the seven types of activity, the mean duration of this type of activity was the shortest, and was significantly shorter than all the other activities. Similarly, the total number of TT typing + TT reading activities (Type 5) ranked fourth, but the mean duration of these activities was the third shortest. This indicates that the time expended on the typing activities (i.e., execution of the changes) during the revision and post-editing processes did not constitute a major proportion of the total. Most of the time was spent on reading activities associated with ST comprehension and TT evaluation, formulation and confirmation.

- The number of the two types of parallel activity (Type 4: TT typing + ST reading; Type 6: TT typing + ST/TT reading) in all tasks was the lowest. This indicates that the student translators did not include much parallel processing during revision and post-editing. We had assumed that professional translators or post-editors might be more proficient at parallel processing, but this needs further investigation as part of a future research project. The mean duration of TT typing + ST/TT reading was only slightly longer than that of TT typing + ST reading. This is probably because the former included attentional shifts during the uninterrupted typing process.

- Although the number of idle units was the third lowest in all tasks, the mean duration of idles was the third longest. Since idles (pauses) could be an indicator of cognitive processing, this might suggest that it took student translators more cognitive effort in formulating the TT than in executing the TT (i.e., the typing activities).

6.3 Summary of Findings

The results and discussions presented in this chapter provide answers to the first two research questions proposed in this study:

RQ1: What types of reading and typing activity can be identified in the self-revision, other-revision and post-editing processes?
RQ2: What are the purposes underlying these activities?

Table 44 below summarises the seven types of reading and typing activities detected in the processes of self-revision, post-editing and other-revision in this study, as well as the percentage of participants who undertook these activities. The number and the mean duration of the activity units are compared both within and across tasks.

Types of Activities	Percentage of Participants			Number of Activity Units across Tasks	Mean Duration of Activity Units across Tasks
	SR	PE	OR		
Type 1: ST reading	100%	100%	100%	PE > OR > SR	SR > PE > OR
Type 2: TT reading	100%	100%	100%	PE > OR > SR	SR > OR > PE
Type 3: TT typing	100%	100%	100%	PE > OR > SR	SR > OR > PE
Type 4: TT typing + ST reading	22.2%	88.9%	66.7%	PE > OR > SR	SR > PE > OR
Type 5: TT typing + TT reading	88.9%	100%	94.4%	PE > OR > SR	SR > OR > PE
Type 6: TT typing + ST/TT reading	33.3%	83.3%	38.9%	PE > SR > OR	SR > OR > PE
Type 7: Idle	88.9%	77.8%	83.3%	PE > SR > OR	SR > OR > PE
Number of Activity Units within All Tasks	Type 2 > Type 1 > Type 3 > Type 5 > Type 7 > Type 4 > Type 6				
Mean Duration of Activity Units within All Tasks	Type 2 > Type 1 > Type 7 > Type 6 > Type 5 > Type 4 > Type 3				

Table 44: Summary of Types of Reading and Typing Activities across Tasks

Table 45 below summarises the potential purposes underlying each type of activity. These purposes were concluded from the retrospection data collected in this study based on Krings (2011) and Hvelplund (2011; 2015). Owing to the limited number of participants, the listings might not be comprehensive. There might be other conscious or unconscious purposes underlying the reading and/or typing activities.

Types of Activities	Purposes	

Type 1:
 	
ST reading
	• ST comprehension and analysis
	   - To extract ST meaning
	   - To confirm accurate understanding of the ST
	   - To confirm accurate meaning transfer of the ST
	   - To generate, test, reject or accept plausible meaning hypotheses of the ST
	
	• Preparation of other processes
	   - To prepare for positive or negative evaluation of the TT
	   - To propose solutions to previously unsolved or newly identified problems
	   - To retranslate the ST	

Type 2:
 	
TT reading
	Reading the existing TT	• TT comprehension and analysis
		   - To extract meaning
		   - To evaluate the translation positively or negatively (problem detection), checking accuracy, fluency, consistency, structure, grammar, equivalence etc.
		   - To propose solutions to the identified problems (decision making)

	Reading the newly produced TT	• Verification of the revision
		   - To compare the newly produced TT with the original (existing) TT
		   - To confirm accurate meaning transfer of the ST
		   - To evaluate the solutions (revisions)

	Reading the entire TT	• Evaluation and verification of the translation
		   - To avoid translation problems (e.g., mistranslation, omission)
		   - To read the TT from a macro-view and check naturalness etc.

Type 3:
 	
TT typing
	• Revision and production of new TT segment(s)
	   - To insert the new TT segment(s)
	   - To delete the inappropriate TT segment(s)
	   - To generate, test, reject or accept the solutions to the problems detected	

Type 4:
 	
TT typing + ST reading
	• ST analysis
	   - To confirm the ST meaning transfer of obscure or difficult parts
	   - To generate, test, reject or accept better translation options
	• TT reformulation
	   - To produce TT segments	

Type 5:
 	
TT typing + TT reading
	• TT formulation
	   - To formulate the subsequent TT segments
	   - To test the TT hypothesis by typing it out and evaluating
	• TT execution
	   - To type the TT segments
	• TT monitoring
	   - To avoid typing errors
	   - To avoid incorrect ST meaning transfer
	• TT evaluation
	   - To evaluate the structure, lexical choice, fluency, accuracy and naturalness of the TT	

Type 6: **TT typing + ST/TT reading**	• Confirmation of the ST meaning transfer while typing and monitoring the emerging TT • ST information retrieval while typing - To remind themselves of the already decoded ST information while typing • Simultaneous ST decoding, TT decoding and typing	
Type 7: **Idle**	• To find certain keys on the keyboard • To decode ST information to propose new TT segment(s) while avoiding the interference of the existing TT	

Table 45: Summary of the Underlying Purposes of All Activity Units

This chapter has explored the seven different types of reading and typing activity in the processes of self-revision, other-revision and post-editing. The number and mean duration of each type of activity were compared both within and across tasks. Examples of cue-based retrospection data were represented and analysed to show the potential purposes behind these activities. The following chapter, Chapter 7, investigates the different working phases in self-revision, other-revision and post-editing, and reports the sequences of reading and typing activities detected in each working phase. In addition, it also presents the four basic types of working style that were discovered in this study, as well as the student translators' personal working styles in all tasks.

Chapter 7

Working Styles of Student Translators

This chapter examines the third and fourth research questions posed in this study: 3) What are the working styles of student translators in performing self-revision, other-revision and post-editing, and 4) how do the working styles of student translators vary within and across tasks?

The third question, concerning the working styles of student translators, was explored through observing and analysing the 54 generated ProgGraphs (see section 5.2.2). This was done by first identifying the working phases in the SR, PE and OR process (section 7.1). Secondly, ProgGraphs are presented as a visualisation tool to demonstrate the sequences of the reading and typing activities in each working phase. Since it was impossible to exhibit all participants' ProgGraphs to compare their reading and typing behaviour, these sequences were transcribed based on a coding system to interpret the sequential activity data in each working phase. These sequential activities were then summarised and categorised, and the frequency of each type of sequential activity was calculated. By scrutinising all the participants' retrospection data, the purposes behind the sequential reading and typing activities in each working phase were identified and analysed to infer the cognitive processes used in SR, PE and OR (section 7.2). Thirdly, based on the findings of the three working phases, the sequences of the reading and typing activities in each phase and the purposes behind each sequential activity, four types of working style in SR, PE and OR were identified: Macro-Micro-Macro processing, Micro-Macro processing, Macro-Micro processing and Micro-processing (sections 7.3.1 – 7.3.4).

The fourth question, the variation in student translators' working styles within and across tasks, was investigated by statistically comparing the frequency of each working style in all tasks (section 7.3.5), and by examining the working styles adopted by each individual across tasks. Three types of revisers were identified: habit-oriented revisers, task-oriented revisers and in-between habit- and task-oriented revisers (section 7.3.6).

Section 7.4 concludes this chapter.

7.1 Working Phases

As discussed in section [2.1.1.1](#), Jakobsen (2003, p. 192) distinguished three working phases in the translation process: orientation (the reading phase before the first keystroke is made), drafting (the translation phase) and revision (a phase when changes are made after the drafting phase). By observing the ProgGraphs of the 54 recorded sessions (3 tasks * 18 participants) in the present study, three working phases were also identified in the student translators' self-revision, other-revision and post-editing processes. However, the definition of the first phase in this study is slightly different from Jakobsen's definition of the orientation phase.
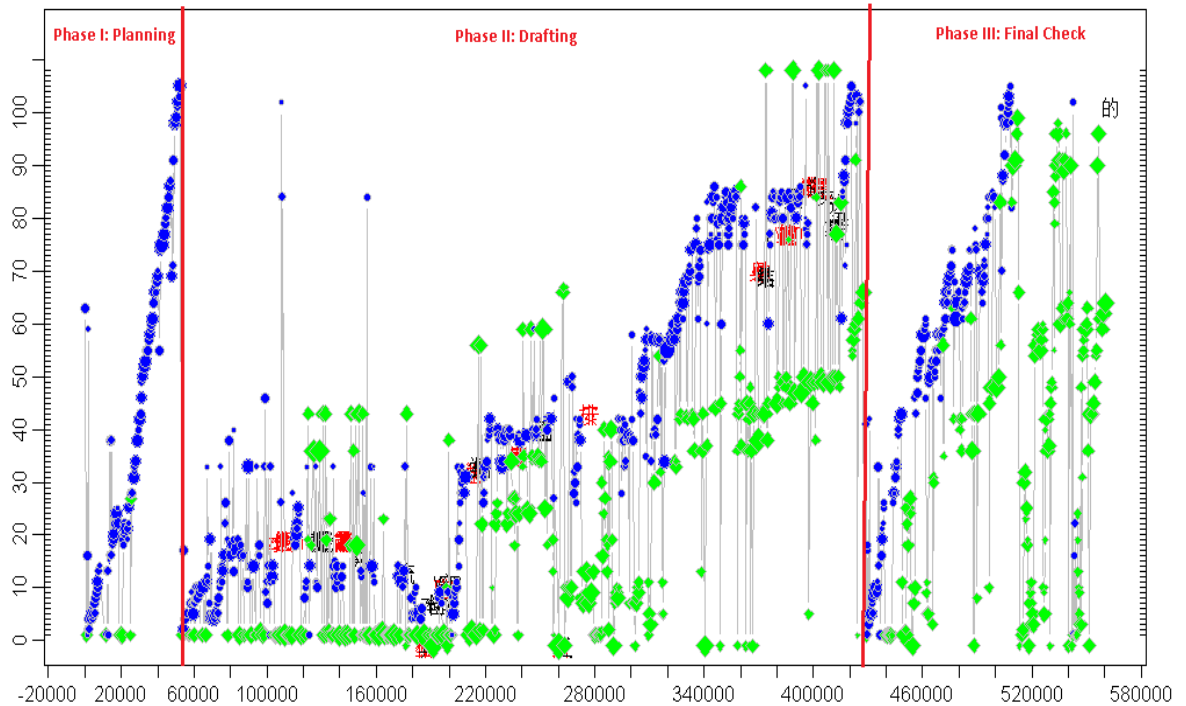
Figure 48: Working Phases (P07's Other-revision ProgGraph)

Figure 48 is an other-revision ProgGraph produced by participant P07. In this graph, the x-axis represents the task time in milliseconds (ms); the y-axis shows the aligned ST and TT information in order. The blue dots stand for ST reading activities; the green diamonds represent TT reading activities, and the black and red symbols represent insertions and deletions respectively.

From Figure 48 it can be seen that, from 0 to 58000 ms (Phase I), the participant was reading through the ST at text level (Unilingual ST reading). Then from 58000 ms to 428000 ms (Phase II), the participant conducted comparative readings and made actual changes at sentence level (the first sentence: X = 58000 – 200000, Y = 0 – 30; the second sentence: X = 200000 – 315000, Y = 30 – 60; the third sentence: X = 315000 – 428000, Y = 60 - 100). From 428000 ms (Phase III), the participant headed back to the very beginning of the

ST, read the ST with the TT text basis (see section 2.4.1.4.2) comparatively without making any changes, followed by two quick unilingual TT readings with one insertion.

In the translation process, translators need to produce the TT from scratch after the initial reading activities. Thus Jakobsen (2003) defines the orientation phase as the reading phase before the first keystroke is made. Unlike translation, the tasks of revision and post-editing are to read, detect problems and make changes when necessary. Therefore, it is inappropriate to follow Jakobsen's definition of 'orientation', as it might happen that the reviser only makes a few keystrokes at the end of the entire session, or makes no keystrokes at all if taken to the extreme.

In this study, the first phase of revision and post-editing usually included a quick unilingual reading of the ST and/or the TT at text or sentence level. This was an initial comprehension phase by an individual, who aimed to get a general view of the ST or the TT itself and plan for the more detailed revisions. This phase is thus defined as the 'planning' phase in the present study. The second phase is equivalent to Jakobsen's drafting phase, where participants read the ST and the TT comparatively in smaller chunks (e.g., a segment) and made changes. It is defined as the 'drafting' phase, in which the most intense activity takes place. The 'final check' phase comes after the drafting phase, where participants head back to the very beginning of the ST or the TT to quickly read and revise the TT again. The TT might be run through one or several times in this phase, and the purpose is to give the TT a final check, or to solve any unsolved problems before submission. This is in line with Shih's (2006b) findings that usually the first run-through of the text during the revision process is more intense (the drafting phase), and later run-throughs tend to be quicker, since the more a translator revises, the more familiar s/he becomes with the TT and the longer the chunks of text s/he can process at a time. The present study also confirms Shih's (2006b) finding that some translators have a re-checking phase (final check phase) at the end of the revision process, with the aim of justifying the changes they have made and reassuring themselves that all problems have been sorted out.

However, it should be noted that the participants' revision and post-editing procedures varied from one to another. The planning phase and the final check phase were optional for some of the participants in this study. As discussed in sections 2.3.3 and 2.4.1.4.3, working phases can be seen as the global plans that the student translators made to carry out the tasks of revision and post-editing. The differences in global plans affected the local plans (i.e., the sequences of the reading and typing activities) of the student translators.

Section 7.2 presents the sequences of the reading and typing activities in each phase across tasks in detail.

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7.2 Sequences of Reading and Typing Activities

Since it was not feasible to present all 54 ProgGraphs in this thesis, a coding system was created to interpret the sequences of the reading and typing activities in each working phase. The abbreviation of each code and its meaning are summarised in Table 46.

Codes	Meaning
Uni	Unilingual reading
Bi	Bilingual reading (comparative reading)
ST	The source text
TT	The target text
t	Reading at text level
s	Reading at sentence level
seg	Reading at segment level (a segment is smaller than a sentence in size)
R	Revision (insertions and/or deletions)

Table 46: Coding System

It should be clarified that in this study, a segment is considered as a piece of the text, the size of which is smaller than a sentence. A segment could be a word, a phrase or a sub-clause in a sentence. Each ST sentence contains approximately 33 words. The reading was considered as being at text level only if 80% of the text (2.5 sentences) was read. Otherwise, the reading was considered as being below text level.

The reading and/or typing activities can be made up of more than one of the following codes. For example, 'UniTTsR' refers to: unilingual TT reading at sentence level with revision. A sequence of the reading and typing activity can be composed of several reading and typing activities. For instance, 'UniTTsR - BitR' refers to two activities: (1) unilingual TT reading at sentence level with revision, followed by (2) bilingual (comparative ST and TT) reading at text level with revision. The types of reading and typing sequence in each phase are interpreted below, along with the relevant graphs as illustration. The coding system used in this chapter is for the identification of working style only.

7.2.1 The Planning Phase and Coding

The planning phase usually encompasses reading activities only, the aim of which is to get an overview of the ST or the TT. As defined by Dragsted and Carl (2013, p. 142) for the translation process, in this phase quick planners read the ST at sentence level, systematic

planners read the ST at text level, and head-starters do not have a planning phase. They start to translate as soon as they receive the ST. In this study, it was found that not all the participants had a planning phase during the self-revision, other-revision and post-editing processes.

7.2.1.1 Self-revision

In the process of self-revision, five out of 18 participants (27.8%) had a planning phase, of whom two read the ST at sentence level (e.g., P02 in Figure 49), and three read the ST at text level (e.g., P04 in Figure 49).

The codes for these two types of reading activity are:

- UniSTs: a unilingual ST reading at sentence level (e.g., P02)
- UniSTt: a unilingual ST reading at text level (e.g., P04)
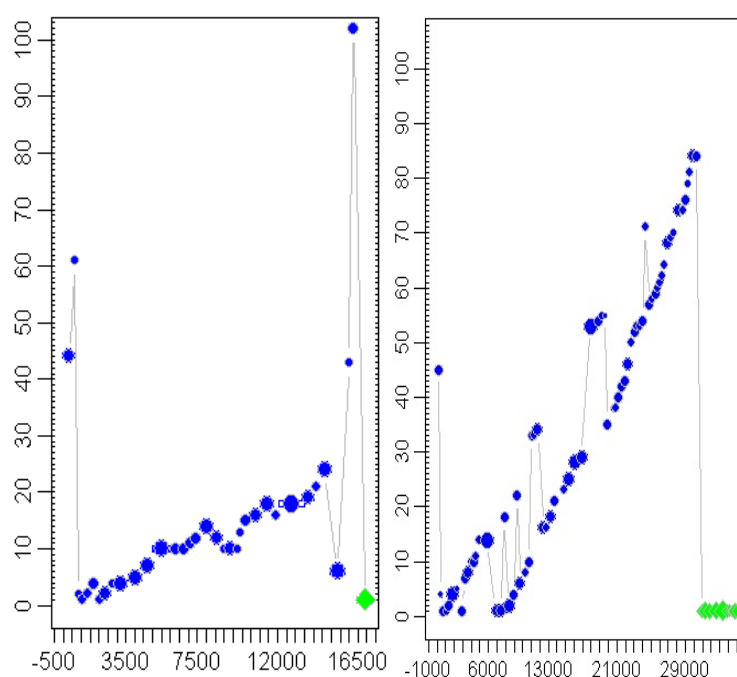
Figure 49: Planning Phase in SR (Left to Right: P02, P04)

7.2.1.2 Post-editing

In the process of post-editing, 11 out of 18 participants (61.1%) had a planning phase, of whom three read the ST at sentence level (e.g., P11 in Figure 50); eight read the ST at text level (e.g., P04 in Figure 50), and one read the TT at text level (e.g., P07 in Figure 50).

The codes for these three types of reading activity are:

- UniSTs: a unilingual ST reading at sentence level (e.g., P11)
- UniSTt: a unilingual ST reading at text level (e.g., P04)
- UniTTt: a unilingual TT reading at text level (e.g., P07).
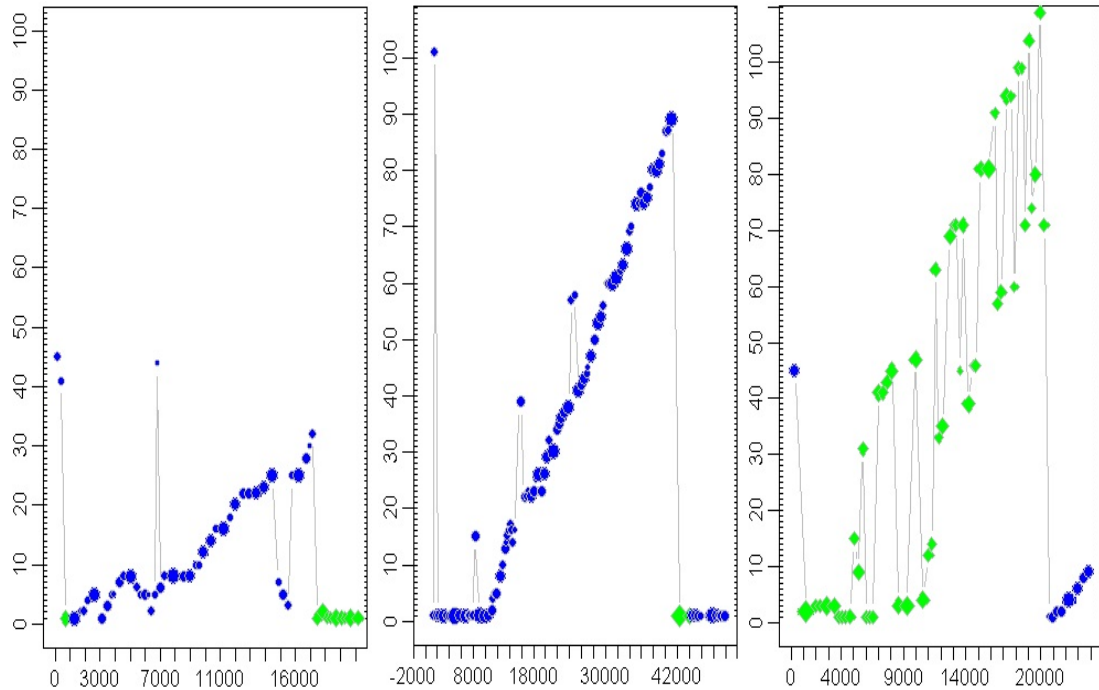
Figure 50: Planning Phase in PE (Left to Right: P11, P04, P07)

7.2.1.3 Other-revision

In the process of other-revision, 10 out of 18 participants (55.6%) had a planning phase, of whom two read the ST at sentence level (e.g., P11 in Figure 51); six read the ST at text level (e.g., P02 in Figure 51); one read the ST and then the TT at text level (e.g., P04 in Figure 51), and one read the TT first and then the ST at text level (e.g., P07 in Figure 51).

The codes for these four types of reading activity are:

- UniSTs: a unilingual ST reading at sentence level (e.g., P11)
- UniSTt: a unilingual ST reading at text level (e.g., P02)
- UniSTt + UniTTt: a unilingual ST reading at text level, followed by a unilingual TT reading at text level (e.g., P04)
- UniTTt + UniSTt: a unilingual TT reading at text level, followed by a unilingual ST reading at text level (e.g., P07).

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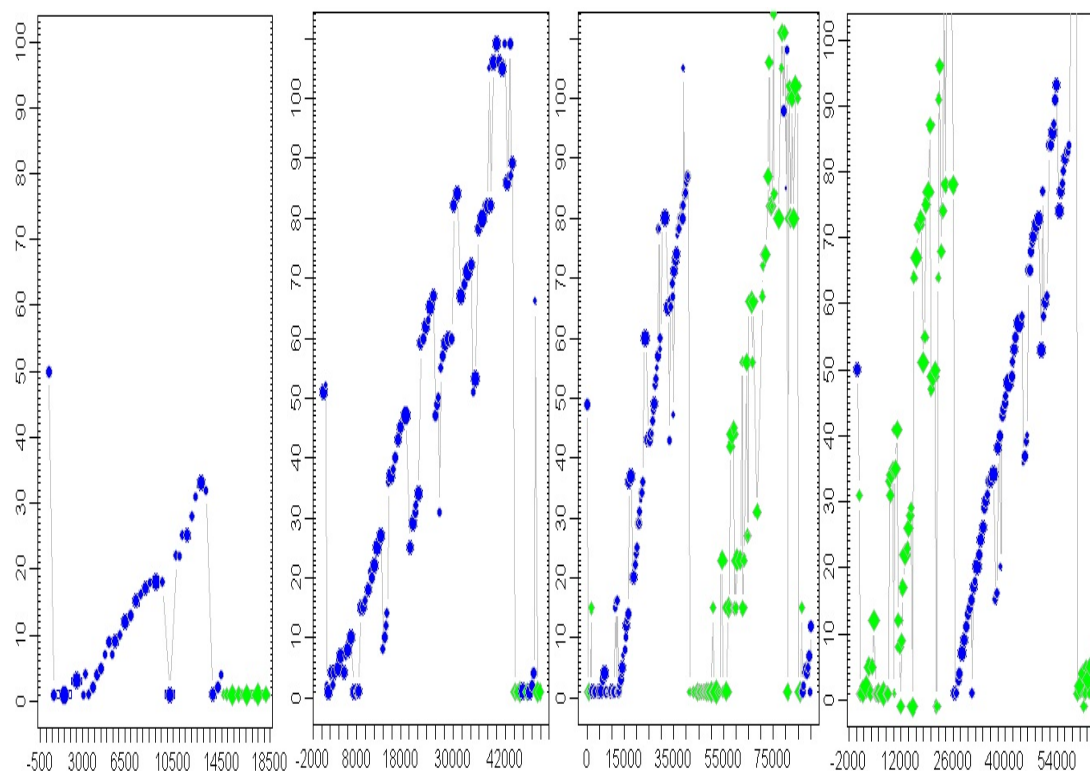
Figure 51: Planning Phase in OR (Left to Right: P11, P02, P04, P07)

From the above statistics it can be seen that the percentage of the participants with a planning phase was higher in PE (61.1%) than in OR (55.6%) and SR (27.8%). By calculating the reading at the different levels, it was found that, in all three tasks, more participants read the ST at text level than at sentence level. Only 5.6% of the participants read the TT at text level in PE. In OR, 11.2% of the participants read both the ST and the TT at text level separately. Half of them read the ST first and then the TT, the other half read the TT first and then read the ST (cf. Figure 52).

	SR	PE	OR
■ UniSTs	11.1%	16.7%	16.7%
■ UniSTt	16.7%	44.4%	33.3%
■ UnitTTt	0.0%	5.6%	0.0%
■ UniSTt + UniTTt	0.0%	0.0%	5.6%
■ UniTTt + UniSTt	0.0%	0.0%	5.6%
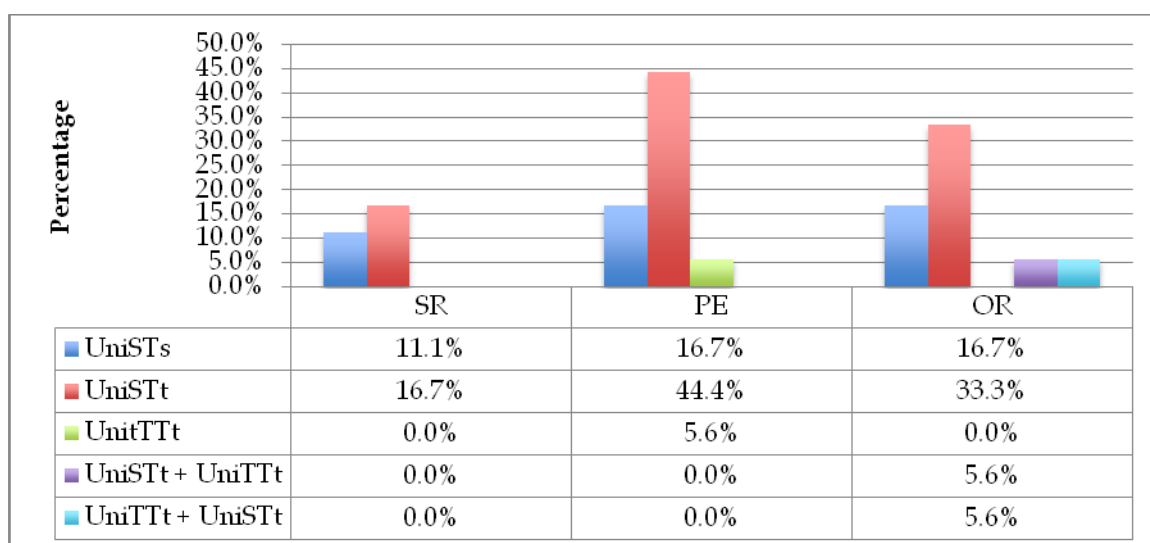
Figure 52: The Planning Phase across Tasks

In contrast to Krings (2011, pp. 324-327), who concluded that the post-editing process usually starts with the entire reading of the ST to get an overview of the ST and to prepare for the localised text analysis, the present study found that, although most participants read the ST at text level, there were also some participants who read the ST at sentence level.

Also contrary to Mossop's (2014, pp. 168-169) suggestion – that the ST should always be read last in all circumstances – and unlike the findings of Shih (2006a, 2006b) and Rasmussen and Schjoldager (2011) – that professional translators do not refer back to the ST on a regular basis in the revision process – the present study found that almost all the student translators read the ST first, with the exception of one participant (P07) who read the TT at text level at the beginning of post-editing and two participants (P04, P07) who carried out two unilingual readings of the ST and the TT. The disparity in the above findings might be owing to the participants' different levels of expertise.

Section 7.2.1.4 presents the participants' retrospection data and analyses the potential purposes underlying the reading activities in the planning phase in all tasks.

7.2.1.4 Subjective and Conscious Reflections on the Underlying Purposes

After the experiment session, the participants were first asked to describe and comment on their revision and post-editing processes with the replay of their eye movements as a cue for retrospection. After their retrospection, the researcher asked two questions related to the research questions of this study based on the post-experiment questionnaire: 'Can you describe how you revise the TT?' and 'Why do you read the ST/TT in this phase in such a way?'. Table 47 below presents the representative answers to these questions in three tasks. The column on the right hand side summarises the purposes of the student translators' sequential activities in the planning phase based on the analysis of their retrospection data.

	Retrospection Data (Chinese)	English Translation	Purposes of Sequential Activities in the Planning Phase
UniSTs	P02: (SR) I did not need to reread the entire ST as I translated it yesterday and knew what the text was about. Today I reread the ST at sentence level to re-comprehend it and revise the corresponding TT.	- ST comprehension in the translation phase - Sentence by sentence ST reading for comprehension and preparation of revision	- ST comprehension in the translation phase - Sentence by sentence ST reading for comprehension and preparation of revision
	P11: (PE) I assumed the quality of the machine translation would be low and I would need to retranslate it, so I read and revised at sentence level.	- Carrying out PE on the assumption that the quality of the MT text is low - Sentence by sentence ST reading for comprehension and preparation of PE	- Carrying out PE with an assumption that the quality of the MT text is low - Sentence by sentence ST reading for comprehension and preparation of PE
UniSTt	P04: (PE) To comprehend the entire ST. I assumed the machine translation would be problematic; therefore, I tried to avoid the TT and comprehend the ST on my own. Otherwise, I would be influenced by the TT, and that would make the task even harder.	- Carrying out PE on the assumption that the quality of the MT text is low - Reading the entire ST for comprehension, avoiding the influence of the TT	- Carrying out PE with an assumption that the quality of the MT text is low - Reading the entire ST for comprehension, avoiding the influence of the TT
UniTTt	P07: (PE) The task was to 'revise' right? That is why I read the TT as a whole to evaluate it from the perspective of a target reader, to find problems and to think about the solutions. After reading the TT, I felt that I might need to retranslate it. Then I began to read and revise at sentence level.	- Realising that the task was to post-edit - Reading the entire TT to evaluate its quality as a target reader, to detect problems and propose solutions	- Realizing that the task was to post-edit - Reading the entire TT to evaluate its quality as a target reader, to detect problems and propose solutions
UniSTt + UniTTt	P04: (OR) I read and comprehended the entire ST first to get a general view of its content. Then I read the entire TT to check whether his/her understanding of the ST was the same as mine, and whether there were any language problems.	- Reading the entire ST to get a general view of the ST content - Reading the entire TT to check the meaning transfer of the ST in the TT and the TT language problems	- Reading the entire ST to get a general view of the ST content - Reading the entire TT to check the meaning transfer of the ST in the TT and the TT language problems
UniTTt + UniSTt	P07: (OR) I usually read and evaluate the entire TT from the perspective of a target reader, to check the language problems, such as naturalness. Then I read the ST on the whole to check whether the TT was in line with that of the ST from a macro-view, such as the style.	- Evaluating the TT as a target reader to check language problems - Reading the entire ST to check the its equivalence to the TT from a macro-view	- Evaluating the TT as a target reader to check language problems - Reading the entire ST to check the its equivalence to the TT from a macro-view

Table 47: Retrospection Data for the Underlying Purposes in the Planning Phase

The descriptions in Table 47 above show that the participants had different understandings of the tasks and used various strategies to process the texts.

The purposes of reading the ST at sentence level included:

- To comprehend the sentence and prepare for detailed revision or post-editing

The purposes of ST reading at text level included:

- To get a general view of the ST content
- To avoid the influence of the TT
- To compare the TT with the ST from a macro-view (e.g., style)

The purposes of TT reading at text level included:

- To evaluate its quality from the perspective of a target reader
- To detect language problems
- To check ST meaning transfer

The purposes of reading the ST and then the TT at text level included:

- ST reading for comprehension
- TT reading for the checking of the ST meaning transfer and TT language problems

The purposes of reading the TT and then the ST at text level included:

- TT reading for the checking of TT language problems
- ST reading for ST and TT comparison in terms of language style.

The purposes of ST reading identified in this study were in line with Krings (2001, pp. 324-327) proposal, namely, to get a general view of the ST content and to prepare for localised analysis or revisions. However, contrary to Mossop's (2014, p. 168) warning that reading the ST at the beginning may influence one's judgement of the quality of the translation, some participants stated that they read the ST first to try and avoid the influence of the existing TT. In SR, no TT reading at sentence or text level was detected. This shows that all the participants tried to re-comprehend the ST and to compare their newly decoded ST information with what had been translated previously. In PE, most of the participants read the ST at text level, the purpose of which was to get a clearer overview of the ST. Only one participant stated that the task of PE was to repair the TT, so s/he read the TT at text level. In OR, the majority of the participants read the ST at sentence or text level. Two participants conducted two unilingual readings of the ST and

the TT at text level. As can be seen from the above list of purposes, different reading orders of the ST and the TT at text level indicated dissimilar mental activities.

The above purposes were primarily summarised from the retrospection data collected for this study. Further investigations are needed to identify more diverse reading patterns in the planning phase and the corresponding purposes.

7.2.2 The Drafting Phase and Coding

By observing all the ProgGraphs, it was found that all the participants had a drafting phase, during which intense reading and typing activities took place. This section first presents the sequences of the reading and typing activities in the drafting phase (section 7.2.2.1), and then compares the reading behaviours in SR, PE and OR based on the translator styles identified by Dragsted and Carl (2013) (section 7.2.2.2). Section 7.2.2.3 analyses the participants' revision and post-editing processes in the drafting phase, and presents a tentative model of the physical and mental activities that occur in the drafting phase during self-revision, post-editing and other-revision.

7.2.2.1 Sequences of the Reading and Typing Activities

The activity unit data (CU) were used to analyse the sequential orders of the reading and typing activities in the three tasks. Since there were hundreds of sequential reading and typing events in the drafting phase (e.g., Figure 53), it is not possible to identify and discuss them all. However, by analysing the sequential orders of the reading and typing activities, it was found that, generally, in the drafting phase, all the participants read the ST and the TT comparatively and made changes at sentence level when necessary in all tasks. Two samples of data (Figure 53 and 54) are presented and analysed below as evidence of this.
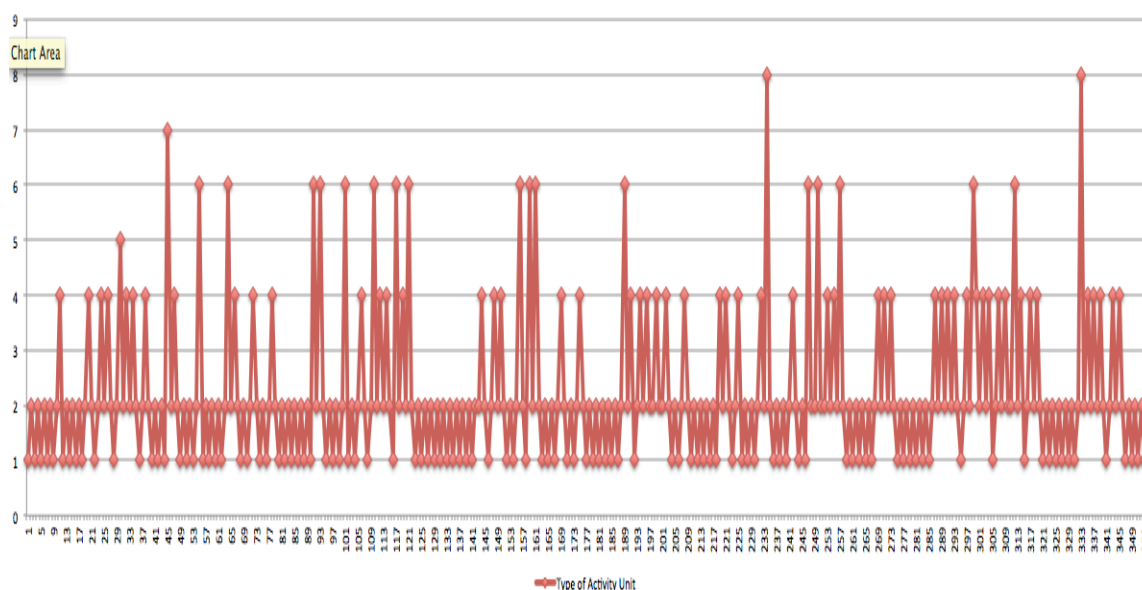
Figure 53: Sequences of Activity Units in the Drafting Phase

Figure 53 is a sample of the activity unit data, which shows the sequential order of the reading and typing activities in the drafting phase. In this graph, the X-axis represents the number of the activity unit (e.g., CU37); the Y-axis represents the types of activity unit as defined by Carl (2015): 1 for ST reading, 2 for TT reading[50], 4 for TT typing, 5 for TT typing + ST reading, 6 for TT typing + TT reading, 7 for TT typing + ST/TT reading and 8 for Idle. Each red diamond represents an activity unit.

From Figure 53 it can be seen that most of the shifts were between 1 and 2 (ST reading and TT reading), which indicates comparative reading of the ST and the TT. TT typing activities 4) normally occurred after comparative reading of the ST and the TT (e.g., CU9). TT typing + ST reading (5) and TT typing + ST/TT reading (7) only appeared once each (CU33 and CU45). The frequency of occurrence of TT typing + TT reading activities (6) was higher than that of TT typing + ST reading (5) but lower than that of TT typing activities (4). Idle units (8) appeared twice in this session.

According to Mossop (2014, p. 166), comparative (bilingual) reading tends to have a micro-focus nature, the purpose of which is mainly to check ST meaning transfer problems. He (2014, pp. 167-169) suggests reading the TT alone first and then reading the texts comparatively to avoid the influence of the context knowledge of the ST. However, since not all the participants had a planning phase, some of them started the revision and post-editing process by comparative reading. Mossop (2014, pp. 168-169) also suggests reading the TT first in comparative reading; however, the data obtained for the current study showed that some participants started revising or post-editing by reading the ST first. For instance, the first activity in Figure 53 was ST reading (type 1).

There is an urgent need for empirical evidence to confirm the effect of reading order on the quality and duration of revision or post-editing. If the actual revision order of the student translators identified in this study were compared with Mossop's (2014) suggestions regarding the most efficient order of revision operations, the findings of this study would provide evidence of areas the student translators needed to work on, which would be useful for translator training.

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[50] Type 3 (source text reading and target text reading) was omitted, as this activity was not detected in the translation processes in Carl and Schaeffer (2014).
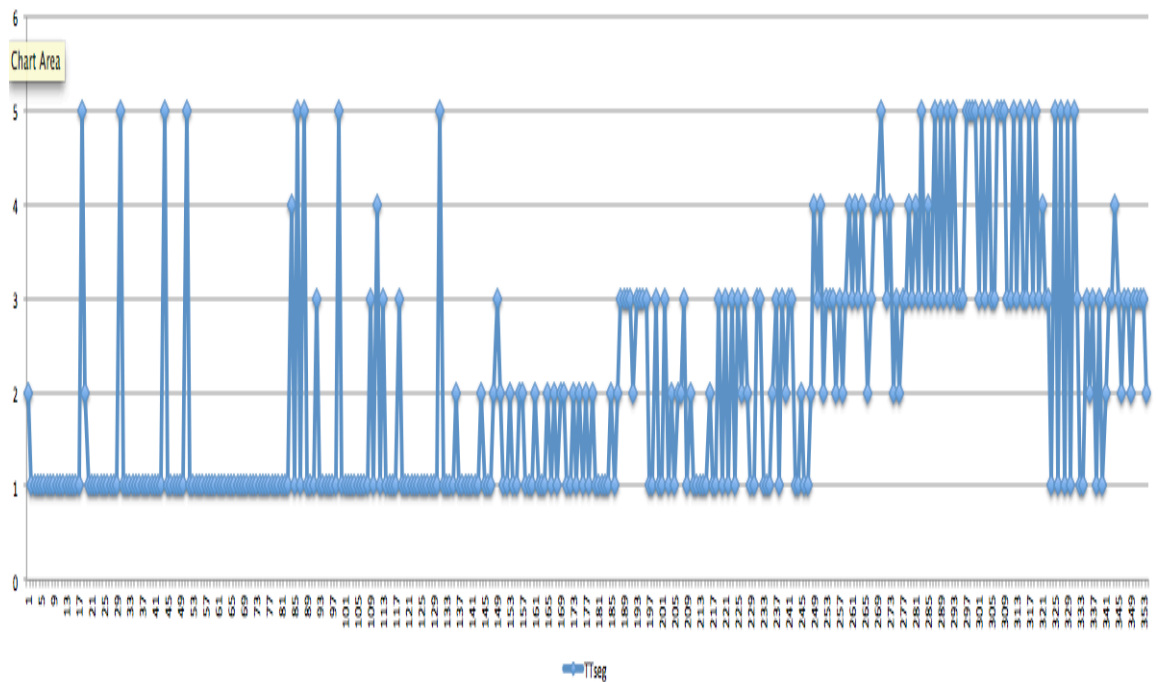
Figure 54: Sentence-by-Sentence TT Processing in the Drafting Phase

Figure 54 above is a sample of the TT processing procedure in the drafting phase. In this graph, the X-axis represents the number of the activity unit; the Y-axis represents the number of the TT sentence, e.g., 1 for the first TT sentence, 5 for the fifth TT sentence. Each blue diamond represents an activity unit (CU).

In Figure 54, it can be seen that, from CU1 to CU137, most of the activities were focused on the first TT sentence. It is noticeable that sentences 3, 4 and 5 attracted some of the activity during this period. After scrutinising the data, it was found that all these activities were noise data caused by eye drift – incorrect landings of the gaze during the shifting between the ST window and the TT window (see section 2.3.2.1). The evidence shows that the durations of these reading activities were much shorter than those of the normal reading activities. For instance, the duration of CU43 was 140 ms (CU43-S:5-T:1-D:140), while the duration of CU286 was 4527 ms (CU286-S:5-T:1-D:4527). Both of these activities were focused on the processing of the ST segments which were aligned with the fifth TT sentence.

From CU138 to CU189, the attention shifted to the processing of the second TT sentence, while there were many re-readings of the first sentence. This might have happened when the participant was working on the cohesion between the sentences, or reading both sentences to identify problems and/or to find solutions.

From CU190 to CU249, the participant was working on the third TT sentence. The first two sentences were also reread interchangeably.

From CU250 to CU281, the participant was mainly working on the fourth TT sentence, with frequent re-readings of the third sentence and some re-readings of the second sentence.

From CU282 to CU325, the participant was working on the fifth TT sentence. The third sentence was also reread. The rest of the CU segments belong to the final check phase.

Figure 54 indicates that, in the drafting phase, all the participants revised or post-edited the TT at sentence level. Re-readings of the TT were likely to happen when the student translators were uncertain about the revisions they had just made. Mossop (2014, p. 180) suggests that, in order to help one focus on micro-linguistic problems, one should read the text backwards, starting to revise from the last sentence. However, this activity was not found in any of the revision or post-editing sessions in the present study.

7.2.2.2 Different Reading Behaviours across Tasks

The participants' ProgGraphs were used to analyse their coordination of the reading and typing activities in the drafting phase across tasks. By observing all ProgGraphs, it was found that although all the participants read the ST and the TT comparatively and made changes at sentence level in all tasks, the reading behaviours in SR, PE and OR were slightly different. Three sample ProgGraphs: SR ProgGraph (Figure 55), PE ProgGraph (Figure 56) and OR ProgGraph (Figure 57), are presented below to demonstrate the student translators' different reading patterns in the three tasks.
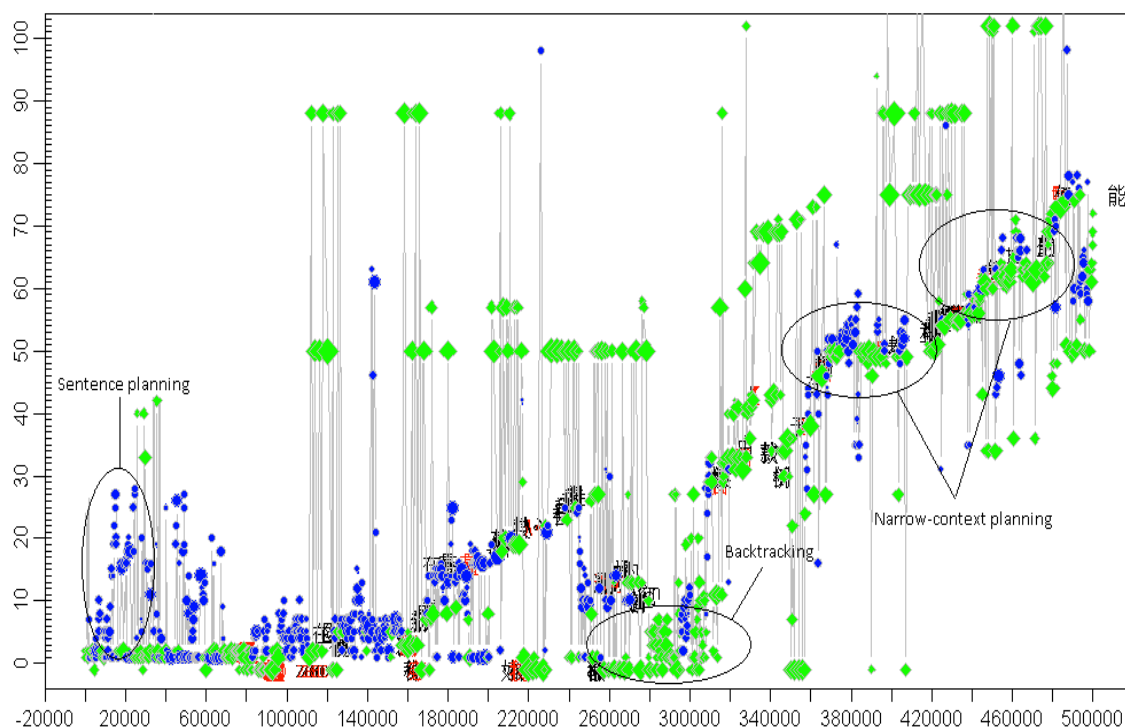
Figure 55: Sample SR ProgGraph in the Drafting Phase

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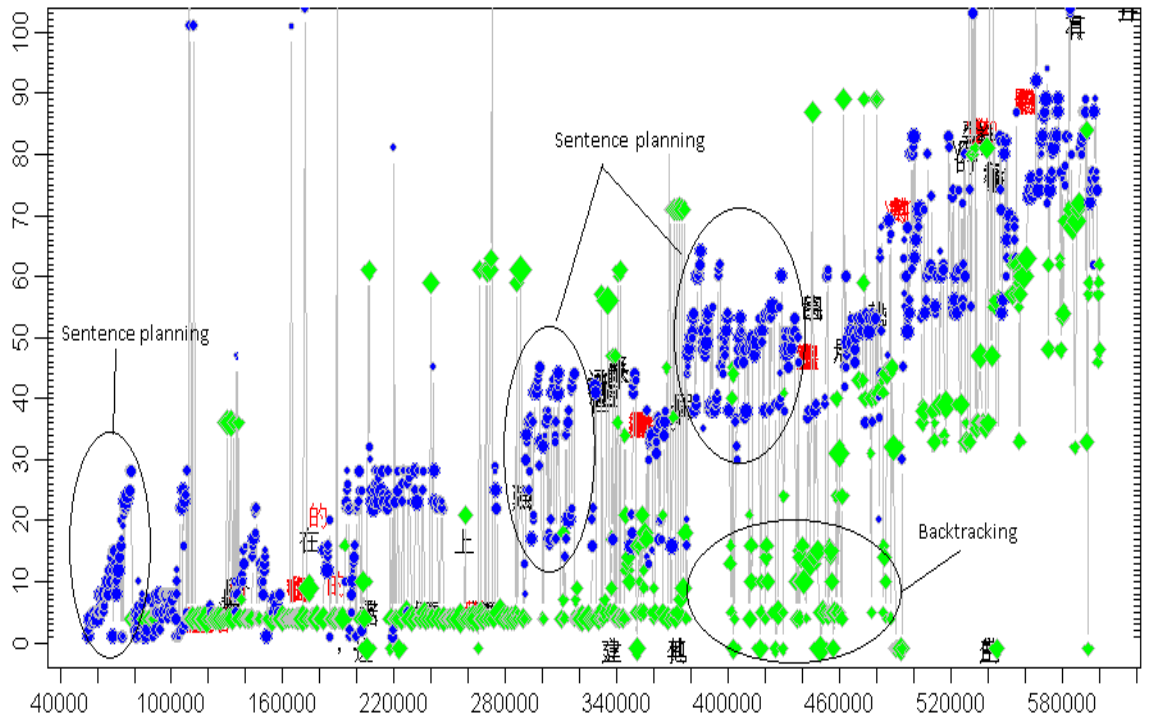
Figure 56: Sample PE ProgGraph in the Drafting Phase
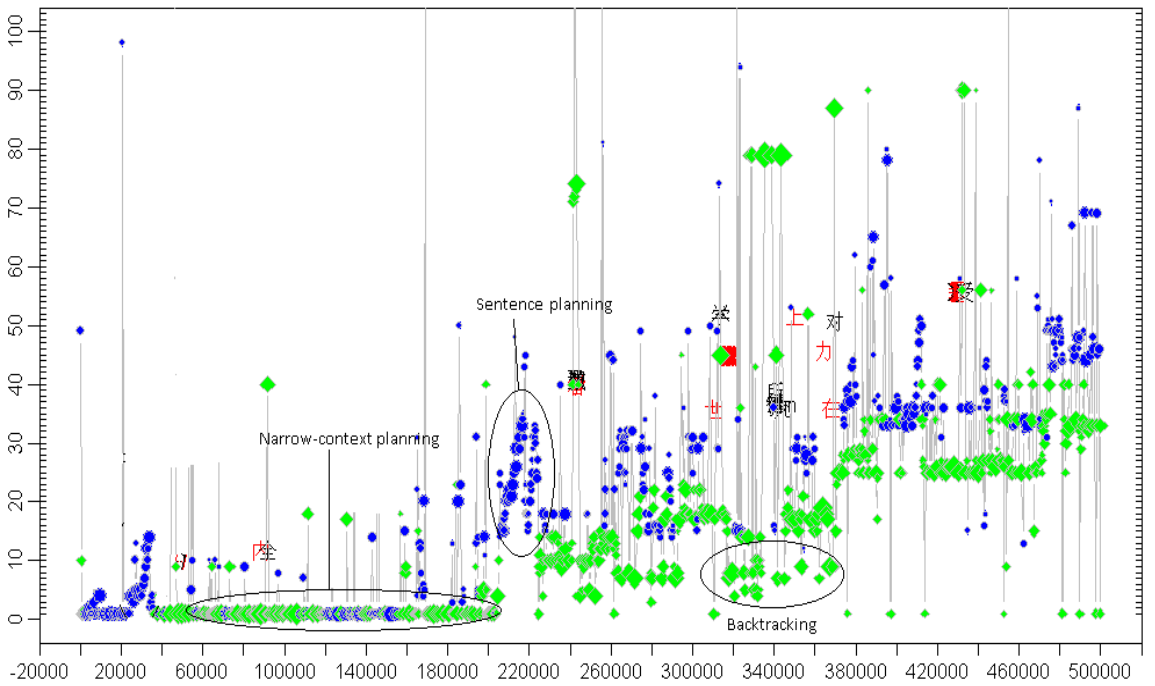
Figure 57: Sample OR ProgGraph in the Drafting Phase

As discussed in section 2.1.3, Dragsted and Carl (2013, p. 144) identified several types of translation (translator) styles by observing the translation ProgGraphs in the translation-drafting phase. These are: narrow-context planning (the ST and the TT segments were read in parallel), broad-context planning (the reading of the ST was above sentence level, which is far more to the right of the TT segments that are being revised), sentence

planning (the reading of the ST was at sentence level) and backtracking behaviour (re-reading of the ST or the revised TT).

In the present study, narrow-context planning, sentence planning and backtracking behaviour were all identified in SR, PE and OR. The only behaviour not found was broad-context planning.This might be an indication that the student translators were more used to decoding the ST information at or below sentence level during the revision and post-editing processes. It is also possible that they were less able to work above the sentence level during the working process.

With respect to the different reading behaviour in the three tasks, it was found that in SR (Figure 55), most of the reading behaviour occurred in a narrow context. Sentence planning activity normally only occurred at the very beginning of the drafting phase. However, in PE (Figure 56), there was more sentence planning activity, which occurred at the beginning or during the drafting phase. In OR (Figure 57), both the narrow-context planning and sentence planning activities occurred during the drafting phase.

The possible interpretations for the different reading behaviours are that, in SR, the participants were familiar with the ST and did not need to reread the ST in a large chunk. In PE and OR, comprehension of the ST was required more constantly, and the quality of the TT in OR was higher than the quality of the machine translation. Therefore, the number of sentence planning activities was higher in PE than in OR. Backtracking behaviour was found in all tasks, as all participants reread some of the segments more than once.

The drafting phase, in most cases, took the longest time and attracted a significantly higher number of fixations compared with the planning phase and the final check phase. However, four participants conducted two comparative revisions, each of which took a similar amount of time. As can be seen in Figure 58, the number of changes made in the second run-through was even higher than that in the first run-through. These dual revisions were considered as a drafting phase, as it seemed that the aim of the second run-through was not to give the TT a final check, but to do another detailed comparative revision.
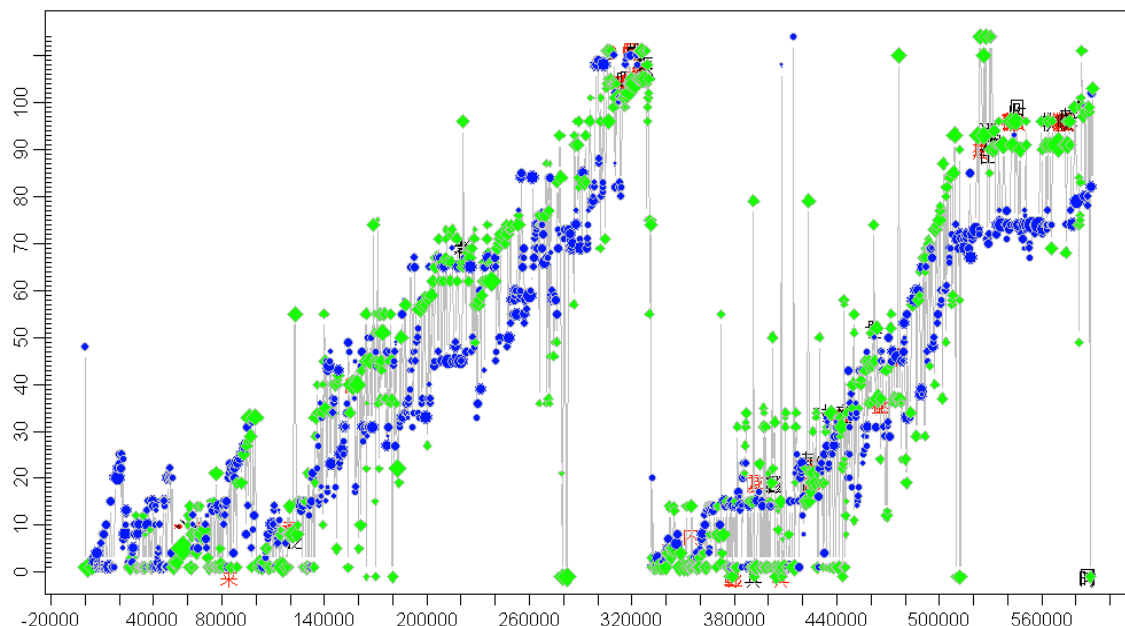
Figure 58: Two Comparative Revisions in OR

The codes for the drafting phase are:

- BitR: a bilingual reading at text level with revision
- BitR + BitR: two run-throughs of bilingual reading at text level with revision.

7.2.2.3 Subjective and Conscious Reflections on the Underlying Purposes

The participants' retrospection data were analysed to infer the potential purposes in the drafting phase in the three tasks. Table 48 presents representative answers to the questions: 'Can you describe how you revise the TT?' and 'Why did you read the ST/TT and revise the TT in this phase in such a way?' The column on the right hand side summarises the purposes of the student translators' sequential activities in the drafting phase based on the analysis of their retrospection data.

Retrospection Data (Chinese)	English Translation	Purposes of Sequential Activities in the Drafting Phase
P01: (SR, PE and OR) 我先理解原文，然后再读译文，一句一句改。如果译文的句子没问题，我就读下面的一句，如果有问题，我可能会反复阅读原文或者译文。比如，如果是语义的问题，像错译、漏译、增译、或者不恰当的创造性翻译，我会再读原文；如果是译文语言问题，比如不通顺、不自然、或者是用词搭配的问题，我会反复读译文，然后修改。如果需要重新翻译，就再翻译，这个在修改机器翻译时比较多。也有的时候发现了问题但不知道该怎么改，这样的情况下要么就反复读原文和译文，看看问题能否解决，能解决就解决，解决不了的话会先放在那儿，最后全部改完之后再回过头去看，如果到最后也没有更好的想法，可能就那样了。总体而言我觉得文章怎么改、怎么阅读主要是看译文存在的问题的多少和性质。改完之后我习惯会再读一遍，确定我解决了我发现的问题，也确定译文作为独立的一段话，抛开原文，是符合我们中文的行文方式和逻辑的。也会考虑译文是否达到了原文本身想要表达的意思，以及 translation brief 里所要求的那些，像目标读者群，翻译的目的，以及译文的风格。如果考虑完这些觉得译文可以了就继续下一句，如果还有问题就继续改。我觉得三个任务都是这个步骤，只是改的多少，时间长短，以及重新翻译这种工作量大小的差异。	P01: (SR, PE and OR) I made sure I understood the ST first, and then read the TT and revised it sentence by sentence. If there was no problem, I went on to the next sentence. If I did find a problem, I reread the ST or the TT and revised. For instance, if it was a meaning transfer problem, such as mistranslation, omission, over-translation or improper creative translation, I reread the ST; if it was a TT language problem, such as failure to achieve fluency, naturalness or appropriate collocation, I reread the TT and revised. If retranslation was needed, I retranslated. This was often required in PE. Sometimes I identified a problem but had no idea of how to revise it. In this case, I normally reread the ST and the TT comparatively to see whether I could come up with a solution. If I had a better idea, I revised the TT; if not, I just left it there and continued revising the next sentence. I postponed it to the very end of the revision and considered it again. If I still did not know how to revise it, I simply gave up. Generally speaking, I think how to revise and how to read the texts depend on the number and the nature of the TT problems. After making changes, I would normally reread the full sentence again, to make sure that I had solved the problems that I identified, to make sure that the TT was natural and logical on its own, and also to make sure that the TT had appropriately expressed the ST content and has achieved the requirements that were stated in the translation brief (i.e., the target readership, the purpose of the translation, the style of the TT etc.). If all were considered, and no problems were found, then I would go on to the next sentence. If it was still problematic, I continued fixing it. The procedures were the same for all tasks. The differences across tasks rest with the number of revisions, the length of task time and the different workload of retranslation.	- Use of knowledge to evaluate the TT (i.e., text type, context knowledge, subject knowledge and world knowledge) - Decision making (to revise or not to revise the TT) - Problem identification and representation (i.e., the nature of the problems) - Problem solving and decision making (what to revise and how to revise the TT)

Table 48: Retrospection Data for the Underlying Purposes in the Drafting Phase

Only P01's retrospection data are presented in Table 48, as all the other participants' descriptions of the self-revision, other-revision and post-editing processes in the drafting phase were quite similar formulations of the core concepts represented in the table. The only difference is that some of the participants claimed they started revision by reading

the ST first and then read the corresponding TT, whereas others stated they read the TT first and consulted the ST where necessary.

When the participants' descriptions of their working procedures in the drafting phase were examined in detail, it was found that the processes of self-revision, other-revision and post-editing were similar to the processes of revision in writing. A tentative model of the drafting phase in revision and post-editing was constructed, based on the revising models of Hayes *et al.* (1987) and Shih (2015), and on the seven types of activities identified in section 6.1. This is presented in Figure 59 below.
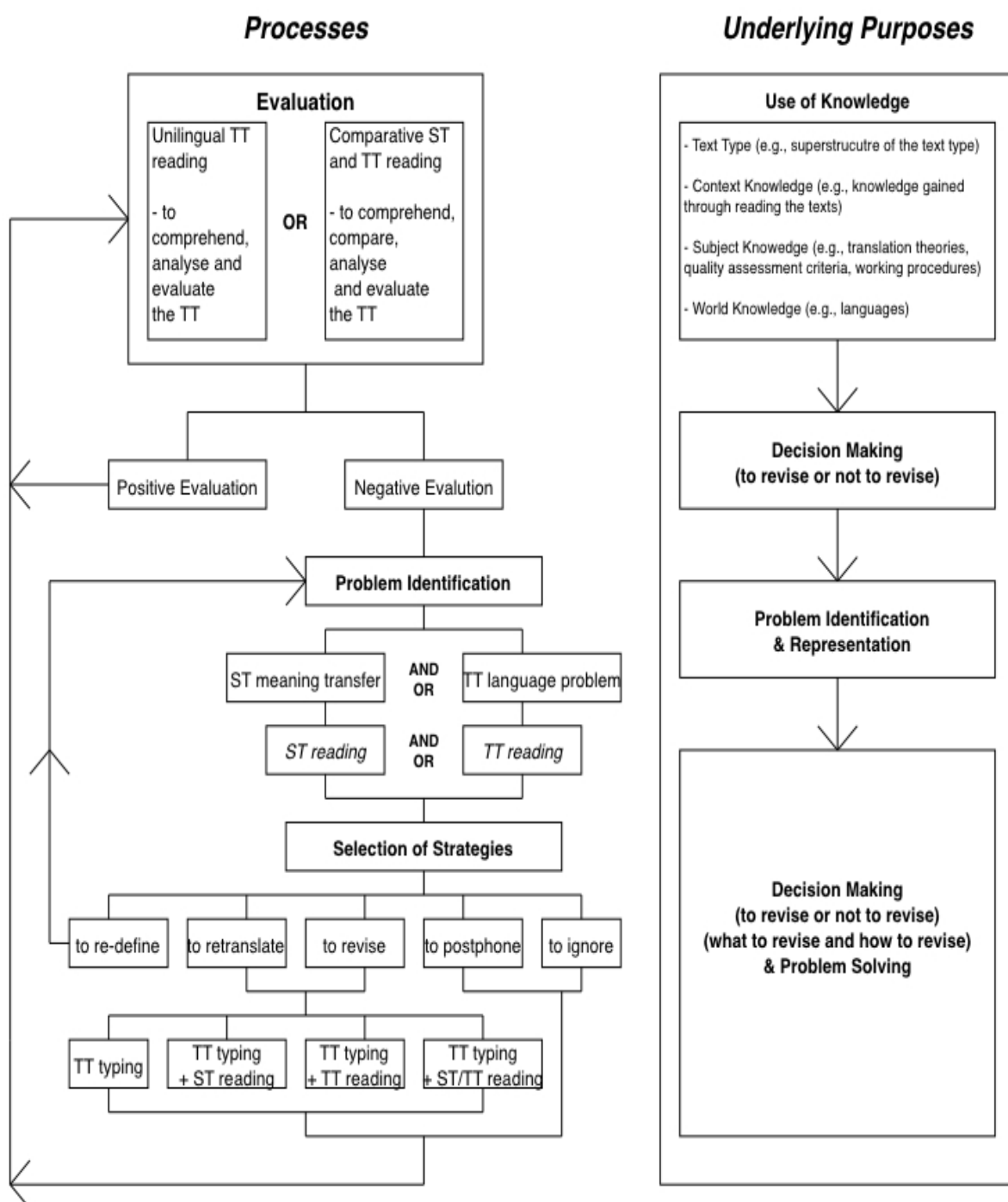
Figure 59: A Tentative Model of the Processes and the Underlying Purposes in the Drafting Phase

As can be seen in Figure 59, the processes of revision and post-editing in the drafting phase included: TT evaluation, problem identification, decision making and problem solving.

In the TT evaluation process, the student translators either read the TT on its own to identify language problems, or read the ST and the TT comparatively to make comparisons and diagnose problems. In this period, the student translators drew on their knowledge in different domains to help with their evaluation. This included their knowledge of the text type (the superstructure of the text type, see section 2.4.1.4.3), knowledge of the context (the knowledge acquired through reading the ST and the TT), subject knowledge (e.g., relevant translation theories, revision and post-editing strategies and processes, quality assessment criteria etc.) and world knowledge (e.g., knowledge about the SL and the TL etc.). Different levels of knowledge base influence the evaluation of the TT and in turn affect the reading and typing behaviour.

The evaluation of the TT is either positive or negative. If positive, attention will be shifted to a new ST or TT segment. If negative, the problem identification process will begin. During this process, the student translators read the TT and/or the ST to determine the type of the problem. If it is an ST meaning transfer problem, the attention will be shifted to the ST (ST reading, Activity Unit Type 1), with the aim of comprehending and analysing the ST information and proposing solutions to the identified problem. If the problem concerns TT language, such as fluency and naturalness, the attention will be mainly focused on the TT (TT reading, Activity Unit Type 2), with the aim comprehending and analysing the TT information and to propose solutions to the identified problem. If a sentence contains both ST meaning transfer and TT language problems, the relevant ST and TT sentence(s) are read comparatively to generate plausible solutions to the identified problem.

The revision strategy selection process begins once the problems have been identified. Decisions are made amongst the following five options: re-define the problem and search for information in the long-term memory to help with the problem identification process; retranslate the ST segment; revise the TT segment; postpone the problem(s) to be fixed at a later time, and ignore the problem when no solutions are found. Once it is decided to retranslate or revise the TT and solutions have been formulated, four types of activity will occur separately and interchangeably during the actual revision process. These are: TT typing (activity unit Type 3), TT typing while reading the ST (activity unit Type 4), TT typing while reading the TT (activity unit Type 5), TT typing while reading the ST and the TT (activity unit Type 6). Idle (activity unit Type 7) might occur during the reading and the typing process.

The revised TT is normally reread for a second evaluation and confirmation. If a positive evaluation is made, the evaluation of the new TT segments begins. If a negative evaluation is made, the whole process starts again in a cycle. It should be noted that one's knowledge not only helps with the evaluation process, but is a decisive factor in every phase of the revision process.

7.2.3 The Final Check Phase and Coding

In the final check phase, it is common to find that the revised TT is quickly reread and changed, if necessary, with the aim of confirming the TT before submission. However, in the present study, it was found that not all participants had a final check phase in SR, PE and OR. The statistics are presented in the following subsections.

An examination of the reading and typing patterns in the final check phase in all ProgGraphs revealed that for those who had a final check phase in SR, PE or OR, the types of reading and typing activity in the final check phase included:

- UniTTs: a unilingual TT reading at sentence level without revision
- UniTTt: a unilingual TT reading at text level without revision
- UniTTsR: a unilingual TT reading at sentence level with revision
- UniTTtR: a unilingual TT reading at text level with revision
- UniTTsSTseg: a unilingual TT reading at sentence level without revision, with ST reading at segment level where necessary
- UniTTsSTsegR: a unilingual TT reading at sentence level with revision, with ST reading at segment level where necessary
- UniTTtSTseg: a unilingual TT reading at text level without revision, with ST reading at segment level where necessary
- UniTTtSTsegR: a unilingual TT reading at text level with revision, with ST reading at segment level where necessary
- UniSTtTTseg: a unilingual ST reading at text level without revision, with TT reading at segment level where necessary
- UniSTtTTsegR: a unilingual ST reading at text level with revision, with TT reading at segment level where necessary.

It should be noted that in the present study, 'unilingual revision' was defined as 'reading and revising the TT without consulting the ST unless necessary' (see section 2.1.1.5). In this section, in order to analyse the participants' reading and typing activities from a more granular perspective, unilingual revision is further divided into three types of reading and typing activity: (1) pure unilingual ST reading or TT reading at sentence or text level,

with or without revision (i.e., UniTTs, UniTTt, UniTTsR, UniTTtR); (2) unilingual TT reading at sentence or text level with ST reading at segment level, where necessary, with or without revision (i.e., UniTTsSTseg, UniTTsSTsegR, UniTTtSTseg, UniTTtSTsegR), and (3) unilingual ST reading at sentence or text level with TT reading at segment level, where necessary, with or without revision (i.e., UniSTtTTseg, UniSTtTTsegR).

Sections <u>7.2.3.1</u>, <u>7.2.3.2</u> and <u>7.2.3.3</u> present the sequences of these activities in SR, PE and OR respectively. Section <u>7.2.3.4</u> presents the retrospection data and analyses the potential purposes underlying these sequences of activities.

7.2.3.1 Self-revision

In the process of self-revision, 15 out of 18 participants (83.3%) had a final check phase. The six types of reading and typing activity sequence (cf. Figures 60 and 61) detected in the final check phase in SR included:

- UniTTt (16.7%, e.g., P01): a unilingual TT reading at text level without revision.

- UniTTtR (11.1%, e.g., P08): a unilingual TT reading at text level with revision.

- UniTTs – UniTTsR – UniTTs (5.6%, e.g., P06): (1) a unilingual TT reading at sentence level without revision; (2) a unilingual TT reading at sentence level with revision, and (3) a unilingual TT reading at sentence level without revision.

- UniTTtSTseg (33.3%, e.g., P03): a unilingual TT reading at text level without revision, with ST reading at segment level where necessary.

- UniSTtTTseg – UniTTt – UniTTtR (5.6%, e.g., P12): (1) a unilingual ST reading at text level without revision, TT reading at segment level where necessary; (2) a unilingual TT reading at text level without revision, and (3) a unilingual TT reading at text level with revision.

- UniTTtSTsegR - UniTTtSTsegR (11.1%, e.g., P16): two run-throughs of unilingual TT reading at text level with revision, with ST reading at segment level where necessary.
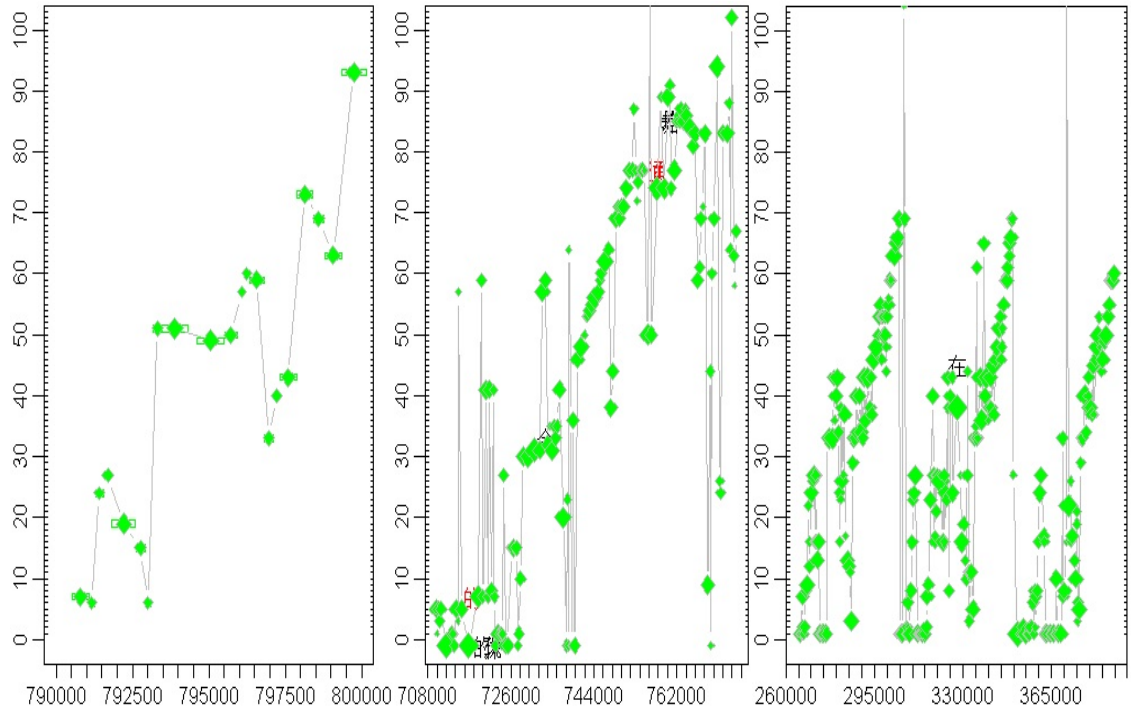
Figure 60: Final Check Phase in SR (Left to Right: P01, P08, P06)
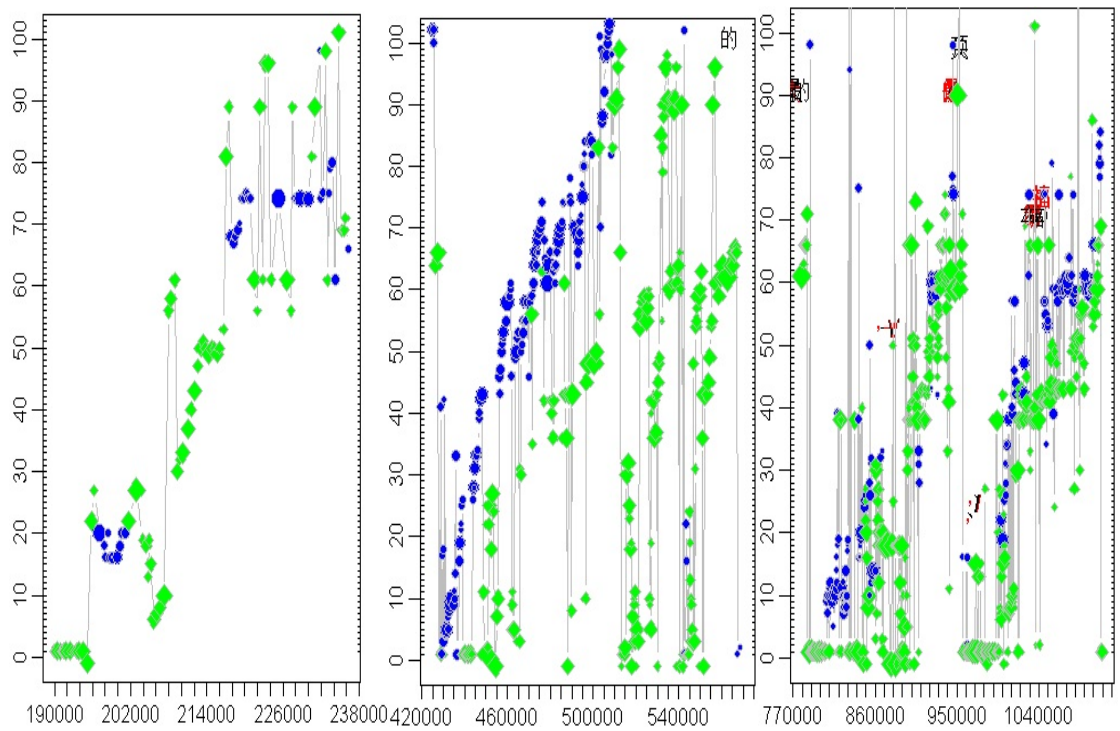
Figure 61: Final Check Phase in SR (Left to Right: P03, P12, P16)

From the above statistics it can be seen that, in the final check phase in SR, most of the participants (33.3%) conducted a unilingual TT reading at text level without revision, and only read the ST at segment level where necessary. Some other participants carried out revision by conducting a unilingual TT reading at text level with (11.1%) or without (16.7%) revision. 22.2% of the participants had two (11.1%) or three (11.1%) run-throughs of the TT.

7.2.3.2 Post-editing

In the post-editing process, 17 out of 18 participants (94.4%) had a final check phase. The six types of reading and typing activity sequence (cf. Figures 62 and 63) identified in the post-editing process included:

- UniTTtR (5.6%, e.g., P01): a unilingual TT reading with revision.
- UniTTtSTsegR (50%, e.g., P03): a unilingual TT reading at text level with revision, with ST reading at segment level where necessary.
- UniTTtSTsegR – UniTTtSTsegR – UniTTt (11.1%, e.g., P04): two run-throughs of unilingual TT reading at text level with revision, with ST reading at segment level where necessary, followed by a unilingual TT reading at text level without revision.
- UniTTtSTsegR – UniTTsSTsegR (16.7%, e.g., P05): a unilingual TT reading at text level with revision, with ST reading at segment level where necessary; followed by a unilingual TT reading at segment level with revision, with ST reading where necessary.
- UniTTtSTsegR – UniTTtR (16.7%, e.g., P07): a unilingual TT reading at text level with revision, with ST reading at segment level where necessary, followed by a unilingual TT reading at text level without revision.
- UniTTt – UniTTt (11.1%, e.g., P12): two run-throughs of unilingual TT reading without revision.

From the above figures, it can be seen that most participants (50%) tended to read and revise the TT at text level, only referring to the ST if necessary. Only 5.6% of the participants revised the TT without consulting the ST. This indicates that for the majority of the participants, ST meaning transfer was still a problem in the final check phase in PE. 44.5% of the participants (e.g., P05, P07 and P12) had two run-throughs of the TT, and 11.1% of the participants ran through the TT three times (e.g., P04).
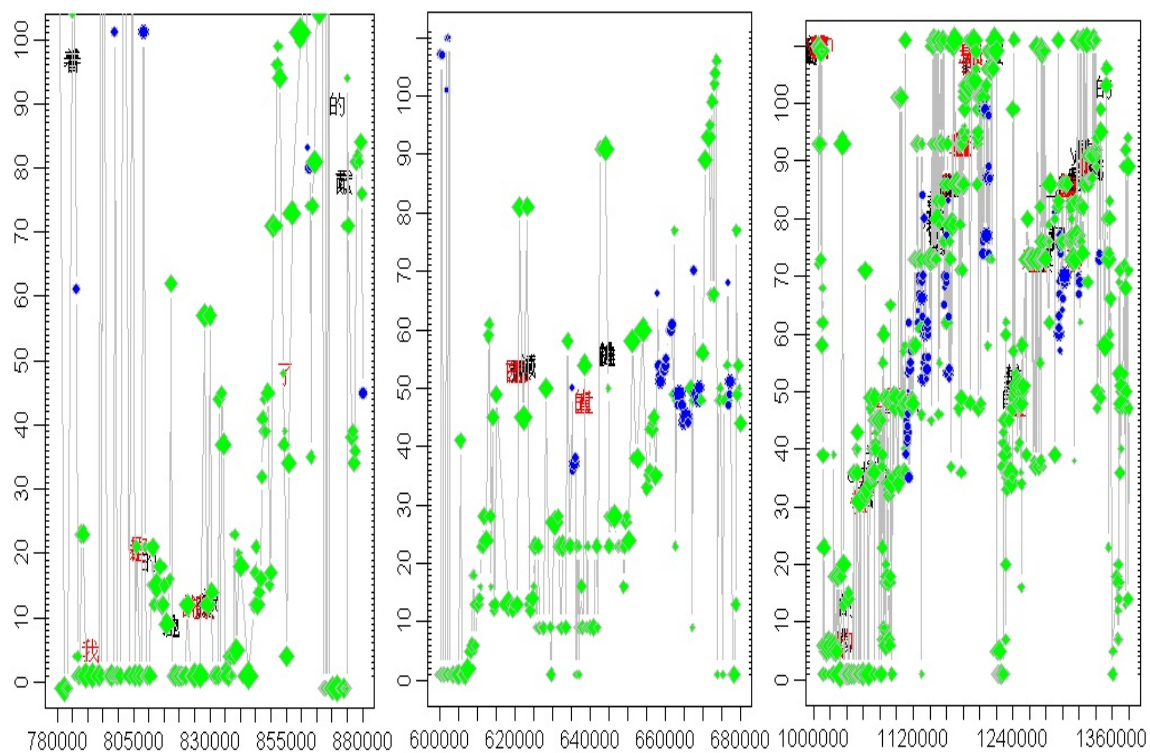
Figure 62: Final Check Phase in PE (Left to Right: P01, P03, P04)
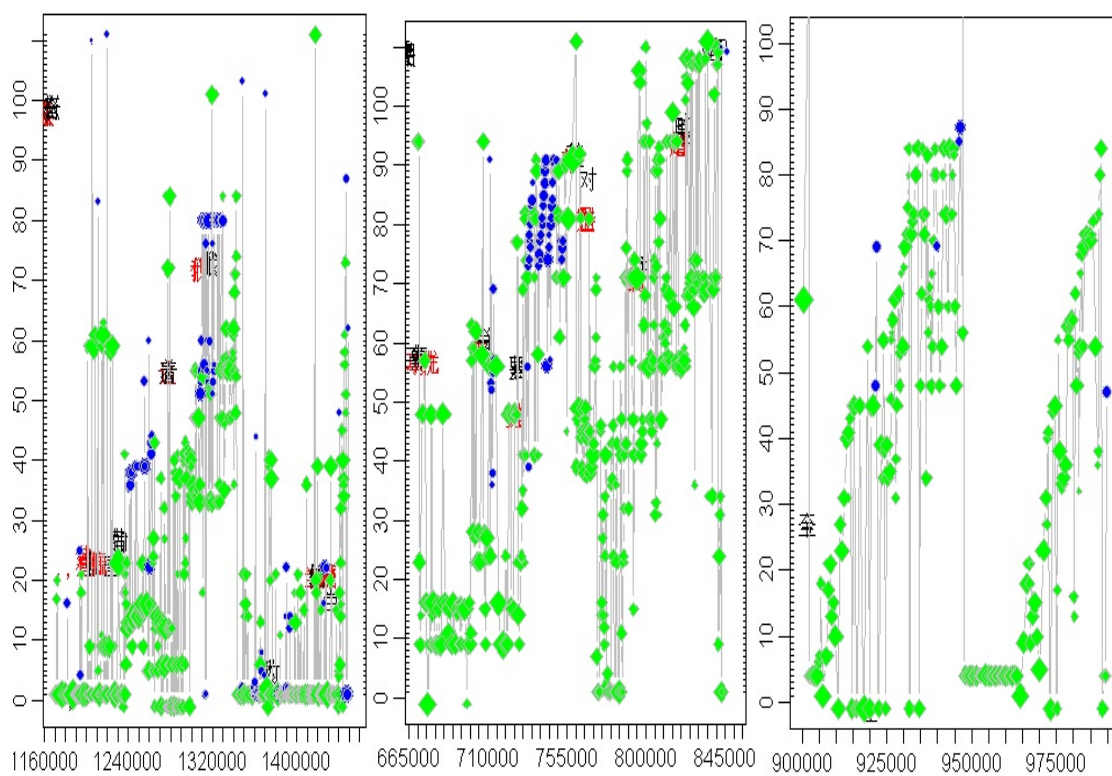
Figure 63: Final Check Phase in PE (Left to Right: P05, P07, P12)

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7.2.3.3 Other-revision

In the other-revision process, 11 out of 18 participants (61.1%) had a final check phase. The five types of reading and typing activity sequence (cf. Figures 64 and 65) detected in the final check phase in OR included:

- UniTTtSTsegR (45.5%, e.g., P03, P08): a unilingual TT reading at text level with revision, with ST reading at segment level where necessary.

- UniTTtR – UniSTtTTsegR – UniTTtR (9.1%, e.g., P04): (1) a unilingual TT reading at text level with revision; followed by (2) a unilingual ST reading at text level with revision, with TT reading at segment level where necessary, and (3) another unilingual TT reading at text level with revision

- UniTTsSTsegR – UniTTsSTsegR – UniTTsSTsegR – UniTTsR – UniTTsSTsegR – UniTTsSTsegR – UniTTsSTsegR – UniTTsR – UniSTt – UniTTsR – UniTTs – UniTTs (9.1%, e.g., P06): (1) three run-throughs of unilingual TT reading at sentence level with revision, with ST reading at segment level where necessary; followed by (2) a unilingual TT reading at sentence level with revision; (3) another three run-throughs of unilingual TT reading at sentence level with revision, with ST reading at segment level where necessary; then (4) a unilingual TT reading at sentence level with revision; (5) a unilingual ST reading at sentence level; then (6) a unilingual ST reading at sentence level with revision, and (7) two run-throughs of unilingual TT reading at sentence level without revision.

- UniTTtR (18.2%, e.g., P09): a unilingual TT reading at text level with revision.

- UniSTtTTsegR – UniTTtR (18.2%, e.g., P11): a unilingual ST reading at text level with revision, with TT reading at segment level where necessary, followed by a unilingual TT reading at sentence level with revision.

From the above descriptions, it can be seen that all participants tended to do unilingual revision in the final check phase in OR; however, one participant (P06) had very distinctive reading behaviours compared with the other participants. S/he quickly ran through the TT and the ST 13 times, and made changes where necessary. This seems to correspond to what Mossop (2014, pp. 165-166) suggests, that is, revising at text level rather than sentence level. Frequent re-readings of the ST and the TT separately at text level might indicate a participant's uncertainty about the TT or the ST. To test this assumption, section 7.2.3.4 presents some representative retrospection data for analysis.

Figure 64: Final Check Phase in OR (Left to Right: P03, P04, P06)

Figure 65: Final Check Phase in OR (Left to Right: P08, P09, P11)

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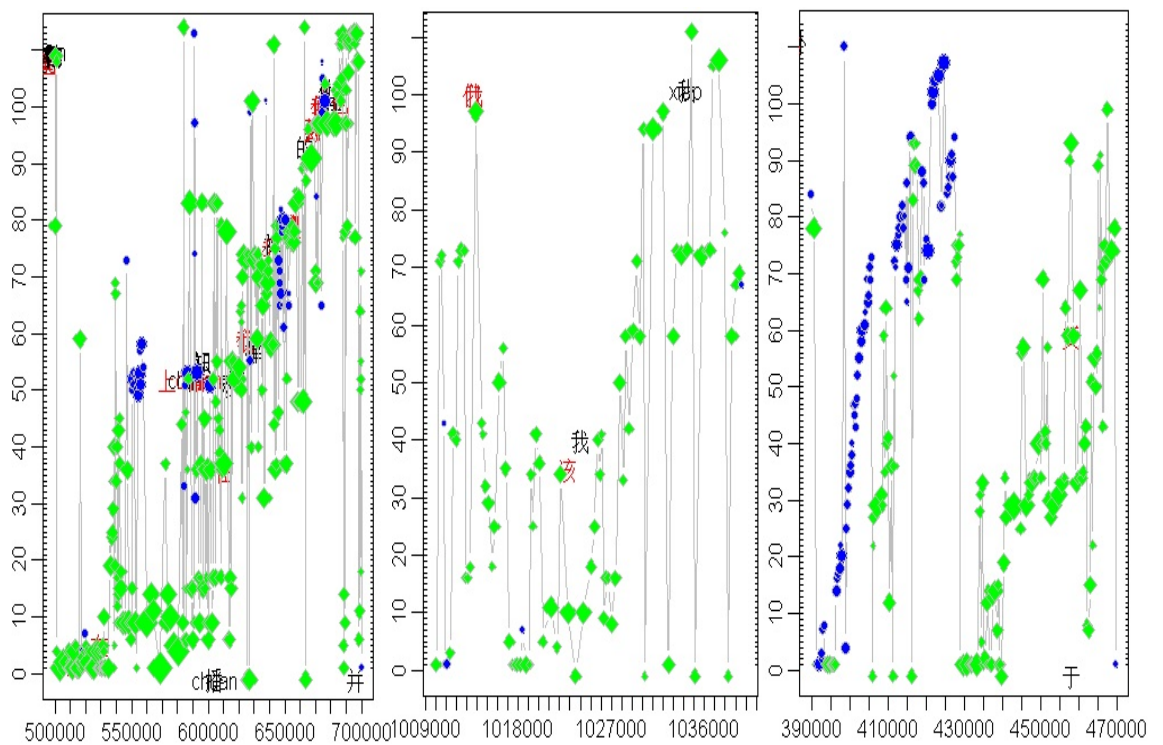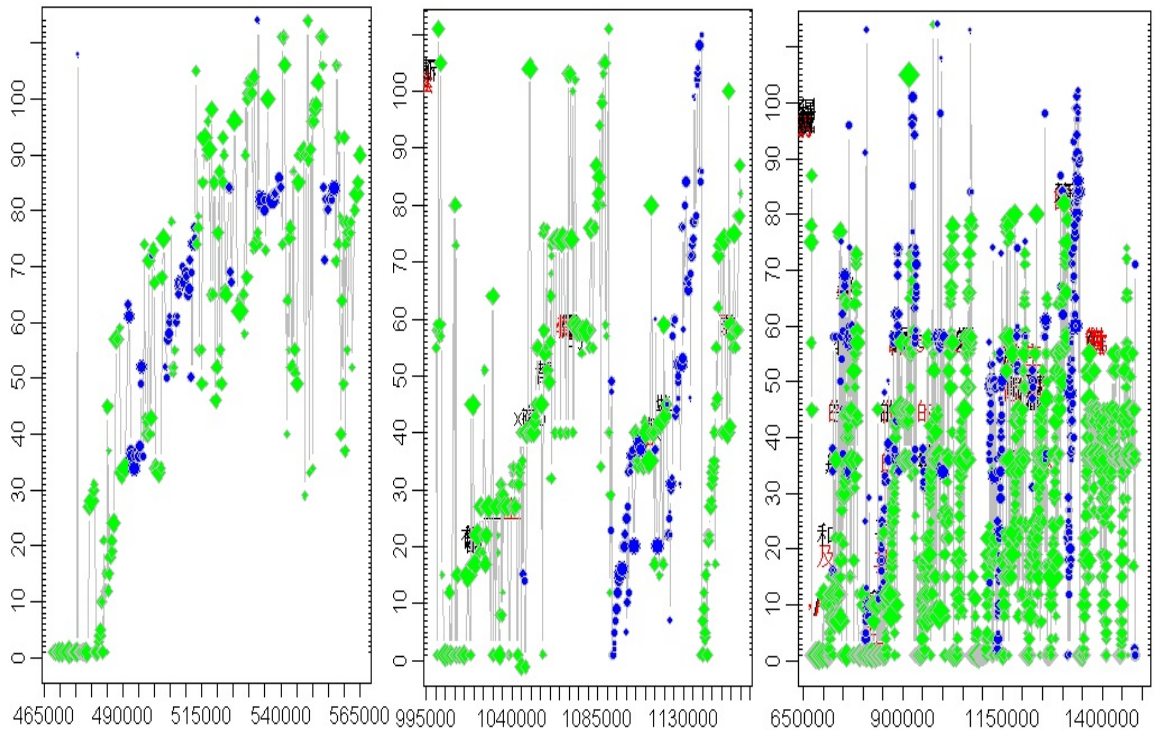
7.2.3.4 Subjective and Conscious Reflections on the Underlying Purposes

Table 49 summarises the answers to the questions: 'Can you describe how you revise the TT?' and 'Why did you read the ST/TT and revise the TT in this phase in such a way?' The column on the right hand side summarises the purposes of the student translators' sequential activities in the final check phase based on the analysis of their retrospection data.

Retrospection Data (Chinese)	English Translation	Purposes of the Final Check Sequential Activities
P08: (SR) 我改完之后，抛开原文又读一遍译文，主要看译文的语言是否流畅。语义的问题在之前修改的时候基本上已经解决了。	P08: (SR) After my revision (in the drafting phase), I read the TT on its own to check fluency. The ST meaning transfer problems were examined in the previous phase.	- To check TT fluency, naturalness and style
P12: (PE) 我最后应该是读了两遍译文。第一遍确定译文的文风跟原文是一致的，第二遍就是完全 TT-focused,不再考虑原文，以读者的角度来看译文的语言是否自然通顺。	P12: (PE) I read the TT twice in all. The first run-through focused on the style, and the second run-through was mainly TT-focused. I read the TT as a target reader to check its naturalness and fluency.	
P05: (PE) 我最后是集中解决在前面没有解决的问题，同时也通读译文检查译文的语言问题。改了一遍之后还有一个词不太满意，最后我又着重改了下。	P05: (PE) I mainly focused on previously unsolved problems and tried to solve them. At the same time, I checked the TL. After the first run-through, I was still dissatisfied with one phrase, so I revised it again.	- To solve TT problems - To deal with uncertainties
P03: (OR) 我主要是看译文，不太确定的地方也会看原文确定一下。	P03: (OR) I mainly read the TT, and only read the ST when I felt uncertain.	
P12: (SR) 我先是原文和译文对照看了一遍，以原文为主，因为我要确定译文是准确的，没有错译漏译等问题。后面又整体看了两遍，主要以译文为中心，检查译文是不是自然。	P12: (SR) Firstly, I read the ST and the TT comparatively. The focus was on the ST, as I had to make sure the TT was translated accurately and there were no problems such as mistranslation and omission. Then I read the TT at text level twice, to check its naturalness.	- To confirm TT accuracy and its degree of equivalence with ST - To check TT naturalness
P06: (OR) 我的确是来来回回读了很多遍，主要是以译文为主，但也整体读了原文，确定译文足够 accurate, 跟原文 equivalent. 我也不知道为什么我会读那么多遍，可能是因为这个翻译本身问题不是很大，而且我也已经改过一遍了，所以读起来没有像那个机器翻译一样那么有阻碍，读得比较快。	P06: (OR) I read the ST and the TT back and forth, but it was mainly TT focused. I read the ST at text level to make sure the TT was accurate and was equivalent to the ST. I had no idea why I read both texts so many times. Perhaps it was because the TT was not problematic and I had revised it once, so it was not hard to go through, and I went through it quickly.	
P04: (OR) 我先是检查了一下改过之后的译文读起来是否通顺，然后又对照原文确认了下没有漏译，最后又快速地读了下译文，检查译文是否自然。	P04: (OR) Firstly, I checked the fluency of the revised TT, then compared the TT with the ST to confirm there was no omission. Finally I quickly went through the TT to check its naturalness.	- To check fluency - To check accuracy - To check naturalness

Table 49: Retrospection Data for Purposes in the Final Check Phase

From the gazing and typing patterns, it appears that the final check phase was more complex than the planning and drafting phases, as there were more run-throughs of the texts and more types of reading and typing sequence combinations. However, the retrospection data indicate very clear and simple mental activities underlying these physical activities, that is, to final-check TT fluency, naturalness, style, accuracy, equivalence and to reconsider previously unsolved problems. From the retrospection data it can also be seen that, when a participant was uncertain about the ST or the TT, re-reading(s) of the text(s) took place (e.g., P03). It is interesting to see that, while most of the participants were very clear about their revision procedures, criteria and motivations (e.g., P04, P05, P08 and P12), P06, who had the highest number of run-through times was not quite sure why s/he read the ST and the TT back and forth.

According to Krings (2001, p. 167), the subprocesses in the overall processes of post-editing and translation 'do not naturally appear in random sequences; instead they are logically related to one another'. This indicates that, apart from the external factors (e.g., time constraints, text complexity level), an individual's reading and typing behaviour is also affected by internal factors, such as the knowledge base level (e.g., subject knowledge) and the confidence level (i.e., certainty). As Shih (2006, p. 310) suggests, a good understanding of one's own working procedures is vital to improving translation and revision performances.

Based on the codes presented in sections 7.2.1, 7.2.2 and 7.2.3, all the participants' reading and typing activities were coded and are reported in Appendix 13. The participants' run-through times were worked out on the basis of the coded activity sequences, and these are presented in Figure 66. It can be seen that most participants went through the TT twice in all tasks, and the same percentage of participants went through the TT three times across tasks. However, the number of participants who went through the TT only once in PE (5.6%) is significantly lower than that recorded for OR (22.2%) and SR (27.8%). By contrast, 16.7% of the participants went through the TT four times in PE, whereas only 5.6% of the participants did so in SR. It is interesting to find that the same number of participants went through the TT five times in all tasks, and 5.6% of the participants went through the TT 13 times in OR.

	SR	PE	OR
■ 1	27.8%	5.6%	22.2%
■ 2	38.9%	50.0%	44.4%
■ 3	22.2%	22.2%	22.2%
■ 4	5.6%	16.7%	0.0%
■ 5	5.6%	5.6%	5.6%
■ 13	0.0%	0.0%	5.6%
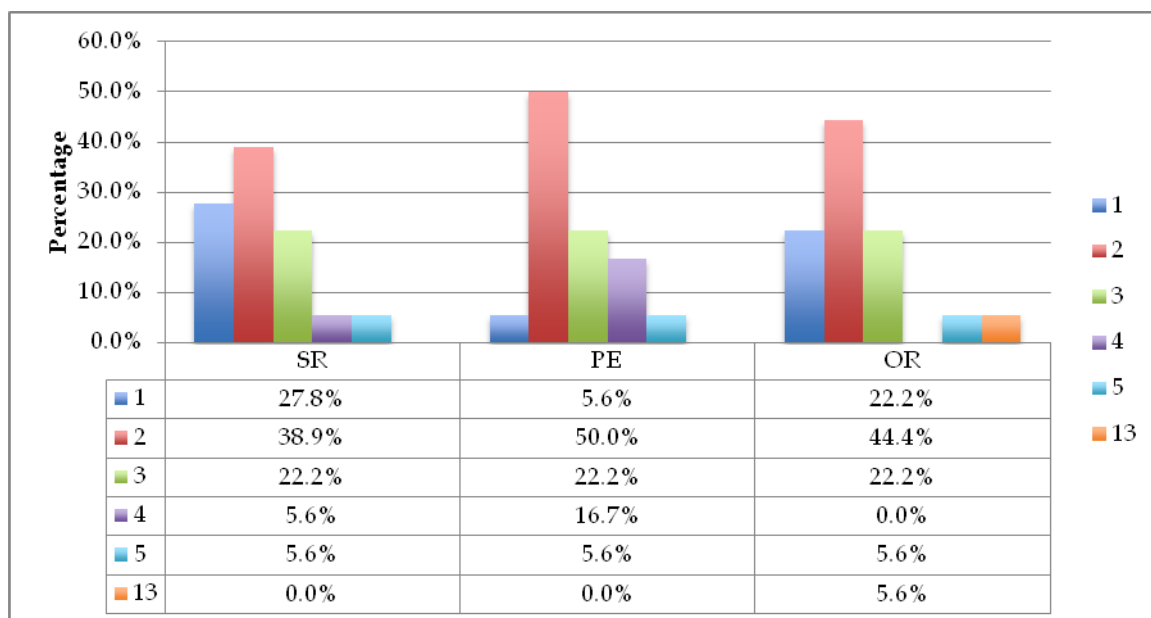
Figure 66: Comparison of Number of Run-throughs by Participants

7.3 Types of Working Styles

In Robert (2013, p. 91), the four types of reading modality in the revision process include:

A: Monolingual proofreading (Unilingual reading)

B: Bilingual proofreading (Bilingual reading)

C: Bilingual proofreading + monolingual proofreading (Bilingual reading + unilingual reading)

D: Monolingual proofreading + bilingual proofreading (Unilingual reading + bilingual reading)

However, in the present study, taking all three working phases into consideration, only procedures B (bilingual reading), C (bilingual reading + unilingual reading) and D (unilingual reading + bilingual reading) were detected in SR, PE and OR. Robert's procedure B is equivalent to 'the drafting phase' in this study, where the participants conducted one or two bilingual revisions. Procedure C is similar to 'a drafting phase with a final check phase', where the participants conducted one or two bilingual revisions and then read the TT for a final check and confirmation. Procedure D is equivalent to 'a planning phase with a drafting phase' in this study, where the participants read the ST and/or TT to comprehend the content for the first time, and then carried out detailed bilingual revisions.

Since, in the final check phase, there were different types of reading modality with various numbers of run-through times, in the present study, a new categorisation method was used to describe the participants' working styles. The categories are: Macro-Micro-

Macro processing, Micro-Macro processing, Macro-Micro processing, and Micro-processing.

Macro-processing refers to:

- ST reading and/or TT reading at text level, with the aim of gaining a general overview of the ST and/or TT in the planning phase (e.g., UniSTt, UniTTt)

- TT-focused reading at text level to ensure its fluency, naturalness and style in the final check phase, regardless of the run-through times and typing activities (e.g., UniTTt, UniTTtR, UniTTtSTseg, UniTTtSTsegR)

Micro-processing refers to:

- Bilingual reading(s) of the ST and the TT, during which detailed revisions are carried out (e.g., BitR, BitR + BitR)

- ST or TT reading at sentence level in the planning phase, with the aim of preparing for the detailed revision in the drafting phase (e.g., UniSTs, UniTTs)

- ST or TT reading at sentence level or reading just a few words of the ST or TT, with the aim of solving previously unsolved problems (e.g., UniTTs, UniTTsR, BiTTsSTseg)

The levels of processing above refer to the different working styles. They should not be confused with the 'attentional processing types' discussed in section 6.3 (ST processing, TT processing, Parallel processing, No recorded data).

7.3.1 Macro-Micro-Macro Processing

Figures 67 and 68 present the two types of Macro-Micro-Macro processing (Ma-Mi-Ma) identified in this study. In Figure 67, the participant read the ST at text level first (Macro-processing), then carried out a detailed bilingual revision (Micro-processing), and in the final check phase, the TT was gone through twice at text level (Macro-processing).
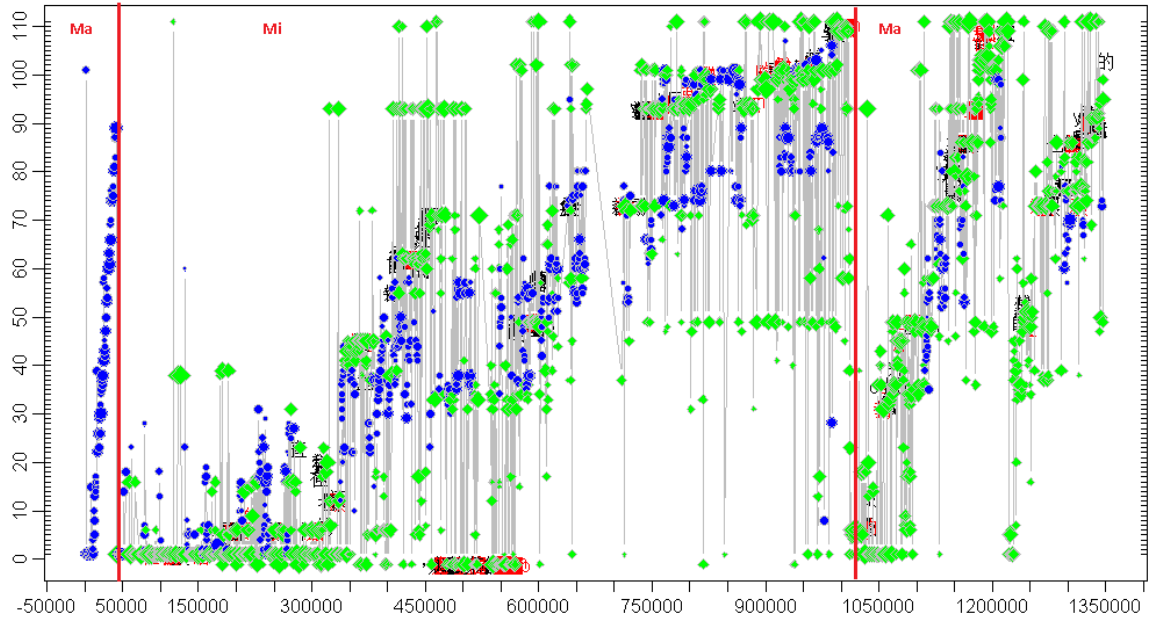
Figure 67: Macro-Micro-Macro Processing (Type 1)
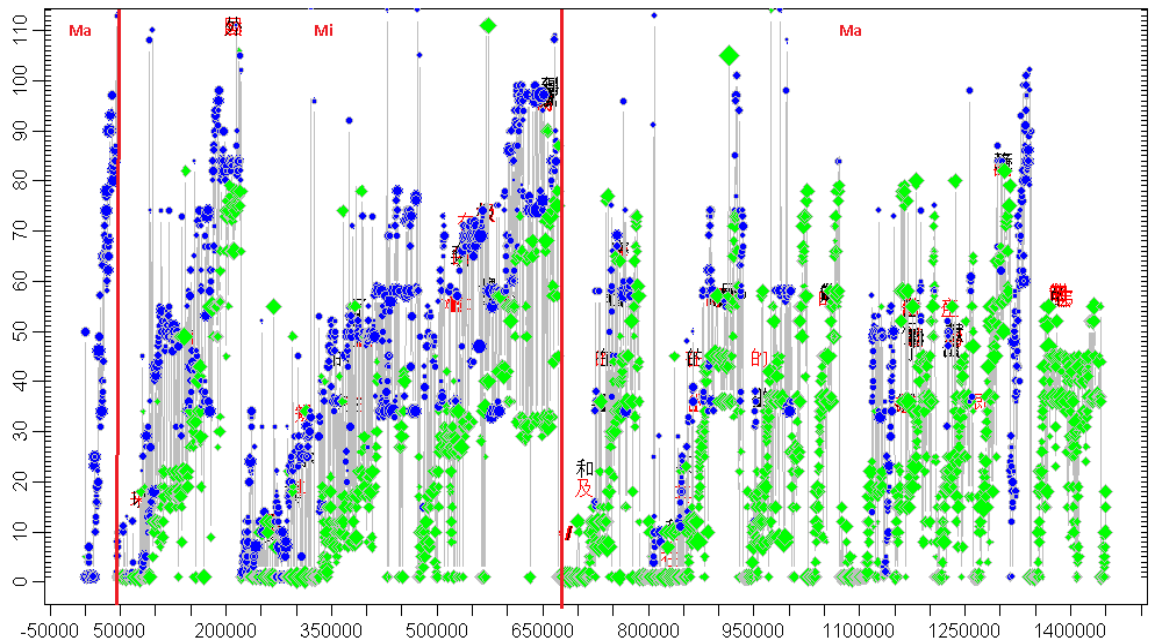
Figure 68: Macro-Micro-Macro Processing (Type 2)

Figure 68 shows another type of Ma-Mi-Ma processing. In the planning phase, the ST was read at text level (Macro-processing). Then the ST and the TT were gone through twice for detailed revision, during which time the ST was read thoroughly (Micro-processing). In the last phase, the TT was read and revised many times and the ST was read at text level. This latter phase is considered as macro-processing, as the participant was final checking the entire TT.

7.3.2 Micro-Macro Processing

Figures 69 and 70 illustrate the two types of Micro-Macro processing (Mi-Ma) identified in this study. Each of the figures below consists of two types of processing: bilingual reading with revision (Micro-processing), and TT-focused reading at text level with or without revision (Macro-processing). The only difference is that, in the example shown in Figure 69, comparative reading started at the very beginning, whereas in Figure 70, the ST was read several times at sentence level before more intense comparative reading started (X = 0 – 50000, Y = 0 – 30). Sentence level reading was not considered as Macro-processing in this study; therefore, both of the figures below belong to Mi-Ma processing. It should be noted that the macro-processing phase does not necessarily contain only one run-through of the TT. There might be more than one quick run-through of the TT at text level.
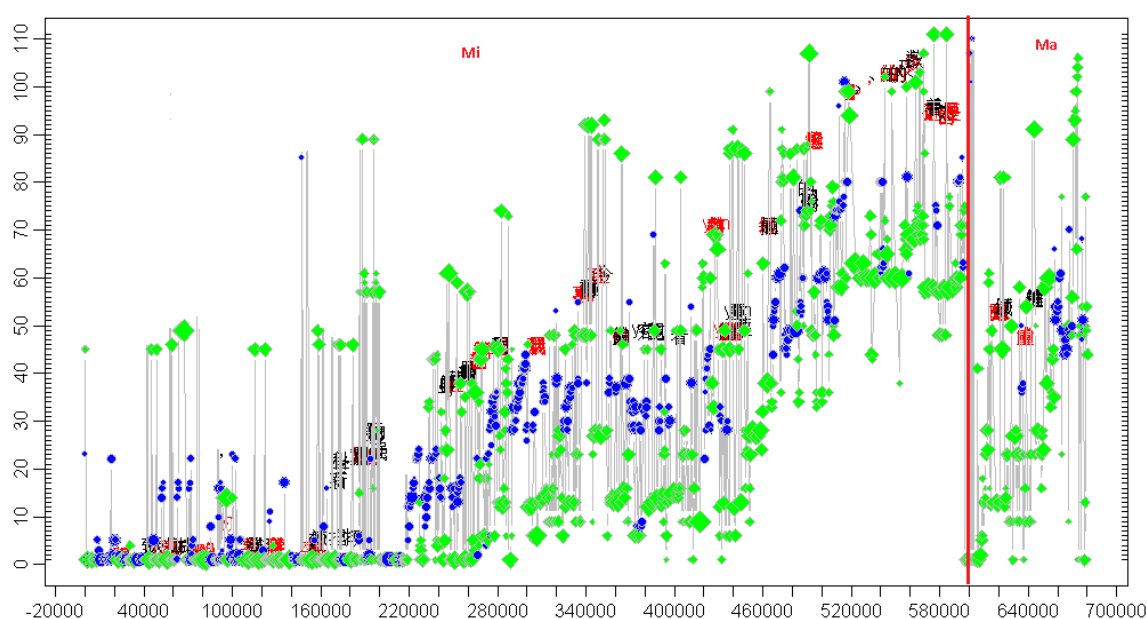
Figure 69: Micro-Macro Processing (Type 1)
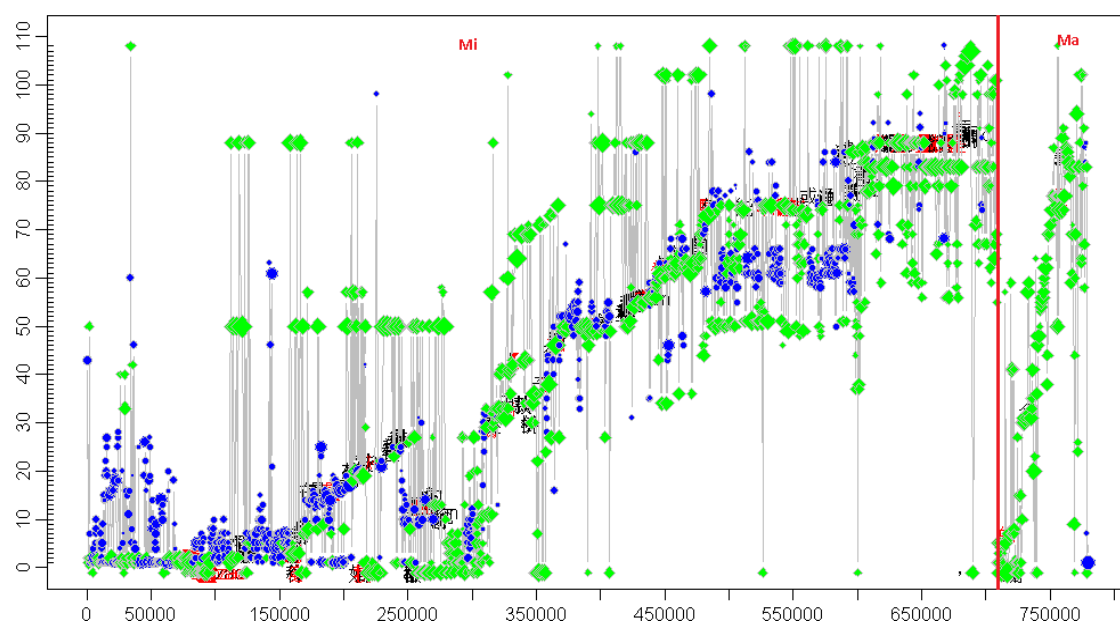
Figure 70: Micro-Macro Processing (Type 2)

7.3.3 Macro-Micro Processing

Figures 71 and 72 illustrate the two types of Macro-Micro processing (Ma-Mi) identified in this study. In Figure 71, the ST was first read at text level (Macro-processing), then detailed bilingual reading and revisions were carried out (Micro-processing). In Figure 72, the TT and the ST were read separately at text level in the planning phase (Macro-processing). Then detailed bilingual reading and revisions were carried out with a final check of the TT at sentence level (Micro-processing). The sentence level reading (X = 320000 – 400000, Y = 30) was considered as part of the Mirco-processing as the participant focused solely on the previously unsolved problem(s), and did not have a tendency to read the TT from a macro-view.
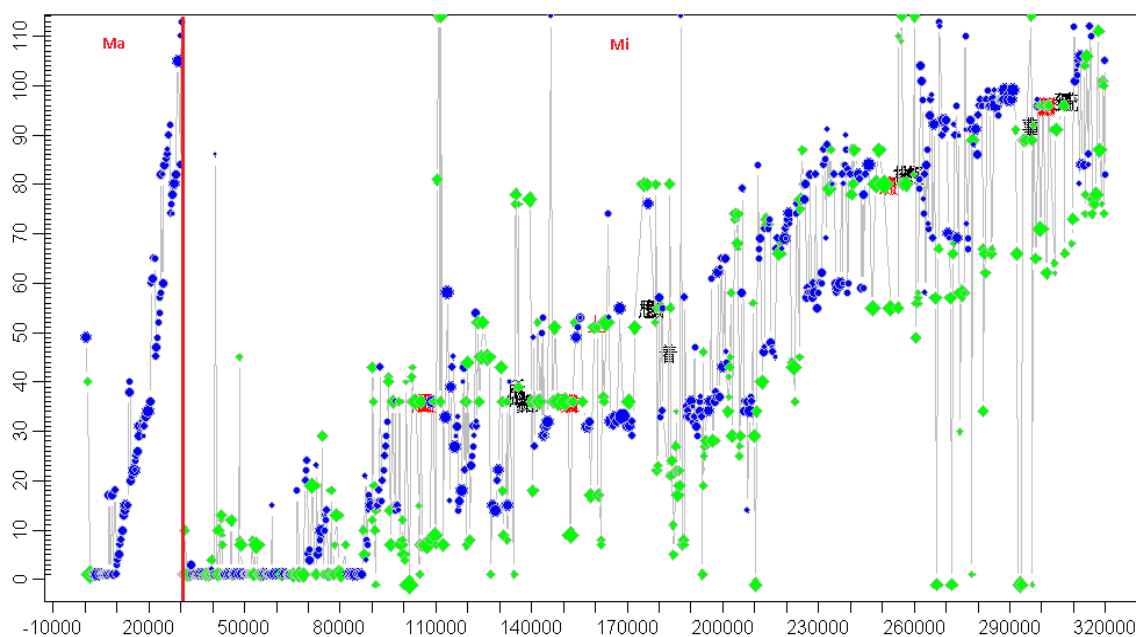
Figure 71: Macro-Micro Processing (Type 1)
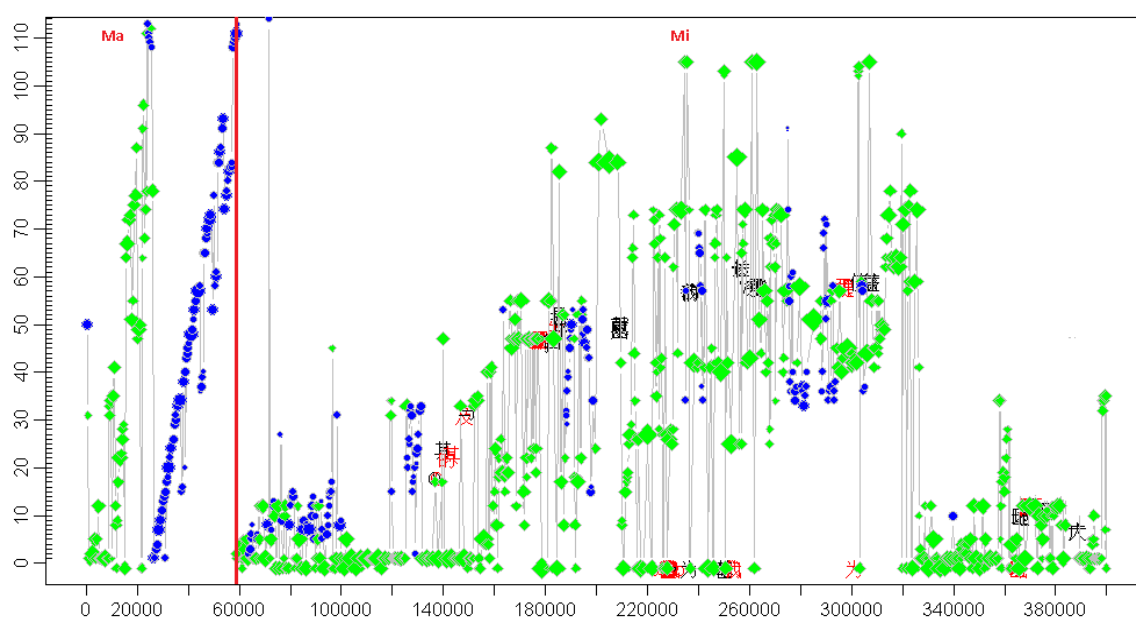
Figure 72: Macro-Micro Processing (Type 2)

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7.3.4 Micro- Processing

Figures 73 and 74 illustrate the two types of Micro processing (Mi) identified in this study. In Figure 73, there is only one run-through of detailed bilingual reading and revisions (Micro-processing). In Figure 74, two run-throughs of detailed bilingual reading and revisions took place, consuming a similar amount of time. As discussed in section 7.2.2, both of the run-throughs were considered as part of the drafting phase. Thus this type of processing was categorised as Micro-processing.
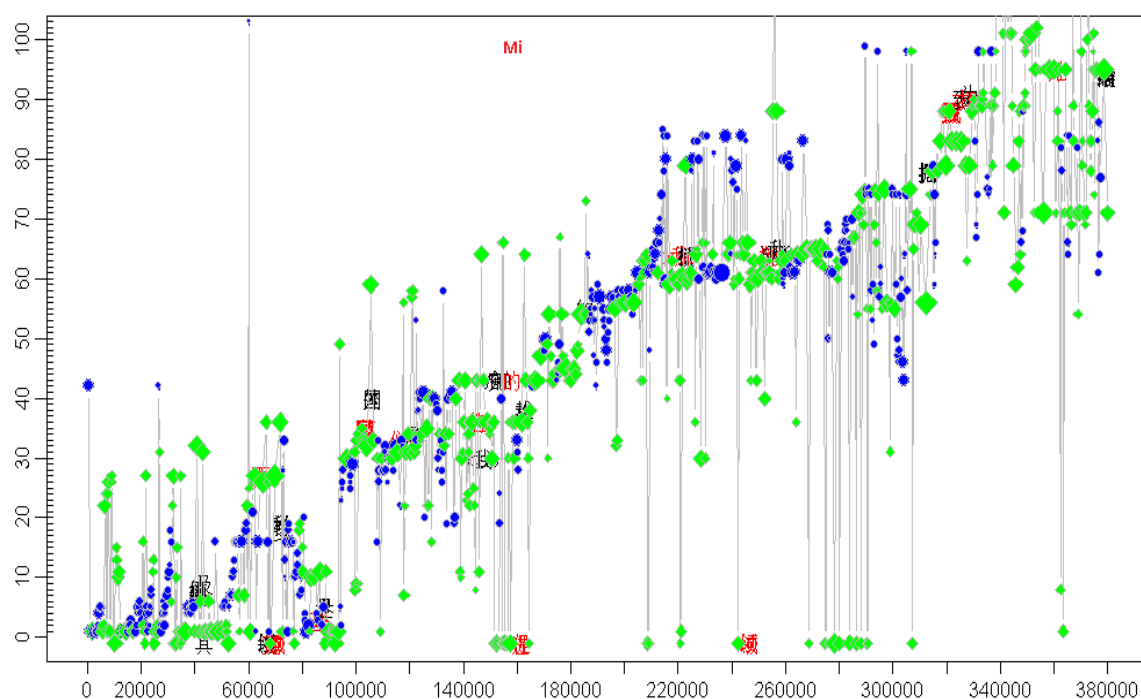
Figure 73: Micro Processing (Type 1)
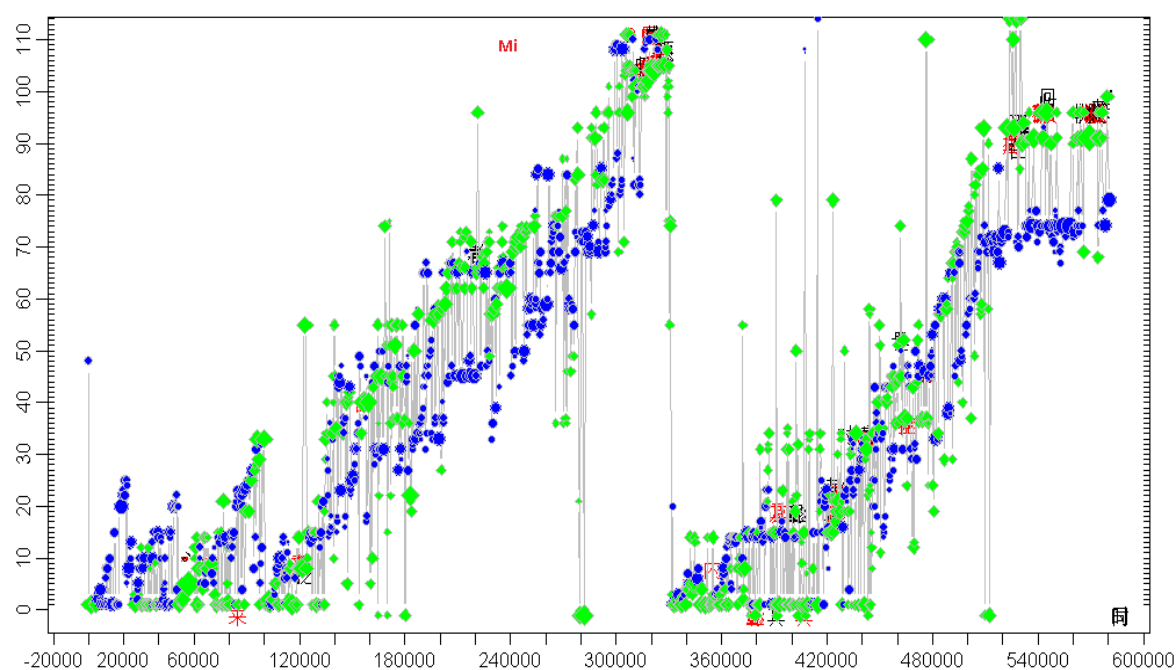
Figure 74: Micro Processing (Type 2)

Shih (2006b) identified two revision processing patterns among professional translators. The first pattern involves one run-through of the TT, during which the text is carefully examined and revised. The time and effort spent on this run-through is comparable to the time and effort spent on the first translation draft. This pattern is very similar to the first type of Micro-processing style (Figure 73) identified in the present study, as it only contains a drafting phase. Shih's (2006b) second revision processing pattern includes two or more run-throughs of the TT. Again, the first run-through is similar to the translation draft phase, during which the TT and the ST are intensively processed. Then in the later run-throughs, the translators seemed to be able to process the TT in larger chunks and there were 'a lot more and a lot longer-distance "SCAN" moves around the TT' (ibid., p. 161). This second revision processing pattern is very similar to the Micro-Macro processing style (Figures 69 and 70) identified in the present study. This working style contains a drafting phase and a final check phase, during which the translator first scrutinises the TT in small units and then re-checks the revised TT in larger chunks. In future, it is worth investigating whether or not professional translators adopt the other two working styles identified in the present study, Macro-Micro-Macro processing and Macro-Micro processing.

7.3.5 Working Styles and Task Types

As can be seen from Figure 75, an examination of the working styles in all three tasks revealed that most of the participants (55.6%) tended to revise the TT in a Mi-Ma mode in SR; 27.8% of the participants conducted Micro revision, and the rest (16.7%) revised the TT in a Ma-Mi-Ma mode. On the contrary, in PE, half of the participants processed the ST and the TT in Ma-Mi-Ma mode, and 38.9% and 11.1% of the participants post-edited the machine translation in Mi-Ma and Mi mode respectively. None of the participants conducted Ma-Mi revision in these two tasks. In OR, an equal percentage of the participants (27.8%) revised the TT in Ma-Mi-Ma, Mi-Ma and Mi modes, whereas 16.7% of the participants processed the text in a Ma-Mi mode.
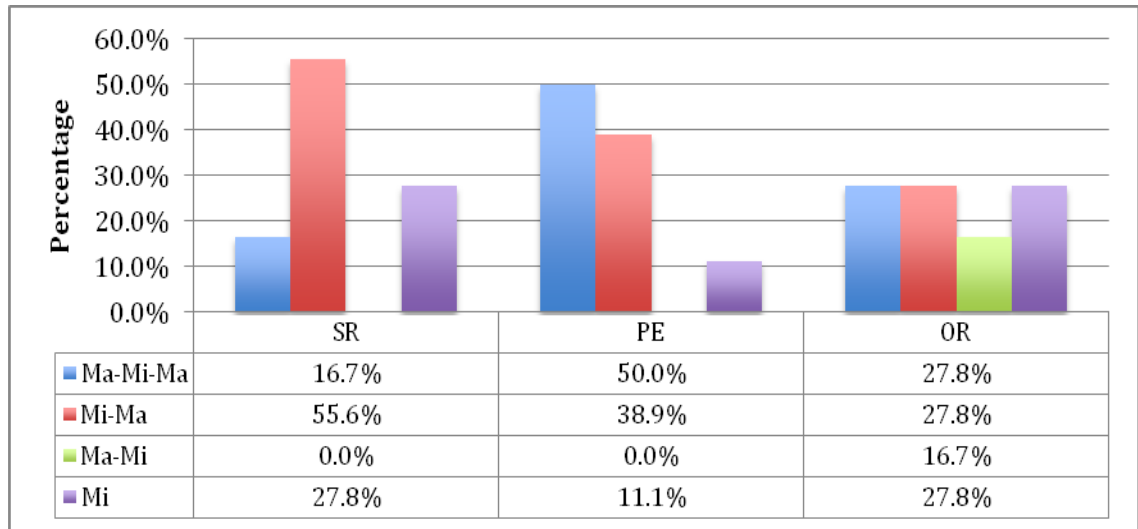
Figure 75: Workings Styles and Task Types

The above statistics indicate that task type is a main factor affecting the participants' working styles. Section 7.3.6 examines the extent to which task type affected the participants' personal working styles.

7.3.6 Personal Working Styles

Figure 76 below shows the percentage of each individual participant's variation in the choice of working style(s) across tasks.
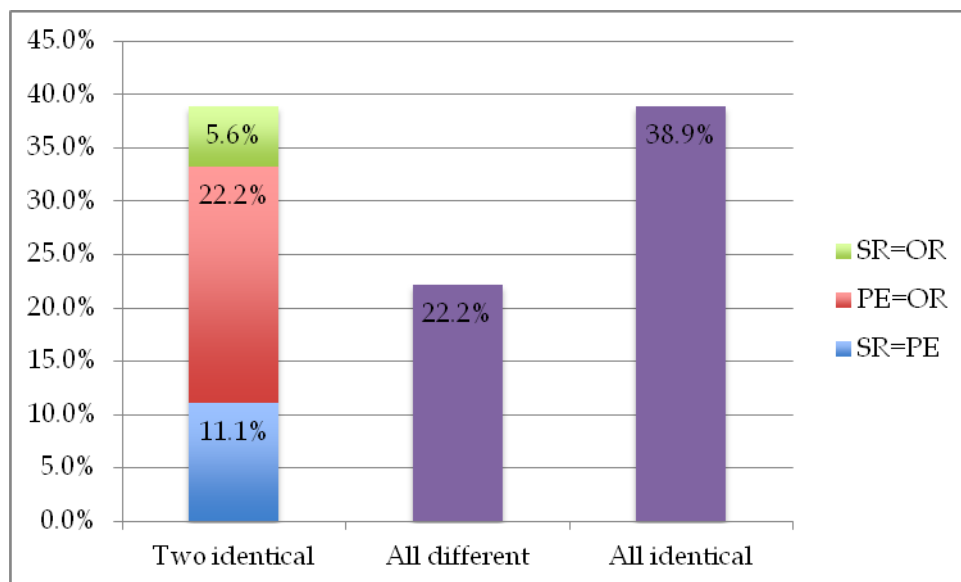
Figure 76: Participants Working Style Comparison across Tasks

By observing each participant's working style across tasks, surprisingly, it was found that 38.9% of the participants adopted exactly the same working style in SR, PE and OR; 5.6% used an identical working style in SR and OR; 22.2% used the same working style in PE and OR; 11.1% used an identical working style in SR and PE (39.8% in total for identical

working style in two tasks), and only 22.2% adopted totally different working styles in SR, PE and OR.

This is an indication that some of the student translators had formed a fixed working style in dealing with different types of revision task, and they were habit-oriented even if taking on different tasks. Those who revised and post-edited the TT in all different working styles seemed to be task-oriented as they changed strategies according to the task type. Those who used identical working styles in two tasks were somewhere between habit-oriented and task-oriented. Further research projects need to be conducted to investigate the last type of revisers.

Figures 77, 78 and 79 present the working patterns of these three types of revisers. It can be seen from Figure 77 that the participant used the same working style, i.e., Ma-Mi-Ma mode, to perform all tasks. In Figure 78, participant P05 used the Ma-Mi-Ma mode to conduct self-revision, adopted Mi-Ma processing to do post-editing, and used a Mi-processing mode to do other-revision. As shown in Figure 79, P08 adopted a Mi-Ma processing approach to conduct self-revision, and used Ma-Mi-Ma processing to carry out post-editing and other-revision.

Since the participants had shown their different preferences in the selection of working style, it would be interesting to find out which working style was the most efficient in each task. This is examined in Chapter 8.

Figure 77: Habit-oriented Reviser P12's Working Patterns in SR, PE and OR (Top to Bottom)

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Figure 78: Task-oriented Reviser P05's Working Patterns in SR, PE and OR (Top to Bottom)
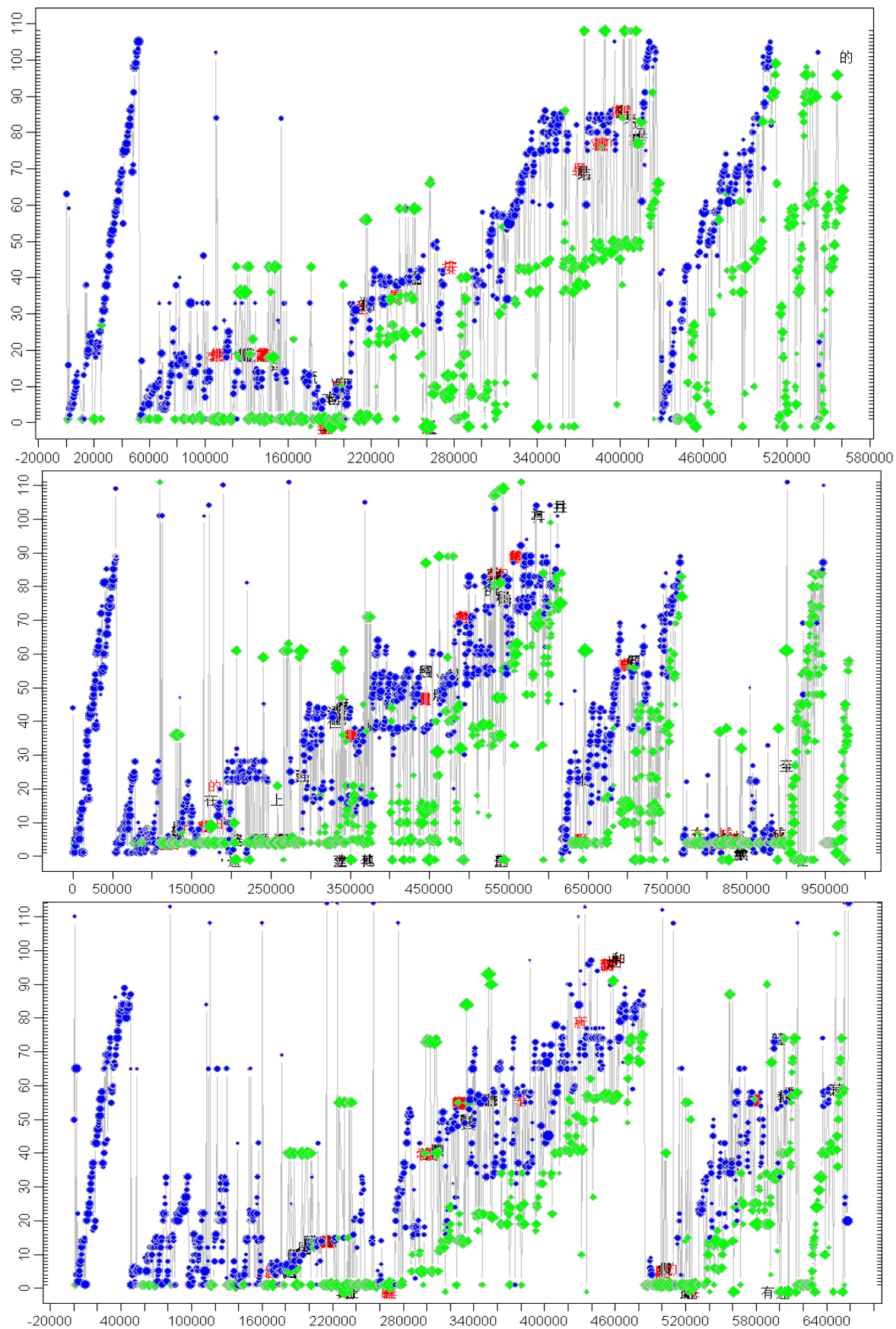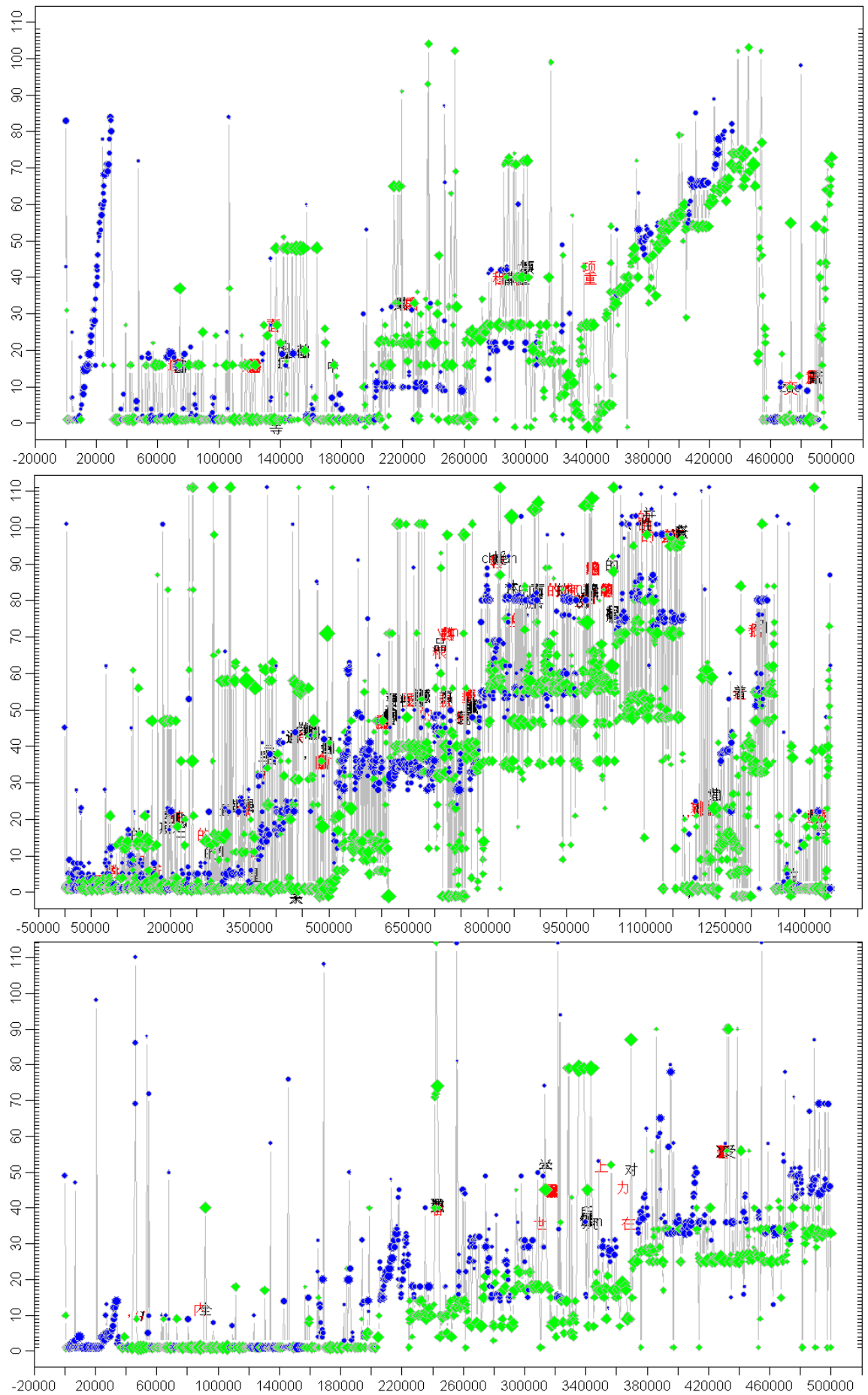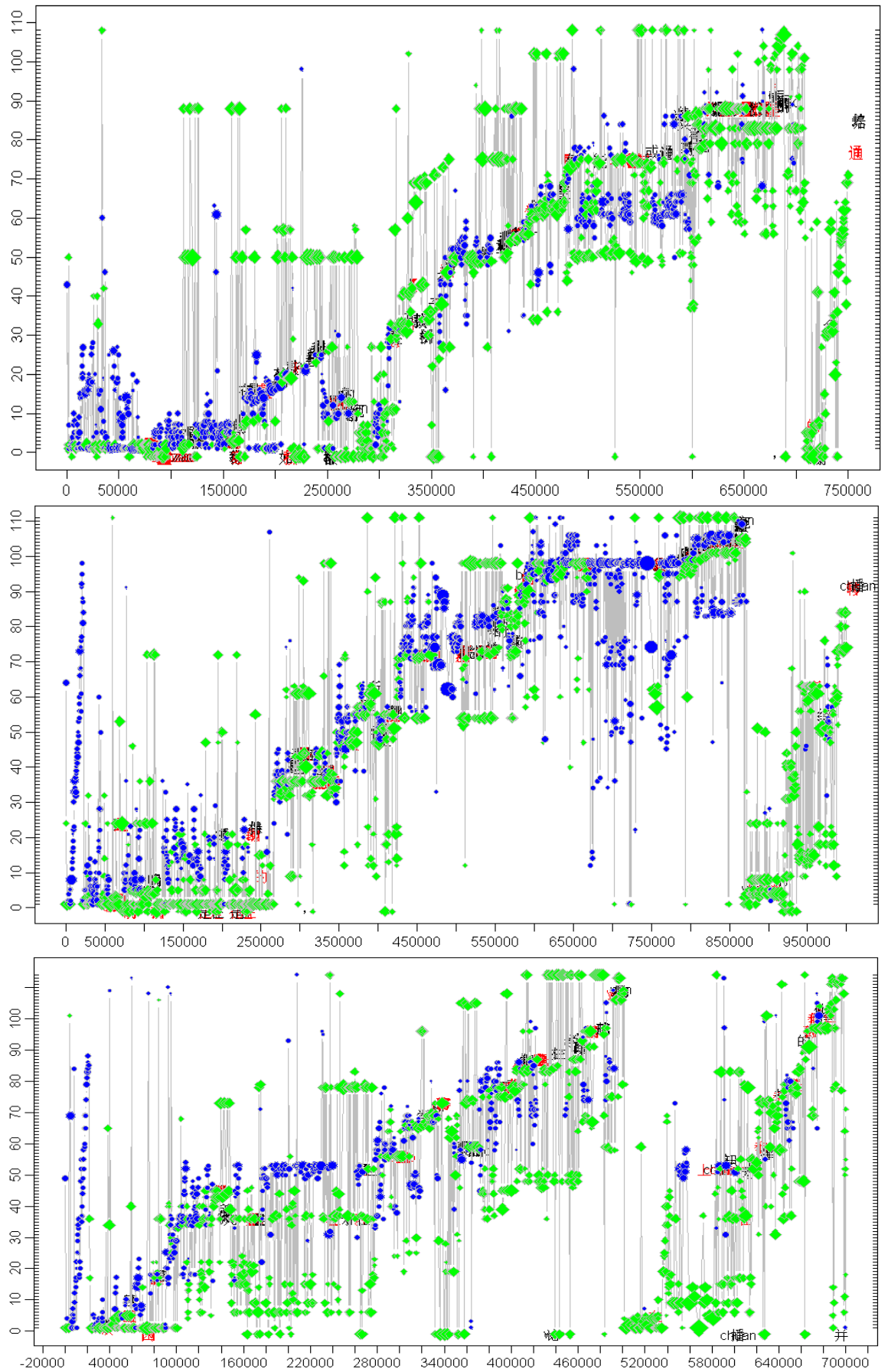
Figure 79: In-between Habit- and Task-oriented Reviser P08's Working Patterns in SR, PE and OR (Top to Bottom)

7.4 Summary of Findings

The results presented in this chapter provide answers to the third and fourth research questions proposed in this study:

RQ3: What are the working styles of student translators in performing self-revision, other-revision and post-editing?

RQ4: How do the working styles of student translators vary within and across tasks?

The working styles of the student translators in SR, PE and OR were explored through the investigation of working phases and the sequences of reading and typing activities in each working phase. By observing the participants' ProgGraphs in all tasks, three phases were identified: the planning phase, the drafting phase and the final check phase. For some of the participants, the planning phase and/or the final check phase was optional. The sequences and patterns of the reading and typing activities in each phase were presented and analysed based on the participants' cue-based retrospection data. Since it was impractical to present all the ProgGraphs in this thesis, the sequences of the reading and typing activities were coded, and the different TT run-through times of participants were calculated and compared across tasks on the basis of these codes.

Since the participants' reading patterns were different in each phase, and their TT run-through times varied both within and across tasks, only three out of four types of Robert's (2013) reading modalities were found to match the findings of the current study. Four types of working style were identified in this study, based on the levels of reading (sentence or text level), the aims of reading (to comprehend the ST or revise the TT as a whole, or to solve previously unsolved problems), and the reading sequences. These are presented in Table 50 below.

Working Styles	Sequences of Reading and typing activities
Macro-Micro-Macro processing	(1) Unilingual ST and/or TT reading at text level (2) Bilingual reading and detailed revision (3) One or many run-throughs of TT-focused reading with or without revision
Micro-Macro processing	(1) Bilingual reading and detailed revision, including unilingual ST or TT reading at sentence level at the very beginning (2) One or many run-throughs of TT-focused reading with or without revision
Macro-Micro processing	(1) Unilingual ST and/or TT reading at text level (2) Bilingual reading and detailed revision, including TT-focused reading and revision at sentence level
Micro processing	(1) One or two run-throughs of bilingual reading and detailed revision

Table 50: Summary of the Four Types of Working Style

Apart from the different levels of knowledge base, it was found that task type was another factor that influenced the student translators' working styles. Table 51 shows the working styles used in SR, PE and OR.

	SR	PE	OR
Ma-Mi-Ma	16.7%	50.0%	27.8%
Mi-Ma	55.6%	38.9%	27.8%
Ma-Mi	0.0%	0.0%	16.7%
Mi	27.8%	11.1%	27.8%

Table 51: Summary of the Working Styles of Student Translators' across Tasks

Despite this, after examining each participant's working styles across tasks, it was unexpectedly found that only 22.2% of the participants adopted different working styles in SR, PE and OR (Table 52), the rest of the participants either employing identical working styles across tasks (38.9%), or using the same working style in two tasks (38.9%). This indicates that some of the student translators had formed a fixed working style for dealing with revision-related tasks.

Habit-oriented Revisers	Task-oriented Revisers	In-between Habit- and Task-oriented Revisers		
SR=PE=OR	SR≠PE≠OR	SR=PE	PE=OR	SR=OR
38.9%	22.2%	**11.1%**	22.2%	5.6%

Table 52: Summary of Reviser Types in SR, OR and PE

The following chapter examines whether working styles affect student translators' working efficiency in terms of task time, in self-revision, other-revision and post-editing.

Chapter 8

Working Styles and Efficiency

This chapter explores the answer to the fifth research question proposed in this study: 5) To what extent does working style affect the working efficiency of the student translators in each task? In the present study, working efficiency was measured solely in terms of task time. The faster a task was completed using a particular working style, the more efficient that style was considered to be. Quality assessment was beyond the scope of the current study.

This research question was explored by examining the correlation between task time and working style/task type (section 8.1). The impact of the student translators' working style on task time is reported in section 8.2. The impact of task type on task time is reported in section 8.3. One-way ANOVA with post hoc tests were run to test the significance of the level of difference; the Tukey-Kramer test and Fisher LSD (see section 5.4) were used to conduct pairwise comparisons.

Section 8.4 concludes this chapter.

8.1 Sub-questions and Statistical Methods

The fifth research question was explored by considering the following two sub-questions:

SQ1: Which working style is the most efficient in terms of task time?
SQ2: Do all participants spend the most time on PE and the least on SR?

As discussed in section 5.4, to reduce the risk of observing significant effects driven by random outliers, the distributions of all data were checked and logarithmically transformed where needed. An example is given in Figure 80.
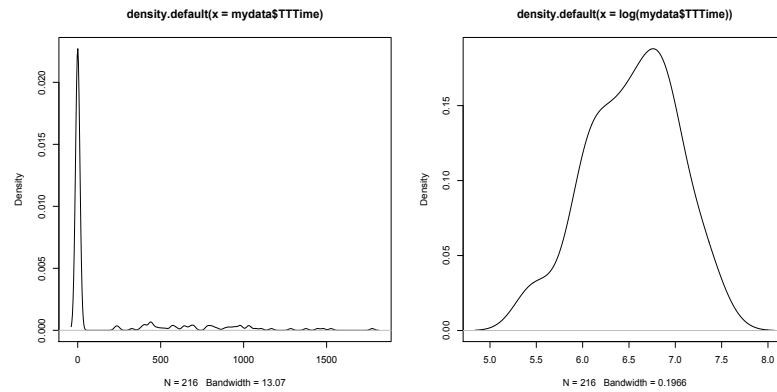
Figure 80: Data Distribution before and after Logarithmic Transformation (Task Time)

8.2 Working Style and Task Time

This section examines the influence of style on task time and answers the first sub-question: Which working style is the most efficient in terms of task time? In this study, there were three types of task: self-revision (SR), post-editing (PE) and other-revision (OR). Four types of working style were identified: Ma-Mi-Ma processing (G1), Mi-Ma processing (G2), Ma-Mi processing (G3) and Mi processing (G4).

Figure 81 below presents the mean task time for each working style across tasks. Ma-Mi processing (G3) was only identified in OR.

	G1	G2	G3	G4
■ SR	505.1	621.4	0	387.2
■ PE	932.7	1094.2	0	1299.3
■ OR	1008.5	584.5	477.1	759.5
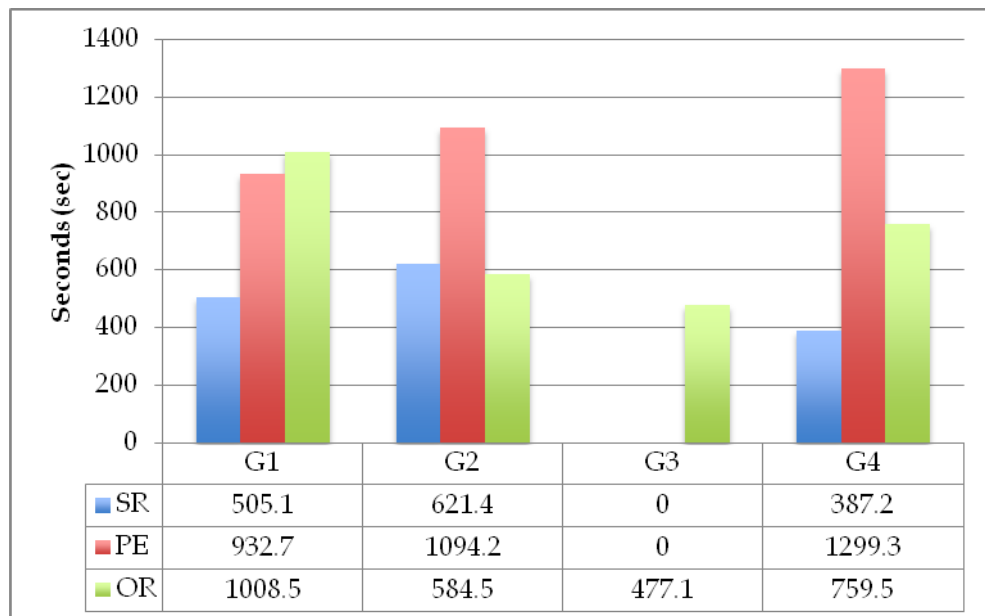
Figure 81: Working Style and Mean Task Time across Tasks

In the one-way ANOVA, the differences between the mean task time for G1, G2 and G4 in SR was found to be significant (F = 3.82, $p < 0.05$). The Tukey-Kramer test was used to conduct three pairwise comparisons. The results showed that in SR, the mean task time

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that G4 (387 s) took to complete the task was significantly shorter than that for G2 (621.4 s, t = 3.91, p < 0.05). The mean task time for G1 (505 s) was not significantly shorter than that for G4 (t = 1.97, p > 0.05) and was not significantly longer than G2 (t = 1.94, p > 0.05) (cf. Figure 82 and Table 53). This indicates that, in SR, G4 (bilingual revision) was the quickest in completing the task; G1 (unilingual ST and/or TT reading + bilingual revision + unilingual revision) was the second quickest; and G2 (bilingual revision + unilingual revision) seemed to be the slowest.

Tukey-Kramer Test for Differences Between Means in SR			
Groups	Difference	Test Statistics	p-level
G1 vs. G2	-116.36	1.94	0.3684
G1 vs. G4	117.88	1.97	0.3592
G2 vs. G4	234.24	3.91	0.0269

Table 53: Working Style Efficiency Comparison in SR

In PE, the difference between G1, G2 and G4 was significant (F = 5.60, p < 0.05). The Tukey-Kramer post hoc tests showed that in PE, G1 (932.7 s) was the most efficient, and it was significantly faster than G4 (1299.3 s), which took the longest time to complete the task (t = 4.72, p < 0.05). G2 (1094.2 s) was the second fastest, but it was not significantly slower than G1 (t = 2.08, p > 0.05) and was not significantly faster than G4 (t = 2.64, p > 0.05) (cf. Figure 82 and Table 54). This indicates that, in PE, G1 (unilingual ST and/or TT reading + bilingual revision + unilingual revision) was the fastest in completing the task, and G4 (bilingual revision) was the slowest.

Tukey-Kramer Test for Differences Between Means in PE			
Groups	Difference	Test Statistics	p-level
G1 vs G2	-161.44	2.08	0.3226
G1 vs G4	-366.57	4.72	0.0075
G2 vs G4	-205.13	2.64	0.1697

Table 54: Working Style Efficiency Comparison in PE

In OR, the difference between G1, G2, G3 and G4 was significant (F = 4.32, p < 0.05). The Tukey-Kramer post hoc tests showed that G3 (477.1 s) was the fastest in completing the task, and was significantly more efficient than G1 (1008.5 s). Although G1 was the least efficient in completing OR, it was not significantly slower than G2 (584.5 s) and G4 (759.5 s). G2 was the second fastest in completing OR, but was not significantly slower than G3 (t = 0.96, p > 0.05) and was not significantly faster than G4 (t = 1.57, p > 0.05). G4 was the

third fastest, and was not significantly slower than G3 (t = 2.53, p > 0.05) (cf. Figure 82 and Table 55). This indicates that, in OR, G3 (unilingual ST and/or TT reading + bilingual revision) was the most efficient, and G1 (unilingual ST and/or TT reading + bilingual revision + unilingual revision) was the least efficient.

Tukey-Kramer Test for Differences Between Means in OR			
Groups	Difference	Test Statistics	p-level
G1 vs. G2	423.93	3.80	0.0695
G1 vs. G3	531.34	4.76	**0.0185**
G1 vs. G4	248.93	2.23	0.4181
G2 vs. G3	107.41	0.96	0.9030
G2 vs. G4	-175.01	1.57	0.6893
G3 vs. G4	-282.42	2.53	0.3137

Table 55: Working Style Efficiency Comparison in OR

The above statistical analysis provides the answers to the second sub-question:

SQ1: Which working style is the most efficient in terms of task time?

Answers:
- In SR, G4 (Mi processing) was the most efficient; G1 (Ma-Mi-Ma processing) was the second most efficient; and G2 (Mi-Ma processing) took the longest time. The difference was significant between G4 and G2.
- Interestingly, in PE, G1 (Ma-Mi-Ma processing) was the most efficient. G2 (Mi-Ma processing) was in the middle, but was not significantly longer than G1. The difference between G1 and G4 was significant.
- In OR, G3 (Ma-Mi processing) was the most efficient, followed by G2 (Mi-Ma processing). G4 (Mi processing) was the third most efficient and G1 (Ma-Mi-Ma processing) took the longest time to complete the task of OR. The difference between G3 and G1 was significant.

The results are summarised in Table 56 below.

Task Type	Total Task Time
SR	G2 > G1 > **G4**
PE	G4 > G2 > **G1**
OR	G1 > G4 > G2 > **G3**

Table 56: Working Style and Mean Task Time

Section <u>8.2</u> examines the effect of working style on the student translators' working efficiency. It was found that the differences between the working styles were significant in each task, according to the one-way ANOVA test.

In SR, G4 (bilingual revision) was found to be the quickest in completing the task. G1 (unilingual ST and/or TT reading + bilingual revision + unilingual revision) was the second. G2 (bilingual revision + unilingual revision) seemed to be the slowest. This indicates that, since it is not necessary to read the ST and/or the TT at text level in either the planning phase or the final check phase, G1 and G2 take significantly more time than G4.

In PE, however, G1 (unilingual ST and/or TT reading + bilingual revision + unilingual revision) was the fastest in completing the task, followed by G2 (bilingual revision + unilingual revision) and G4 (bilingual revision). This indicates that the reading of the ST and/or TT on the text level in the planning phase might be helpful in increasing the speed of post-editing.

In OR, it was found that G3 (unilingual ST and/or TT reading + bilingual revision) was the most efficient, followed by G2 (bilingual revision + unilingual revision), G4 (bilingual revision) and G1 (unilingual ST and/or TT reading + bilingual revision + unilingual revision). Again, it seems that the reading of the ST and/or TT on the text level in the planning phase might be helpful in increasing the speed of revising others' work. However, unilingual revision in the final check phase seems unnecessary in terms of working efficiency, as G1 was ranked last in this category and was significantly slower than G3.

Based on the findings of this exploratory study, it is proposed that:

- In revising one's own work, Mi-processing (bilingual revision) should be adopted.
- In revising another student translator's work, Ma-Mi processing (the procedure of unilingual reading of the ST and/or the TT at text level with bilingual revision) should be adopted.
- In post-editing, Ma-Mi-Ma processing (the procedure of unilingual reading of the ST and/or the TT at text level, followed by bilingual revision and unilingual revision) should be adopted.

Please bear in mind that the above suggestions are mainly drawn from the findings of the present study, which used student translators as participants. In addition, these suggestions are made only on the basis of time efficiency. The quality of the final work was not evaluated. Further investigations need to be carried out to compare the effect of

working styles on the quality of revision and post-editing in order to provide more definitive suggestions.

8.3 Task Type and Task Time

This section examines the effect of task type on total task time, and answers the fifth question: Do all participants spend the most time on PE and the least on SR?
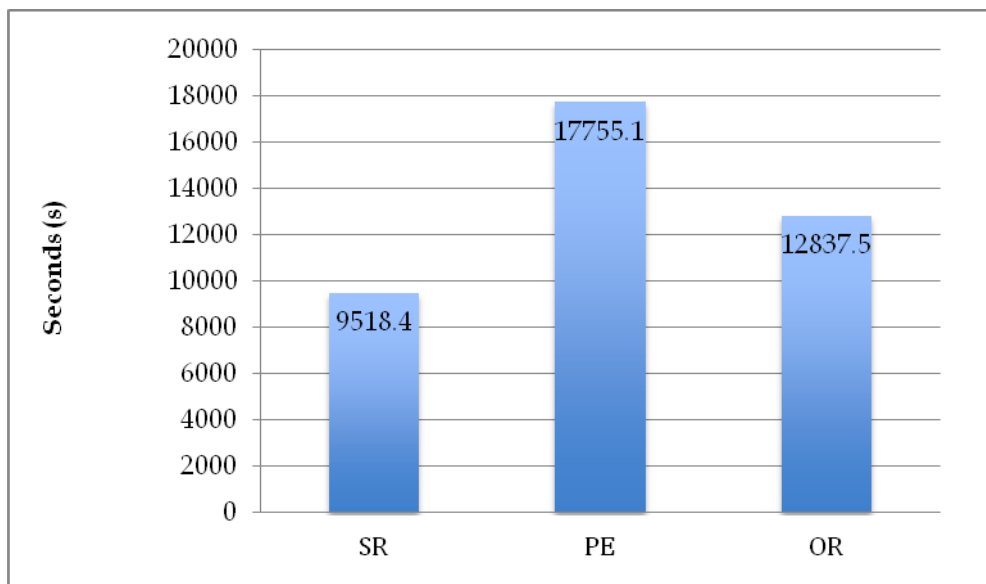
Figure 82: Total Task Time across Tasks

According to the one-way ANOVA, the total task times for SR, PE and OR were significantly different ($F = 13.20$, $p < 0.0001$). Three post hoc pairwise comparisons were conducted in the Fisher LSD tests (see section 5.4). As can be seen in Figure 82, the total task time for PE was 17,755.1s. This is almost twice the length of that for SR (9,518.4s) ($t = 5.10$, $p < 0.0001$). It took the participants a significantly longer time to complete PE than OR (12,837.5s, $t = 3.10$, $p < 0.05$). They also needed a slightly longer time for OR than for SR ($t = 2.00$, $p = 0.0504$) (cf. Table 57 and Figure 82).

Fisher LSD			
Group vs. Group (Contrast)	Difference	Test Statistics	p-level
OR vs. PE	-303.23	3.10	0.0031
OR vs. SR	196.05	2.00	0.0504
PE vs. SR	499.27	5.10	0

Table 57: Task Time Comparison across Tasks

However, if one takes a closer look at the total task time that every participant spent on each task, it can be seen that not all participants spent the most time on PE (Figure 83).
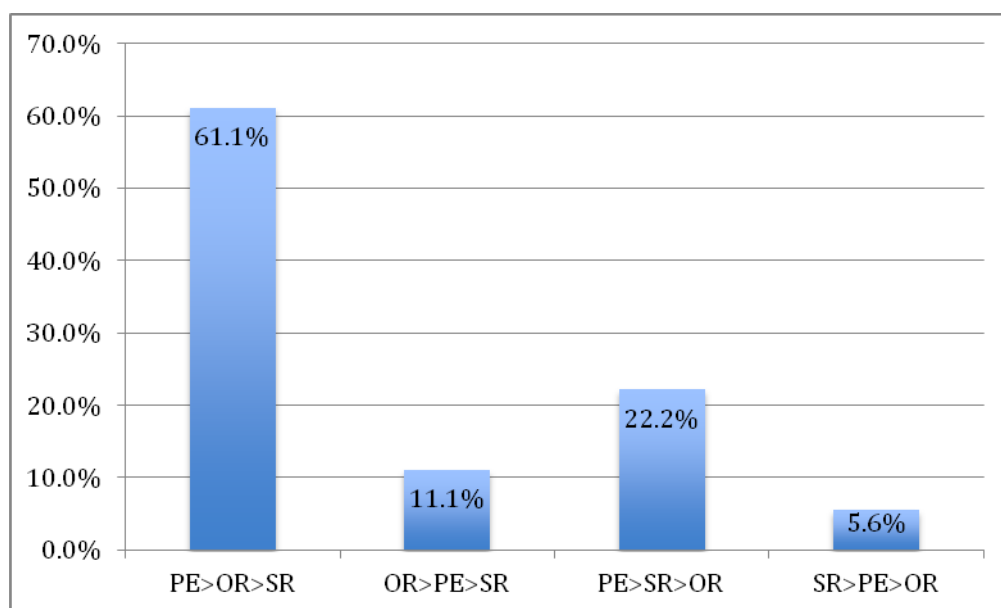
Figure 83: Participant Variations in Total Task Time

The above statistics provide the answers to the fifth sub-question:

SQ2: Do all participants spend the most time on PE and the least on SR?

Answer: Generally speaking, the answer is no.

- 11.1% of the participants spent more time on OR than on PE or SR (OR > PE > SR).
- 22.2% of the participants spent more time on PE than on SR or OR (PE > SR > OR).
- It took 5.6% of the participants more time to finish SR than PE or OR (SR > PE > OR).
- 61.1% of the participants took more time to complete PE than OR or SR (PE > OR > SR).

Since the student translators were asked to do a full post-editing, it seems that PE should have been more time-consuming and labour intensive than OR and SR. Section 8.3 examined the above assumption and found that, although the majority of the student translators spent more time on PE than on OR and SR, 11.1% spent more time on OR than on PE, and 5.6% spent more time on SR than on PE. It should be noted that the raw text for PE was not expected to be of a similar quality or standard to the SR or OR, where human translation had already taken place. This is probably why most of the student translators in the current study spent more time on PE. In addition, the participants in this

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study had not received any formal training in SR, OR or PE in advance of conducting any of the tasks. This might explain why some of these student translators were more efficient at PE than at revising human translations – they lacked effective self-revision and other-revision strategies.

8.4 Summary of Findings

The results presented in this chapter provide answers to the last research question proposed in this study:

RQ5: To what extent do working styles affect the working efficiency of student translators in each task?

Answers: Based on the findings of this exploratory study, it is suggested that:

- Micro-processing (bilingual revision) be used for self-revision
- Micro-Macro processing (unilingual reading of the ST and/or the TT at text level with bilingual revision) be used to revise others' translations
- Macro-Micro-Macro processing (unilingual reading of the ST and/or the TT at text level, followed by bilingual revision and unilingual revision) be used to post-edit (full post-editing) a raw machine translation.

The above suggestions were constructed based on the findings of this study, in which the participants were student translators. Further investigations need to be carried out to test professional translators' performances in conducting self-revision, other-revision and post-editing. Besides, it should also be noted that, although the majority of the participants spent the longest time on post-editing, there were some participants who spent most of their time on self-revision (5.6%) or other-revision (11.1%).

In the following chapter, a conclusion to this study is presented, the limitations of the research are outlined, and some suggestions are made for future research.

Chapter 9

Conclusion

The purpose of this study was to identify the working styles of student translators in three different tasks: SR, (full) PE, and OR, using a data decoding and analysis method in English-into-Chinese process-oriented research within a CRITT data collection and analysis framework. Eye tracking, keylogging and cue-based retrospection techniques were triangulated as data elicitation methods. Both quantitative and quantitative analyses were conducted to interpret the data. In order to examine the student translators' coordination of physical and mental activities, five research questions were formulated, as listed below:

RQ1: What types of reading and typing activity can be identified in the self-revision, other-revision and post-editing processes?

RQ2: What are the purposes underlying these activities?

RQ3: What are the working styles of the student translators in performing self-revision, other-revision and post-editing?

RQ4: How do the working styles of the student translators vary within and across tasks?

RQ5: To what extent do working styles affect the working efficiency of the student translators in each task?

To answer these questions, an empirical investigation of 18 student translators' self-revision, other-revision and post-editing processes was carried out. Theories and research in translation-related studies (e.g., revision, translation and post-editing styles and processes), language comprehension and production (e.g., Kring's text comprehension analysis model and Kellogg's language production model), and cognitive psychology (e.g., cognitive information-processing model, working memory, visual attention etc.) were drawn on to serve as the theoretical underpinnings of the present study.

A brief summary of the findings is presented in Table 58. In sections 9.1 to 9.3, the results and findings for each research question are reviewed. Section 9.4 outlines the

strengths and limitations of this study, discusses possibilities for future research and concludes the study.

Research Questions	Brief Summary of the Findings
RQ1	Seven types of reading and typing activity identified in all tasks
RQ2	Different purposes underlying each type of activity
RQ3	Three working phases and four types of basic working style identified across tasks
RQ4	Three types of revisers identified
RQ5	Different working styles suggested for specific tasks

Table 58: Research Questions and Brief Summary of Findings

9.1 Student Translators' Physical and Mental Activities Revisited

In this study, the 'physical activities' of the student translators refer to their reading and typing activities in doing translation-related tasks, while 'mental activities' refer to their purposes when carrying out the reading and typing activities. The 'working styles' of the student translators refer to their coordination of the physical and mental activities.

Questions 1 and 2 investigated what the student translators did during the SR, OR and PE processes, and why they did it.

By analysing the activity data, seven types of reading and typing activities were identified in all three tasks. This confirmed the assumption that the basic reading and typing activities would all be the same in translation-related tasks.

These activities included:

- Type 1: ST reading unit (source text reading unit).
- Type 2: TT reading unit (target text reading unit).
- Type 3: TT typing unit (target text typing unit).
- Type 4: TT typing + ST reading unit
  (target text typing while reading the source text unit).
- Type 5: TT typing + TT reading unit
  (target text typing while reading the target text unit).
- Type 6: TT typing + ST/TT reading unit
  (uninterrupted target text typing while quickly shifting the gaze between the source text and the target text).
- Type 7: Idle (no recorded activity, the length of which is longer than one second).

These activities are the basic elements of the reading and typing activity sequences. Although all types were identified in each task, not every participant performed all seven types of physical activity. ST reading, TT reading, and TT typing were performed by 100% of the participants across tasks, while TT Typing + TT reading were performed by 100% of the participants in PE only. Apart from this, the occurences of almost all the other activities were the lowest in SR (e.g., 22.2% for TT typing + ST reading; 33.3% for TT typing + ST/TT reading), with the exception of Idle, which was the highest in SR. First of all, the different distribution of the reading and typing activities among the participants infers individual differences in working style. Secondly, the low frequency of the parallel activities (TT typing + ST reading; TT typing + ST/TT reading) for most of the participants in SR indicates that they were mainly focused either on ST processing or on TT processing. Thirdly, the fact that a high number of participants had idle units (pauses) might be an indication of a high cognitive load (O'Brien, 2006; Dragsted, 2010). This should be further investigated by comparing the participants' pupil sizes across tasks.

With respect to the number of reading and typing activities, PE had the highest number, followed by OR and SR, in all tasks. According to the participants' retrospection data, many re-translated several parts of the MT output, although they were reminded that they could ignore stylistic and textual problems, and that the expected quality was medium. This was probably because the requirements in the task brief, as well as the other post-editing guidelines, such as 'accurate grammar', had made them mistakenly think that the full post-editing job was not dissimilar to a translation job, and that the quality of the post-edited text should be the same as that of a human translated text.

With regard to the duration of each type of activity, it was found, surprisingly, that the mean duration of all activities was longer in SR than in PE or OR. Based on the participants' retrospection data, possible interpretations are: (1) they had gained familiarity with the ST and the TT during the translation period. With the macrostructure of the texts in mind, they could easily retrieve the text knowledge from their long-term memory and process the texts in larger attentional sizes (durations); (2) they were aware of the uncertainties or problems that had not been solved during the translation phase, and therefore, in SR, focused longer on the problematic areas. According to Jensen (2011, p. 232), the more difficult a task, the greater the number of attentional shifts, and the lower the duration of attention units. This could also be used to explain the highest number of activities, and the fact that the duration of all five types of activity was the lowest in PE, as it was assumed that the task of PE was the most difficult.

The most common reasons given for reading the ST were to comprehend and analyse the ST (e.g., to extract ST meaning; to confirm accurate understanding of the ST; to confirm accurate meaning transfer of the ST, and to generate, test, reject or accept

plausible meaning hypotheses of the ST) and to prepare for other processes (e.g., to prepare for positive or negative evaluation of the TT; to propose solutions to previously unsolved or newly identified problems, and to retranslate the ST).

It was also found from the retrospection data that the reading of the TT comprised three types of reading activity: reading the existing TT, reading the newly produced TT, and reading the entire TT, which corresponds with Krings' (2001) findings. The underlying purposes of these three types of TT reading were different, however. The reading of the existing TT was mainly to comprehend and analyse the TT; the reading of the newly produced TT was to verify the revision (previous decisions), and the reading of the entire TT was largely to evaluate and verify the TT from the perspective of target readers, and to check the naturalness of the TT.

The aim of TT typing was to propose and/or produce new TT segments by making deletions and insertions.

Reading the source text while typing is a type of parallel activity. The participants reported that this was an ST analysis and TT reformulation process. In other words, they were producing the TT while generating, testing, rejecting or accepting better translation options. The extent of this activity was limited, and the mean duration was quite low compared with other activities, such as ST reading or TT reading.

Reading the TT while typing was a complex process. On the one hand, the TT was formulated in the mind and executed with the hand; on the other hand, the TT typing activities were monitored and the TT contents were evaluated.

TT typing while reading the ST and the TT was a sequence of reading and typing activities. That is to say, while the typing activities were going on, the gaze shifted from the ST to the TT, or from the TT to the ST. During this process, the appropriateness of the ST meaning transfer was evaluated and/or confirmed while typing; the ST information could be retrieved through quick shifts. It is possible that ST and TT decoding and typing activities took place simultaneously, but this conclusion is derived mainly from the participants' subjective and conscious data.

The last type of activity was Idle, otherwise called pause. No data were registered during an idle period (the threshold was one second). Typically, the participants might look down to find a certain key on the keyboard, or move their eyes away, or even close their eyes during their thinking process.

The identification of these seven types of activity and the analysis of the purposes underlying these activities provided a theoretical basis for the analysis of the student translators' working styles.

9.2 Working Styles of Student Translators Revisited

Question 3 asked when, how (in what sequences) and why did the student translators' revise and post-edit?

By analysing all the participants' revision and post-editing ProgGraphs, three basic working phases were detected: the planning phase, when the participants read the ST and/or the TT at text or sentence level to get a general overview of the content; the drafting phase, when the ST and the TT were compared and the TT was revised in detail (this was the most time- and labour-intensive phase), and the final check phase, when the participants read the TT and/or the ST at text or sentence level, mainly in order to check the naturalness of the TT. Not all the participants had a planning phase and/or a final check phase, which is in line with Carl (2015). However, Shih (2006b) found that most professional translators have a re-checking (final check) phase, with the aim of justifying their revisions and reassuring themselves that all problems have been sorted out. This disparity might be owing to the different levels of expertise of the participants in the current study. The three phases identified in this study are very similar to those detected by Jakobsen (2003) in the translation process, although he considered the first keystroke as the anchor of the drafting phase. In revision and post-editing, this does not apply.

In the drafting phase, similar reading patterns to those observed by Dragsted and Carl (2013) in the translation process were identified in the revision and post-editing processes. In SR, there was much evidence of narrow-context planning, which means the ST and the TT were read in parallel; in PE, there was more sentence planning, where the reading of the ST was at sentence level and was far more to the right of the TT. In other words, the ST was previewed more broadly than the TT segment that was being processed. In OR, there was a combination of narrow-context planning and sentence planning. Back-tracking behaviour was observed in all tasks.

Generally speaking, in all tasks, the reading and typing activities in the drafting phase were more intensive than in the planning and final check phases. The students translators worked at word or sentence level during the drafting phase, whereas in the final check phase they tended to work at text level. This is in line with Shih (2006b), who found that the majority of the professional translators spent the most time on their first run-through of the translation draft, and in later run-throughs they were able to process the TT in larger chunks. This indicates that, regardless of the level of expertise, the more a translator revises the TT, the longer the chunks s/he can process at a time.

Based on the retrospection data and the findings of the activities in the previous explorations (research questions 1 and 2), as well as Shih's (2003) revision model and

Hayes *et al.*'s (1987) model of the revision process in writing research (1987), a tentative model of the revision and post-editing drafting process was proposed.

By comparing the findings of the present study with Mossop's (2014) suggestions regarding revision procedures and Robert's (2008; 2013; 2014) empirical investigations into revision procedures and efficiency, it was found that the revision procedures of the student translators were slightly different from our assumption.

Firstly, many of the student translators started their revision either by reading the entire ST and/or TT, or by conducting comparative revision. This is the opposite of Mossop's (2014) suggestion – doing a unilingual TT reading and/or revision without referring to the ST. Robert (2008; 2013; 2014) devoted her study to the investigation of revision styles and efficiency, and concluded that: (1) the most frequently used revision styles were a single bilingual reading, a single unilingual reading, a unilingual reading followed by a bilingual reading, and a bilingual reading followed by a unilingual reading; and (2) apart from the fact that unilingual revision is both the fastest and the poorest in quality, there is little variation in the other types of revision style.

These data was collected from two small-scale surveys in 2006 and 2007, and all her subsequent empirical investigations were based on this finding. Although this might be a true reflection of the daily working style of professional translators, the potential problem is, as observed by Künzli (2007) and Englund Dimitrova (2005), that professional translators do not often do what they claim to do: although fully aware of the golden rules, they may not always follow them. Empirical investigations should thus be based on more objective and unbiased findings.

Secondly, it seems that both Mossop and Robert were suggesting two to three readings of the texts, but some of the student translators in the present study went through the texts many times. In Shih (2006a; 2006b), some of the professional translators said that they would normally revise once or twice, while others stated that they would go through the TT three to four times. It is therefore also worth investigating whether the number of run-throughs affects the time and quality of revision and post-editing.

Based on the reading patterns, this study identified four types of working style. Macro-Micro-Macro processing includes a quick unilingual ST and/or TT reading at text level, followed by one or two detailed bilingual revisions at text level, then one or several ST and/or TT readings at text level with the aim of final-checking the naturalness of the revised text. Both Macro-phases were optional, therefore the three other working styles were: Micro-Macro processing, Macro-Micro processing, and Micro-processing. Robert's (2013; 2014) unilingual revision style was not found in this study, but this might be owing to the difference in participants' expertise (i.e., professional translators may prefer unilingual revision). Shih (2006b) identified two revision processing patterns of

professional translators. The first pattern includes only one detailed run-through of the TT, but the translators spent a similar amount of time and effort on it to the amount they spent on the first translation draft. This pattern is comparable to the Micro-processing working style identified by the present study. The Micro-processing style only includes a drafting phase, in which intensive reading and typing activities take place. Shih's (2006b) second revision processing pattern is similar to the Micro-Macro processing style recognised by the current study. It consists of two or more run-throughs, but the first run-through normally consumes more time and effort than later run-throughs. It is worth investigating in future research whether or not the other two working styles, Macro-Micro-Macro processing and Macro-Micro processing, can be identified in the revision and post-editing processesof professional translators.

Question 4 examined how the student translators differed from each other in working on tasks of varying degrees of complexity.

It was found that, in SR, more than half (55.6%) of the participants chose to use Mi-Ma processing, while nobody used Ma-Mi processing. In PE, most of the participants used Ma-Mi-Ma processing (50.0%) and Mi-Ma processing (38.9%), and again, no participant used Ma-Mi processing. In OR, the same proportion (27.8%) used Ma-Mi-Ma, Mi-Ma and Mi processing , whereas 16.7% of the participants chose to use Ma-Mi processing.

It seems that the participants varied considerably in selecting their working styles. However, it was surprising to find that 38.9% of the participants were habit-oriented, which is to say, they did not change their working style across tasks. The change of task complexity did not affect their method of self-revising, revising others or post-editing. 22.2% of the participants were task-oriented, using three completely different working styles in three tasks. This indicates that the task-oriented revisers were very flexible in adjusting their strategies to work on different tasks. Another 38.9% of the participants used identical working styles in two of the three tasks, thus placing them in between the habit-oriented and task-oriented revisers.

Since Robert's (2013; 2014) tests did not show significant differences among different revision styles, the present study provided a further opportunity for a significance test to be carried out. The results are reported in the following section.

9.3 Working Styles and Efficiency Revisited

Question 5 asked which working style(s) were the fastest in completing the tasks. The effect of task type on task time was further tested to compare individual task completion times.

By running one-way ANOVA post hoc tests, pairwise comparisons were carried out to compare the mean task time for each working style within tasks.

It was found that the differences among the working styles in terms of time efficiency in each task were significant. This indicates that working styles have a strong effect on task completion time.

- In SR, G4 (Mi processing) was the most efficient, and was significantly faster than G2 (Mi-Ma processing). G1 (Ma-Mi-Ma processing) was the second most efficient, and did not take a significantly longer time to finish the SR.

- Interestingly, in PE, G1 (Ma-Mi-Ma processing) was the most efficient, and was significantly faster than G4 (Mi processing). G2 (Mi-Ma processing) was the second fastest, but did not take significantly longer than G1.

- In OR, G3 (Ma-Mi processing) was the fastest, and was significantly more efficient than G1 (Ma-Mi-Ma processing). G2 (Mi-Ma processing) was again second, and was followed by G4 (Mi processing).

Based on the analysis of the data presented above, suggestions regarding the efficiency of working styles in self-revision, other-revision and post-editing can be made. These are presented in Table 59:

Task	Most Efficient Working Style	Least Efficient Working Style
SR	Micro-processing (Bilingual revision)	Micro-Macro processing (Bilingual + Unilingual revision)
PE (full)	Macro-Micro-Macro processing (Unilingual + Bilingual + Unilingual revision)	Micro-processing (Bilingual revision)
OR	Macro-Micro processing (Unilingual + Bilingual revision)	Macro-Micro-Macro processing (Unilingual + Bilingual + Unilingual revision)

Table 59: Working Style Selection for Different Tasks

It was also found that the total task time spent by participants on PE was significantly longer than that spent on OR or SR. However, although 61.1% of the participants fell into this category, 11.1% spent more time on OR than on PE or SR, 5.6% spent more time on SR than on PE or OR, and 22.2% spent more time on PE than on SR or OR.

9.4 Strengths, Limitations and Future Avenues

This study triangulated non-intrusive eye tracking with keylogging methods which generated objective and unbiased data for both quantitative and qualitative analyses. The UAD and ProgGraphs provided empirical evidence of student translators' self-revision, other-revision and post-editing processes, which can be used in future studies for research

or pedagogical purposes. The theoretical framework drawn from multiple disciplines laid a solid foundation for the analysis of the retrospection data. By combining the 'eyes', the 'keys' and the 'minds', this study presents a fuller picture of what occurs in student translators' conscious or unconscious minds.

This study has presented a data compilation procedure that can be used in English-into-Chinese, or say, any language-into-Chinese process studies, under the data collection and analysis framework of CRITT TPR. This will enable more researchers to conduct eye tracking and keylogging experiments to collect and analyse data that suit their specific needs in research into translation or writing.

This study identified four basic working styles from the analyses of the data, tested their efficiency in different tasks, and made some suggestions for the revision and post-editing procedures. However, since only student translators were involved as participants in this study, a comparative analysis of translators with different levels of expertise was not possible. Based on her findings, Shih (2006b, pp. 202-204) offers some recommendations for student translators, suggests aspects of pedagogical design for translator training, and states that student translators should be taught how to revise and be given feedback on their work. Similarly, one of the overall aims of the current research was to demonstrate in visual form the behaviours and strategies that student translators adopt in self-revision, other-revision and post-editing, and to provide insights for translator instructors so that the areas that student translators need to work on in revision and post-editing can be identified and targeted in training. In future, follow-up work will be centred on the investigation of the working styles that professional translators have routinised in self-revision, other-revision and post-editing, and of the efficiency of each working style in different tasks. By comparing the revision and post-editing processes of student translators and professionals, future research will contribute to translator training, in particular to the development of course syllabuses on self-revision, other-revision and post-editing, as well as to research into the revision and post-editing processes in the field of translation. Furthermore, in future, the data collected in this study will also be explored from both linguistic and cognitive perspectives by combining the linguistic data (e.g., actual revision changes) with eye movement data (e.g., fixation counts or the duration of a particular linguistic unit) to reveal the student translators' revision and post-editing problem-solving strategies and to contribute to translation pedagogy.

Although the compilation process of 54 batches of raw logging data (18 participants * 3 tasks) was very time-consuming and labour intensive, from the perspective of individual working styles, 54 samples are still far from sufficient. It is

hoped that, in future, more experimental research could further probe into professional translators', revisers' and post-editors' cognitive processes and working styles.

Owing to limitations of time and space, this study did not conduct an analysis of translation quality. Future research is planned, using the data obtained in this study, to look into the working styles from a more 'zoomed' view. For instance, it will ask what types of error professional and student translators detect in revision, and what sort of gaze patterns they use for detecting that kind of error and solving problems; how run-through times affect the quality of revision and working efficiency; how translators' cognitive load varies in using different working styles; how many participants in this study used identical working patterns in translation, self-revision, other-revision and post-editing (the translation data are to be analysed), and to what extent their working styles in translation mirrored or differed from the working styles they use in post-editing.

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Appendices

Appendix 1: Source Texts

Text A:

Cambridge University is recognised internationally for creative thought and transformative research of the highest calibre across a broad subject based of sciences, social sciences and the humanities. Our research and scholarship benefit from and help to shape national and international agendas. In future, we will continue to foster interdisciplinary and multidisciplinary ideas and create collaborative research environment. We expect our research to generate outcomes which enhance social and human well-being, or have the potential to do so through shaping academic disciplines. We aim to be a place where the most motivated students and leading researchers choose to work and visit. (100 words)

Text B:

At Warwick, our commitment to be demonstrably a centre of world class research and innovation across all of our academic disciplines remains as strong as it always has been. We share resources and knowledge with academic communities throughout the world through collaborative partnerships. We present our major areas of research strength around key global priorities and challenges currently confronting the world, such as food security and energy. We concentrate on the positive impacts of Warwick research on society at large, particularly in areas of knowledge transfer. Our aim is to undertake exciting, ground-breaking, excellent and in many instances, policy-relevant research. (100 words)

Text C:

Oxford leads and actively supports a wide range of regional, national and international initiatives designed to showcase the value of research and its intellectual, social, cultural, industrial and economic impacts. Research carried out by Oxford's staff, students and alumni has made an enormous impact on the world of ideas. Our ambitions are influenced by more than eight centuries of learning, scholarship, research and public engagement. We will continue to provide a supportive research environment in which scholars, at every stage of their career, can flourish and develop. We will also keep attracting the very best research students nationally and internationally. (100 words)

Appendix 2: Departmental Ethical Approval

School of Modern Languages and Cultures

Research Ethics Monitoring and Approval Form

Ethical consideration and approval is required for learning, teaching and research activities where ethical issues are identified, for example work involving human participants, animals or environmental impact. Within the School of Modern Languages and Cultures, activities involving human participants and their data (such as interviews or surveys) are likely to be the primary focus of ethical review. This form is intended to gather information about proposed research projects by PGT and PGR students and members of academic staff for which ethical approval might be required. It should be completed **if you have identified any ethical issues in relation to your proposed research project (e.g. collection and use of personal data).** If you are unsure whether or not your application requires ethical approval, please contact the Research Office and the School's Director of Research.

- Academic staff who are not seeking external funding for a project should complete the form and submit it to the Director of Research along with an outline (300 words max.) of the proposed research project at least six weeks before the proposed research activity is due to be carried out
- For external funding applications, the form should be completed and submitted with the application when it is submitted for internal review by Director of Research and Head of School
- MA Course Directors and PGR supervisors are responsible for identifying any ethical issues related to research activity by PGT and PGR students and submitting the form to the Director of Research on their behalf. The form should be accompanied by an outline of the thesis (for PGR students) or proposed dissertation/coursework assignment (for PGT students)

Name: Jin Huang

Category: PGR

Supervisor/Course Director: Dr Binghan Zheng; Dr Federico Federici

Module [PGT only]: Translation Studies

Title of project: Working Styles of Student Translators in Revision and Post-editing: an Empirical-Experimental Study with Eye-tracking, Keylogging and Cue-based Retrospection

Questionnaire

1. Where will the research take place?*

The experiments will take place in the Eye tracker lab (253b) at school of Modern Languages and Cultures, Durham University.

Note: when conducting or collaborating in research in other countries, Principal Investigators should comply with the legal and ethical requirements existing in the UK and in the countries where the research is being conducted.

2. What are the aims of the project?

The aims of the project are to probe into translators' cognitive process of translation revision and post-editing by analysing their physical activities (e.g. sequences of reading and typing activities) and mental activities (e.g. purposes of reading and typing activities), and to find out the working styles of student translators in the tasks of self-revision, other-revision and post-editing.

3. How many participants are involved?

36

4. How will potential participants be identified?

The target participants are MA students enrolled in English-Chinese Translation programme. A call for participation email will be sent to recruit potential participants.

5. What sort of data will be collected?

Eye tracking, keystroke logging and verbal data (through cue-based retrospective interview) will be collected.

6. Will you seek written or verbal consent from your informants regarding project participation and the use of any data that you might generate? If YES, please provide further details. If NO, why not?

Yes. Participants will be first of all introduced to the aims of study, experiment procedures, and tasks that they are expected to do. Then they will be guided to read the written consent form carefully. They are allowed to ask any questions before they sign the consent form. A verbal recount of their agreement to the terms in the form, as well as a copy of the signed consent form will be given to them.

7. Will you give your informants a written summary of your project and the uses of any data that you might generate? If NO, why not?

Yes. I will give the participants a brief written summary of my project with explanation of the types of data the study have generated.

8. Will data be anonymised?

The Data will be completely anonymised. Every participant will be randomly allocated to a number, such as P1, P2, P3 etc. No personal data will be shown in any forms of publication.

NOTE: the provision of an information statement and verbal consent are suitable for informal interviews or surveys where no personal data is collected or the information is anonymised. For full interviews or surveys in which personal/sensitive/confidential data is collected both a written summary of the project and a written consent form is recommended (or an audio recording of the verbal consent process).

9. Will the data be destroyed at the end of the study?

No.

10. If NO, what will happen to the data after the end of the study?

The data will be kept for future research analysis by the researcher.

11. For how long will it be kept after the end of the study?

5 years.

12. Will written consent for the use of data for the anticipated future research be obtained?

Yes.

13. Are there any other ethical issues arising from your project? If YES, please outline below.

No.

Declaration

I have read:

1. The University's document on Ensuring Sound Conduct in Research http://www.dur.ac.uk/resources/hr/policies/research/ensuringsoundconduct.pdf and believe that my project complies fully with its precepts.

2. The Principles for Data Protection (Data Protection Act 1998) http://www.dur.ac.uk/data.protection/dp_principles/

3. The Guidance for Research Using Personal Information http://www.dur.ac.uk/resources/data.protection/100929ResearchDPAAdviceV1.3.pdf

Signed ……Jin Huang…………   Date: ……6 August 2013……

Appendix 3: Pre-experiment Questionnaire

QUESTIONNAIRE - PARTICIPANT BACKGROUND INFORMATION

I. Personal Information

Name:……………………

Gender: □ M   □ F

Age:…………………….

Major (Undergraduate): …………………………

Which of the following option(s) best describe(s) your eye condition?

□short-sighted   □far-sighted   □astigmatic   □normal

Do you need to wear glasses in the experiment?

□yes   □no

If yes, what type of glasses do you need to wear?

□glasses with frame   □soft contact lenses   □hard contact lenses

What is your pupil colour? ……………….

Eye operation(s):

□yes (in year ....)   □no   □will do (in year….....)   □n/a

Droopy eyelids: □yes   □no   □n/a

Downward eyelashes: □yes   □no   □n/a

II. Professional Information

Languages L1…......................... **L2**…......................... **L3**….........................

Chinese input method(s) you use:…………………………………………………….

Are you a touch typist (in typing Chinese characters)?
□yes □no □not sure

Years of formal translator training: …................. year(s)

Years of translation experience:…................. year(s)

Do you use machine translation? □yes □no

Have you received any training on post-editing[51]?
□yes (please specify your experience………………...) □no

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[51] In simple terms, post-editing refers to the revision of the raw machine translation output conducted by a human translator.

Appendix 4: Participant Information Sheet

- **Title of the Study:**

Working Styles of Student Translators in Revision and Post-editing: an Empirical-Experimental Study with Eye-tracking, Keylogging and Cue-based Retrospection

- **Introduction**

You are invited by Ms Jin Huang (jin.huang@durham.ac.uk), a PhD student in Translation Studies at Durham University, to take part in her research project entitled *Working Styles of Student Translators in Revision and Post-editing: an Empirical-Experimental Study with Eye-tracking, Keylogging and Cue-based Retrospection.*

- **Research Aims**

This research aims to investigate student translators' cognitive processes during revision and post-editing to discover what their working styles are in different tasks.

- **Why have you been invited?**

You are invited to take part in the experiment as you meet the inclusion criteria for this research: (1) you are a translation student at postgraduate level in a UK HE institution; (2) you have Chinese as your mother tongue and English as your second language.

- **Do you have to take part?**

Participation in this research is purely voluntary. You have the right to decide whether to take part in the experiment or not. You have the right to withdraw at any time during the experiment without affecting your status. Refusing to participate or withdrawing from participation will not affect your position in any other respect.

- **What are you supposed to do in the experiment?**

In this experiment, you will be given four tasks to complete.
1) Text Copying. You will be introduced to the eye-tracking system, the keylogging software, as well as the do's and don'ts of the experiment before undertaking any tasks. Then you will be given a 100-character Chinese text to copy into Chinese in Translog-II.

Sogou is used as the Chinese input method. Please take time to get used to the software and the computer devices.

2) Translation. You will be given an English text to translate into Chinese in Translog-II **without accessing any form of reference tool**. The translation brief will be provided. There is **no time limit** for this task. Please complete it under normal working conditions.

3) Post-editing. You will be given an English text with its Chinese translation produced by 'Google Translate' to post-edit. There is no time limit for this task. Please follow your normal working mode.

4) Cue-based retrospective interviews will be conducted after the experiment on each day.

- **What are the potential risks?**

Currently there is no known potential risk from participating in such empirical studies involving triangulating eye tracking and keylogging.

- **Confidentiality of Personal Data and Project Data**

Your personal data will not be recorded or evaluated throughout the entire experiment. The project data you produce will only be used for the current research. Your name will be kept anonymous at all times, including in future publications. Other researchers will have access to this data only if they agree to preserve the confidentiality of the data and if they agree to the terms specified above. The data will be stored in the university computer in the school Eye-tracker lab (253b) with password-protected access.

- **Consent Form**

If you are clear about all the information stated in this information sheet and have no further questions, please read and sign the informed consent form. You and the researcher will each retain a copy.

- **Researcher Contact Details**

If you have any questions or need to know more information, please contact the researcher Ms Jin Huang at <u>jin.huang@durham.ac.uk</u>.

Jin Huang
PhD Candidate in Translation Studies
School of Modern Languages and Cultures, Durham University
A5, New Elvet Riverside, Durham, DH1 3JT

Appendix 5: Informed Consent Form

I, the undersigned, confirm that (please tick box as appropriate):

1.	I have read and understood the information about the project, as provided in the Information Sheet dated 7 December 2013.	☐
2.	I have been given the opportunity to ask questions about the project and my participation.	☐
3.	I voluntarily agree to participate in the project.	☐
4.	I understand I can withdraw at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.	☐
5.	The procedures regarding confidentiality have been clearly explained (e.g. use of names, pseudonyms, anonymisation of data etc.) to me.	☐
6.	If applicable, separate terms of consent for interviews, audio, video or other forms of data collection have been explained and provided to me.	☐
7.	The use of the data in research, publications, sharing and archiving has been explained to me.	☐
8.	I understand that other researchers will have access to this data only if they agree to preserve the confidentiality of the data and if they agree to the terms I have specified in this form.	☐
9.	Select only **one** of the following: I would like my name used and understand what I have said or written as part of this study will be used in reports, publications and other research outputs so that anything I have contributed to this project can be recognised.	☐
	I do not want my name used in this project.	☐
10.	I, along with the Researcher, agree to sign and date this informed consent form.	☐

Participant:

_____   _____   _____
Name of Participant   Signature   Date

Researcher:

_____   _____   _____
Name of Researcher   Signature   Date

Appendix 6: Experiment Guidelines

Do's and Don'ts

Please:

a. Make sure you switch your mobile phone off during the experiment

b. Make sure you get used to the lab environment (light, humidity, chair, desk, computer screen, keyboard, mouse, Chinese input method etc.)

c. Make sure you are fully ready for the experiment (no eating, drinking or visiting the toilet during the experiment)

d. Make sure you understand the procedure of this experiment

e. Make sure you follow the experiment requirements (sitting distance, calibration etc.)

f. Make sure you are serious during the experiment (no talking, laughing or relaxing)

g. Make sure you know how to operate 'stop logging' in Translog when you finish the experiment

h. Please let the experimenter know if you have any questions before the experiment starts

i. Please let the experimenter know if, during the experiment, you feel any discomfort or illness that will require you to quit the experiment

j. Please be aware that the four tasks you perform during these two days are equally important.

k. Please try to sit still without too many movements

l. Please make sure you click on 'stop logging' in Translog as soon as you finish the task.

Please:

    a.   **Do not look at anywhere other than the screen**

    b.   **Do not cup your chin in your hand at any time**

    c.   **Do not stretch your arms at any time**

    d.   **Do not change the size of the Translog window**

    e.   **Do not change the font and typeset of the ST and the TT in Translog**

Appendix 7: Task Brief

1. Where and how will the translation be used?

The target text will be <u>published together with the source text on a website</u> where the public can access it.

2. Who is the target audience?

The target audience will be both male and female <u>adults</u> who are <u>educated to degree level</u>.

3. Style of address to the reader

The translation should be written in a <u>formal</u> way.

4. What is the desired response from readers?

The readers expect the target text to be <u>in natural Chinese</u>.

Appendix 8: Post-editing Guidelines

Post-editing Guidelines (Full Post-editing)

1) The message transferred should be accurate

2) Grammar should be accurate

3) Ignore stylistic and textual problems

4) Ensure that key terminology is correctly translated

5) Edit any offensive, inappropriate or culturally unacceptable information

6) All basic rules regarding spelling, punctuation and hyphenation still apply

7) For tagged formats, ensure all tags are present and in the correct positions

8) Throughput expectations: high

9) Quality expectations: medium

Appendix 9: Post-experiment Questionnaire

QUESTIONNAIRE - PARTICIPANT FEEDBACK

A. On Self-revision

Do you usually revise your own draft immediately after translation?

☐yes (how many times……….) ☐no

Do you usually revise your translation after some drawer time?

☐yes (length of drawer time……….) ☐no

Do you feel it is necessary to revise your translation draft in this experiment or not? Why?

☐yes ☐no ☐perhaps

Please specify here:

Are there any problems with your translation draft?

Which of the following best describes your understanding of the ST?

☐I have a better understanding of the ST today than I had yesterday.

☐My understanding of the ST today is the same as it was yesterday.

☐My understanding of the ST today is worse than it was yesterday.

☐Other (please specify:_____)

Which of the following best describes your impression of the TT?

☐The TT looks very fresh to me.

☐The TT looks a bit fresh to me.

☐The TT looks the same to me.

☐Other (please specify:_____)

How many times did you revise the target text from start to finish? Why?

What are your focuses and criteria during (each time of) self-revision?

Which of the following best describes your self-revision activities (behaviour in the revision)? Why?

□ ST reading   □ TT reading   □ TT typing

□ ST reading and TT typing   □ TT reading and TT typing

□ TT typing with ST reading and TT reading   □ no activity

Other:

Which of the following are your main self-revision activities (behaviour in the revision)? Why?

□ ST reading   □ TT reading   □ TT typing

□ ST reading and TT typing   □ TT reading and TT typing

□ TT typing with ST reading and TT reading   □ no activity

Other:

Can you describe how you revise the TT, and why?

B. On Other-revision

Do you usually ask other people to revise your translation draft?

□yes (why?…………………….)   □no (why not?............................)

Have you ever revised other people's translation?

□yes (how often?……….)   □no (in the future?............)   □perhaps

Do you feel it is necessary to revise this translation draft or not? Why?

□yes   □ no   □perhaps

Please specify here:

Are there any problems with this translation?

How many times did you revise the target text from start to finish? Why?

What are your focuses and criteria during (each time of) other-revision?

Which of the following best describes your other-revision activities (behaviours in the revision)? Why?

□ ST reading   □ TT reading   □ TT typing

□ ST reading and TT typing   □ TT reading and TT typing

□ TT typing with ST reading and TT reading   □ no activity

Other:

Which of the following are your main other-revision activities (behaviour in the revision)? Why?

□ ST reading   □ TT reading   □ TT typing

□ ST reading and TT typing   □ TT reading and TT typing

□ TT typing with ST reading and TT reading   □ no activity

Other:

Can you describe how you revise the TT, and why?

How different is other-revision compared with self-revision?

C. On Post-editing

Have you ever post-edited machine translation before?

▢yes (please specify your years of experience………………...) ▢no

Do you feel it is necessary to post-edit this machine translation output or not? Why?

▢ yes   ▢ no   ▢perhaps

Please specify here:

Do you think a light or a full post-editing should be performed on this machine translation output? Why?

▢light   ▢full

Please specify here:

Are there any problems with this machine translation?

How many times did you revise the machine output from start to the finish? Why?

What are your focuses and criteria during (each time of) post-editing?

Which of the following best describes your post-editing activities (behaviour in the revision)? Why?

▢ ST reading   ▢ TT reading   ▢ TT typing

▢ ST reading and TT typing   ▢ TT reading and TT typing

▢ TT typing with ST reading and TT reading   ▢ no activity

Other:

Which of the following are your main post-editing activities (behaviour in the revision)? Why?

▢ ST reading   ▢ TT reading   ▢ TT typing

▢ ST reading and TT typing   ▢ TT reading and TT typing

▢ TT typing with ST reading and TT reading   ▢ no activity

Other:

Can you describe how you revise the TT, and why?

How different is post-editing from other-revision, and self-revision?

D. On Text and Task Comparison

How would you rate the complexity of the <u>three source texts</u> you have just worked on? (1<5) *(source texts provided)*

Translation (Cambridge):   □1 □2 □3 □4 □5

Post-editing (Warwick):   □1 □2 □3 □4 □5

Other-revision (Oxford):   □1 □2 □3 □4 □5

How would you rate the overall quality of the <u>three target texts</u> you have worked on? (1<5) *(target texts provided)*

Self-revision (Cambridge): □1 □2 □3 □4 □5

Post-editing (Warwick):   □1 □2 □3 □4 □5

Other-revision (Oxford):   □1 □2 □3 □4 □5

How would you rate the complexity of the <u>four tasks</u> you have performed? (1<5)

(target texts provided)

Translation (Cambridge):   □1 □2 □3 □4 □5

Self-revision (Cambridge): □1 □2 □3 □4 □5

Post-editing (Warwick):   □1 □2 □3 □4 □5

Other-revision (Oxford):   □1 □2 □3 □4 □5

E. On Experiment Validity

How satisfied are you with the lab environment (e.g. experiment device – computer screen, keyboard, mouse, eye-tracking and keylogging software, Chinese input method; chair and desk; light and humidity etc.)? (1<5)

□1　□2　□3　□4　□5

Please specify where needed:

How satisfied are you with the researcher's preparation and guidance in completing the experiments (task description; consent form; questionnaires; eye-tracking and keylogging introduction; Do's and Don'ts in the experiment; translation brief)? (1<5)

□1　□2　□3　□4　□5

Please specify where needed:

How would you rate your naturalness in conducting the tasks in this experiment? (1<5)

□very natural　　□natural　　□neutral　　　□not natural

Please specify where needed:

Was there any interference during the experiment that affected your performance?

□yes　　　　　□no

Please specify where needed:

How reliable would you consider the data collected in this experiment?

□reliable – very reliable (I suggest using my data for research analysis)

□not reliable – reliable (I suggest not using my data for research analysis)

Please specify where needed:

Appendix 10: Text and Task Complexity Data

Tasks / Participants	Self-revision	Other-revision	Post-editing
P1	Text A complexity (1<5): 2	Text B complexity (1<5): 2	Text C complexity (1<5): 2
	Task complexity (1<5): 4	Task complexity (1<5): 2	Task complexity (1<5): 3
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P2	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 4	Task complexity (1<5): 2	Task complexity (1<5): 3
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P3	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 4	Task complexity (1<5): 3	Task complexity (1<5): 2
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P4	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 3	Task complexity (1<5): 3	Task complexity (1<5): 4
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P5	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 2	Task complexity (1<5): 3	Task complexity (1<5): 4
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P6	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 4	Task complexity (1<5): 3	Task complexity (1<5): 2
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P7	Text A complexity (1<5): 2	Text B complexity (1<5): 2	Text C complexity (1<5): 2
	Task complexity (1<5): 4	Task complexity (1<5): 2	Task complexity (1<5): 3
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P8	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 4	Task complexity (1<5): 2	Task complexity (1<5): 3
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P9	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 4	Task complexity (1<5): 3	Task complexity (1<5): 2
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P10	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 3	Task complexity (1<5): 3	Task complexity (1<5): 4
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P11	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 2	Task complexity (1<5): 3	Task complexity (1<5): 4
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P12	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 4	Task complexity (1<5): 3	Task complexity (1<5): 2
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P13	Text A complexity (1<5): 2	Text B complexity (1<5): 2	Text C complexity (1<5): 2
	Task complexity (1<5): 4	Task complexity (1<5): 2	Task complexity (1<5): 3
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3

P14	Task complexity (1<5): 4	Task complexity (1<5): 2	Task complexity (1<5): 3
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P15			
	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 4	Task complexity (1<5): 3	Task complexity (1<5): 2
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P16			
	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 3	Task complexity (1<5): 3	Task complexity (1<5): 4
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P17			
	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 2	Task complexity (1<5): 3	Task complexity (1<5): 4
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		
P18			
	Text A complexity (1<5): 3	Text B complexity (1<5): 3	Text C complexity (1<5): 3
	Task complexity (1<5): 4	Task complexity (1<5): 3	Task complexity (1<5): 2
	Task complexity due to source texts incomparability or different qualities of target texts? Latter		

Appendix 11: Experiment Validity Data

	Lab Environment Satisfaction (1<5)	Researcher's preparation and guidance satisfaction (1<5)	Naturalness of performance in the experiment	Interferential factors affecting performance in the experiment	Reliability of the data
P1	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
P2	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
P3	5	5	Natural	No	Reliable (I suggest using my data for research analysis)
P4	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
P5	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
P6	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
P7	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
P8	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
P9	5	5	Natural	No	Reliable (I suggest using my data for research analysis)
P10	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
P11	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
P12	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
P13	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
P14	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
P15	5	5	Natural	No	Reliable (I suggest using my data for research analysis)
P16	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
P17	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)
P18	5	5	Very natural	No	Reliable (I suggest using my data for research analysis)

Appendix 12: Discount Voucher

Appendix 13: Coding for All Activities

Participants	SR	PE	OR
P01	(BitR) [52] – UniTTt	(BitR) – UniTTtR	(BitR)
P02	UniSTs – (BitR)	UniSTt – (BitR) – UniTTtSTsegR	UniSTt – (BitR)
P03	(BitR) – UniTTtSTseg	(BitR) – UniTTtSTsegR	(BitR) – UniTTsSTseg
P04	UniSTt – (BitR) – UniTTtR	UniSTt – (BitR) – UniTTtSTsegR – UniTTtSTsegR – UniTTt	UniSTt + UniTTt – (BitR) – UniTTt – UniSTtTTseg – UniTTt
P05	UniSTt – (BiR) – UniTTsSTsegR – UniTTt	(BitR) – UniTTtSTsegR – UniTTsSTsegR	(BitR)
P06	UniSTs – (BitR + BitR) – UniTTt – UniTTtR – UniTTt	UniSTt – (BitR + BitR) – UniTTtSTsegR – UniTTt	UniSTt – (BitR) – UniTTsSTsegR – UniTTsSTsegR – UniTTsSTsegR – UniTTsR – UniTTsSTsegR – UniTTsSTsegR – UniTTsSTsegR – UniTTsR – UniSTt – UniTTsR – UniTTs – UniTTs
P07	BiTTtSTsegR	UniTTt – (BitR) – UniTTtSTsegR – UniTTtR	UniTTt + UniSTt – (BitR) – UniTTsegR
P08	(BitR) – UniTTtR	UniSTt – (BitR) – BiTTtSTsegR	UniSTt – (BitR) – UniTTtSTsegR
P09	(BitR)	UniSTt – (BitR) – UniSTsTTsegR – UniTTtR	UniSTt – Bit – (BitR) – UniTTt
P10	(BitR) – UniTTtSTseg – UniTTtSTseg	(BitR)	(BitR)
P11	(BitR) – UniTTs	UniSTs – (BitR) – UniTTtSTsegR – UniTTtSTsegR	UniSTs – (BitR) – UniSTtTTseg – UniTTtR
P12	UniSTt – (BitR) – UniSTtTTt – UniTTtR	UniSTt – (BitR) – BiSTtTTtR – UniTTsSTsegR – UniTTt – UniTTt	UniSTt – (BitR) – UniSTtTTseg – UniTTtSTsegR
P13	(BitR + BitR) – UniTTsSTsegR	(BitR + BitR) – UniTTtSTsegR	(BitR + BitR)
P14	(BitR) - UniTTt	UniSTs – (BitR) – UniTTsSTsegR	UniSTs – (BitR) – UniTTtSTsegR
P15	(BitR)	UniSTs – (BitR + BitR)	(BitR + BitR)
P16	(BitR + BitR) – UniTTtSTsegR – UniTTtSTsegR	(BitR) – UniTTtSTsegR	(BitR + BitR) – UniTTs
P17	(BitR) – UniTTsSTseg – UniTTsSTsegR	(BitR) – UniTTtSTsegR	(BitR) – UniTTsSTsegR
P18	(BitR)	UniSTt – (BitR) - UniTTs	UniSTt – (BitR)

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[52] To distinguish the different phases, the activities in the drafting phase are put in parenthesis. The codes before the parenthesis belong to the planning phase, and the codes after the parenthesis belong to the final check phase. The hyphen indicates the change of activity sequence.