Towards a classification of translation styles based on eye-tracking and keylogging data

Barbara Dragsted and Michael Carl

Copenhagen Business School | Denmark

Abstract: This article seeks to formulate translator profiles based on process data from keylogging and eye-tracking, while at the same time identifying features which are shared by all translators in a sample consisting of both students and professionals. Data have been collected from 12 professional translators and 12 graduate students translating three texts of varying complexity. We found that individual behavioural characteristics with respect to initial orientation in the source text (ST), online ST reading, and online and end revision remained relatively constant across texts of varying complexity, supporting our hypothesis that translator profiles can be observed which are independent of the difficulty of the translation task. The analysis of the data also indicated that translators could be grouped into broad categories of locally-oriented and globally-oriented translation styles, which are partly, though not entirely, comparable to styles known from writing research. We also identified shared features with respect to reading and revision behaviour during drafting. Common to all translators was that they looked beyond the source text word they were about to translate, and that they made revisions while drafting the translation.

Keywords: translation processes, keylogging, eye-tracking, translation styles, translation models

journal of WRITING RESEARCH

1. Introduction

In studies of cognitive processes in translation, it is common to distinguish between groups of translators with varying levels of expertise and proficiency, i.e. between students/novices and professionals/experts (see e.g. Jääskeläinen 1991; Jensen 2001; Jakobsen 2003; Tirkkonen-Condit 2005; Jakobsen & Jensen 2008; Angelone 2010; Dragsted 2010; Jääskeläinen 2010). However, within such groups, we often see differences: Novices may somewhat resemble experts, and vice versa, at least under some conditions. Also, the translation process may differ depending on instrumental competences such as typing skills. For instance, students who are skilled typists may exhibit expert-like behaviour because of their ability to produce text quickly.

Yet, even if translator behaviour and processes vary, from one individual to another, both across and within groups of experts or novices, it may be assumed that certain basic features of the translation process are necessarily common to all translators, at all levels of experience, under all conditions. For instance, it can be expected that translation always involves planning more than one word ahead because the absence of such planning would imply pure word-for-word translation. Thus, it seems that a reasonable approach when providing explanations and models of translation processes would be to a) identify features which are common to all translators and b) categorise translators according to individual behavioural characteristics (personal translator profiles/translation styles).

In our study, process and product data from 12 student and 12 professional translators were analysed to investigate, firstly, whether features common to all 24 translators, irrespective of expertise, can be identified and, secondly, whether and how individual behavioural characteristics that are not shared by all the translators in the sample may be categorised.[1] We expected that individual characteristics would not be completely idiosyncratic, but that several translators would share some of the same features and could subsequently be grouped into categories. In particular, we expected to observe a relationship between the style of the translator and level of expertise. Thus we assumed that students would tend to fall into one group sharing certain characteristics, and professionals would tend to fall into another, which would imply that translation profiles and styles may change as the translator gains experience.

2. Modelling the translation process

In studies of cognitive processes in translation, several attempts have been made to capture the various facets of translation in models that account for all the processes involved in producing a translation, inspired for instance by mental models from the fields of cognitive psychology and information processing (see for instance Krings 1986a; Hönig 1991; Gile 1995; Kiraly 1997; Danks & Griffin 1997; Jakobsen 2011). These models have in common that they include components of source-text (ST) input and target-text (TT) output, as well as interaction with background knowledge (stored in

long-term memory) and external resources. However, the nature of the relationship between ST input and TT output is described differently in each case.

Gile (1995, 101ff) emphasises the sequentiality of translation (as compared with simultaneous interpreting) and proposes a model according to which the translator first reads a source-language (SL) translation unit (defined as a "processing unit"), then formulates a "meaning hypothesis", i.e. assigns a meaning to the translation unit by drawing on source-language knowledge, general world knowledge and possibly external information sources, and then checks the meaning hypothesis for plausibility. Subsequently, having finished the processes involved in understanding the ST, the translator moves on to reformulating the meaning hypothesis in the target language, drawing again on general world knowledge and on knowledge of the target language, and checks for fidelity and general acceptability, continuously revising the TT until a satisfactory version has been arrived at. In short, the translation process can be divided into a comprehension phase and a reformulation phase, each of which consists of several steps, and draws on knowledge stored in long-term memory or is available via external resources. Gile also notes, however, that "[o]ftentimes, the translator does not test the Meaning Hypothesis until after verbalising it in the target language" (Gile 1995, 110), indicating that comprehension and production activities are more integrated than seemingly implied by the sequential model.

Similarly, Danks & Griffin (1997, 173ff) propose a model beginning with the ST, which the translator comprehends by engaging in "the same sorts of language comprehension processes as are used in everyday comprehension" (ibid, 173), i.e. by drawing on interaction between different levels of language processing (from the phonological level to the situational level). Somewhat contrary to Gile's (1995) sequential perspective, Danks & Griffin suggest that the translator does not comprehend the ST fully before beginning the process of translation, but rather works on various possible translation solutions while still attempting to comprehend the ST. Once a possible TT has been produced, the translator checks it for adequacy and fidelity to the ST, a process which may continue to move through an evaluate-revise loop until an acceptable version has been formulated, again in line with Gile (1995). Evidence from translation process studies, showing increased gaze activity when reading for the purpose of translation compared with reading for normal comprehension purposes (Jakobsen & Jensen 2008), indicates that translators may indeed already engage in translation-related activities during ST reading.

Tirkkonen-Condit (2005) proposes a "monitor model" which assumes a cognitive resource that alerts the translator to an upcoming translation problem: "[L]iteral translation is a default rendering procedure, which goes on until it is interrupted by a monitor that alerts about a problem in the outcome. The monitor's function is to trigger off conscious decision-making to solve the problem" (p. 11). Carl & Dragsted (2012) provide empirical evidence for such a model, and discuss examples showing that deeper ST understanding is prompted by problems occurring in the TT rather than a lack of ST comprehension.

Like Tirkkonen-Condit's monitor model, Krings's (1986a; 1986b) model centres on the concept of the "translation problem": Text segments involving a translation problem elicit the application of one or more translation strategies.[2] The presence of such strategies is marked by problem indicators, in the form of either a particular verbalisation or some effect on the translation process, for instance pauses, modifications of the TT or the use of reference books. The absence of translation problems, on the other hand, coincides with the absence of translation strategies, i.e. if the translator encounters no translation problems, the source language text item will be transferred directly and automatically into a target language item (Krings 1986a, 137; 1986b, 265).

On the basis of eye-tracking and key-logging data, Jakobsen (2011) has found indications of a recurrent "micro-cycle", i.e. a processing pattern consisting of six steps, some of which can be skipped or, conversely, can be repeated several times. Again, the processing cycle starts with an act of comprehension, namely reading the chunk of ST which is about to be translated (step 1). The translator then shifts his/her gaze to the TT to locate the position where the TT is about to be produced (step 2). The translation is typed and monitored (steps 3 and 4), and the translator's gaze shifts back to the ST, where the relevant reading area is located and the current ST word is read again (steps 5 and 6) (Jakobsen 2011, 48).

In summary, the translation models described above focus around the interaction between ST and TT processing (sequential vs. parallel processing) as well as translators' handling of translation problems. In 5 below, we will discuss the extent to which our analyses offer support to the models described in this section.

3.   Writing styles and translation styles

In writing research, it is common to operate with classifications of writers according to their different writing styles, and "different models classifying writing profiles have been developed" (Opdenacker, Stassen, Vaes & Van Waes 2009). While recognising the fact that "the writing process is highly individualistic" (Boehm 1993: 15), writers can be grouped into categories according to the way they prioritise their efforts during the writing task.

The writing process can be divided into three main sub-processes: planning, formulating and revising, and the way in which writers tend to organise and prioritise these determine their writing styles or writer profiles (Opdenacker et al. 2009). Different classifications have been suggested. Boehm (1993) makes a distinction between *Mozartians* and *Beethovians*. Beethovians are "discoverers" who generate ideas as they write the text, and postpone much of the revision work to the end, whereas Mozartians are planners, who write from ideas they have generated beforehand and revise the text as they go along.

Hayes & Flower (1980) propose four different writing styles: a) *depth first*, where the writer plans, writes and revises one sentence at a time, b) *postponed review*, in which

the writer writes down his/her thoughts as they occur and reviews them later, c) *perfect first draft*, involving a thorough planning process directed at the text as a whole and aimed at producing a flawless first draft and d) *breadth first*, where the writer plans and produces a full draft before any revision is carried out.

In a similar vein, Van Waes & Schellens (2003) present a five-part model, which distinguishes between *initial planners*, *first draft writers*, *second draft writers*, *non-stop writers*, and *average writers*. *Initial planners* spend a long time on the preparatory phase and make few revisions at the end, i.e. during the final revision phase. *First draft writers* (or Stage I writers) devote little time to initial planning and end revision, but spend most of their time on the drafting phase (Stage I), which is characterised by many revisions and frequent recursions. *Second draft writers* (or Stage II writers) spend quite some time on initial planning and postpone most of their revisions to the final revision phase, whereas the first draft is produced relatively quickly. *Non-stop writers* produce text quickly, spending little time on initial planning, making few revisions (in general), and rarely pausing during drafting. *Average writers* are not characterised by a clear profile, but make up an average of the other profiles (see also Opdenacker et al. 2009). Another classification of writing styles, proposed by Chandler (1993), is the description of writers as either *watercolourists*, who are similar to *non-stop writers*, *architects*, who are similar to *initial planners*, *bricklayers*, who are similar to *first draft writers*, or *oil painters*, who are similar to *second draft writers*.

Writing in translation differs in several ways from writing in general. Although the nature of translation may vary depending on the textual/contextual conditions and the translator's perception of his/her own role, regardless of the text and the translator's approach to the task (e.g. producing a formal or a functional translation),the translation process involves an element of reproducing a message which has already been spoken or written by someone else. In one way, this can be said to complicate the process, because it deprives the translator of the possibility open to writers to "bypass possible production difficulties by rearranging the sequence of information and ideas or by dropping or modifying some of these" (Gile 1995:166). On the other hand, the very fact that lexical and syntactic choices, and of course the aims, content and "plot", are already given by the ST can be said to make the translation task easier than a normal writing task (Gile 1995), involving less planning at sentence and paragraph level (Immonen & Mäkisalo 2010: 57).

Despite differences between normal writing and translation processes, it seems plausible that features characteristic of writing can be observed in translation as well. Like writing, the translation process can be divided into sub-processes: a planning phase, a drafting phase and an end revision phase; and translators can be expected to exhibit different behaviour with respect to their organisation of the translation process into these phases (Englund-Dimitrova 2010). Below we will investigate this assumption and categorise translators according to observed translation behaviour on the basis of eye-tracking and keylogging data. Specifically, the following hypotheses will be investigated:

1. Individual characteristics will remain constant across different texts of varying complexity (see below) revealing personal translator profiles
2. Characteristics will not be idiosyncratic but can be grouped into categories – or translation styles – sharing similar features
3. Translation style may be a predictor of the level of expertise (student vs. professional translator)

4. Research design and methods

This section will account for the research design and the methods used to collect and analyse data, and, where relevant, discuss the considerations related to setting up the experiments and analysing the results. The data used for our analyses were collected in connection with Jensen's PhD thesis from 2011, which may be consulted for a detailed description of the research design (Jensen 2011).

4.1 Participants

The experiments involved 24 participants, 12 of whom were professional full-time translators with at least two years' professional experience of translation between Danish and English, and 12 of whom were MA students at the Copenhagen Business School, specialising in translation between Danish and English.

4.2 Procedure

All the experiments took place in a lab at a computer which was connected to a Tobii 1750 remote eye tracker (see 4.4 below). Each participant translated three source texts (see Appendix A, which also reports the average production time for each of the three texts) from English (L2) into Danish (L1). Semi-randomised presentation sequences of the source texts were used, in order to minimise the risk that observations were (partly) the result of a repeated presentation sequence (Jensen 2009: 97).

The source texts were presented to the participants in the keystroke logging program Translog User (Jakobsen & Schou 1999), which displays the ST in the top area of the screen and enables the translator to produce the TT in the bottom area. The participants were instructed to produce translations that would satisfy their usual quality criteria. However, they did not have Internet access and were not allowed to use dictionaries or other similar support. Although the source texts did not contain specialised terminology, this restriction with respect to the use of reference material is a weakness, and generally, as in many experimental translation process studies, the ecological validity of the experiment can be said to have shortcomings: The participants found themselves in an unusual situation in a lab working with programmes which were unfamiliar to them and without their usual aids and tools. However, although this may have had an influence on the participants' performance generally, we do not believe that it has strongly influenced their reading behaviour.

4.3   Texts

The texts consisted of 132 to 148 words and were taken from articles that appeared in British newspapers in 2008. The articles dealt with subjects of a general nature, in order that no participant should have an advantage over other participants by possessing expert knowledge in a specialised area.

The texts were selected on the basis of varying complexity, established by means of three quantitative indicators: measurements of readability, calculations of word frequency, and calculations of the number of occurrences of non-literal expressions, i.e. idioms, metaphors, and metonyms (see Jensen 2009: 88ff for an elaborate account of how source text complexity was measured). On all three measures, Text A was the least and Text C the most difficult text (see Appendix A).

In Jensen's experiments, the experimental texts were translated under varying degrees of time pressure (see Jensen 2011: 94). The presentation sequence of the source texts was semi-randomised to avoid that texts of a certain complexity were always translated under the same degree of time pressure (Jensen 2011, 95ff). The present paper will not deal with time pressure per se as an explicit variable, but where relevant it will be taken into consideration as it may potentially influence our interpretation of the data.

4.4   Data

The process data consisted of eye-tracking and keystroke logging data from the three tasks. For the collection of eye movement data, we employed a Tobii[3] 1750 remote eye tracker, which runs at a frame-rate of 50 Hz and uses binocular eye tracking. The texts were presented on a TFT display with a resolution of 1280x1024 pixels. Participants were seated 55-60 cm from the monitor, and then followed a short gaze calibration procedure. For analysis of the eye-tracking data, we used Tobii's eye-tracking analysis program ClearView, which creates visualisations and calculates statistics on eye-tracking recordings. Additionally, we employed a gaze-to-word mapping tool, which automatically identified words which participants fixated upon longer than 200ms.[4]

Keystrokes were analysed in Translog Supervisor (Jakobsen & Schou 1999), which enables dynamic replay of the production process in real time and shows a linear representation of all keystrokes and fixations as well as time stamps and intervals between keystrokes (pauses) with 20 millisecond precision. In addition to the process data, the experiments generated product data in the form of translated output from all participants. All target texts were manually aligned with their ST at word or phrase level.[5] The combination of aligned source and target texts with eye movement and keystroke logging data enabled the presentation of translation progression graphs (see Figure 2 and Appendices B-F) showing relations between translation product and translation process data in time (Carl & Jakobsen 2009). Thus, we were able to see, for instance, whether the translator was looking at a ST word while (or immediately before) producing a translation of it, or whether he/she was looking at another word further

down in the ST. To supplement the eye movement and keystroke logging data, we analysed task times and time spent on individual phases of the translation task.

5. Results and analyses

The analysis below is based on the basic assumption that translation, as well as other writing activities (see section 3), is divided into three phases: planning, drafting and revising. More precisely, our investigation of shared features and individual characteristics of translator behaviour will focus on initial ST orientation (the planning phase), online ST orientation (the drafting phase), and revision/editing. If translators display similar behaviour in the three different texts, this would support our assumption that translators have individual translator profiles, whereas different behaviour would indicate that text properties play a more important role.

5.1 Initial ST orientation

'Orientation' generally means how and where translators gaze at the text, and 'initial orientation' describes the translator's preliminary reading or skimming of the ST before starting to produce the translation. We know from previous studies (Jakobsen 2002; Carl, Dragsted & Jakobsen 2011) that the amount of initial planning may vary. Some translators prefer to systematically read the whole ST before they start translating, some translators skim the text quickly, some translators read the first few phrases or sentences, and some simply go straight ahead with TT production.
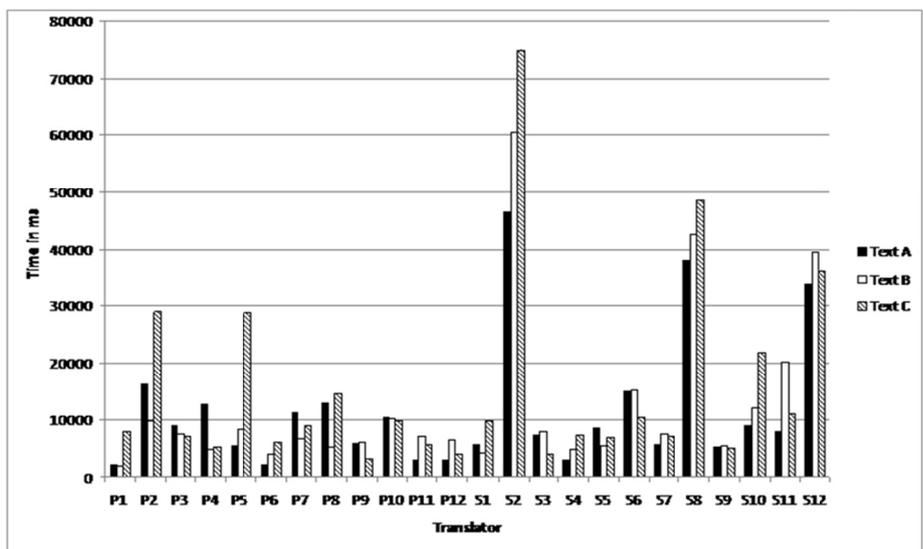
Figure 1: Time (in ms) spent on initial ST orientation across the three texts of varying complexity (P = professional; S = student).

In our analysis, initial orientation was calculated as the amount of time spent before typing the first character in the TT. On average, the 24 translators spent 3.3 per cent of the total task time on this phase across the three texts, and most of them spent less than 10 seconds (in all tasks), which, it should be remembered, includes the planning required for translating the first segment. Common for all the translators was a general tendency for the initial planning phase to be of approximately the same duration across all three tasks.

Substantial individual differences could be observed between the translators with respect to initial orientation. In particular, three of the students (S2, S8, S12) spent relatively long time before they started translating the text. However, time measurements alone provide no clear evidence that time was indeed spent on initial orientation. The translator could also have been struggling with the headline or the first sentence, reading it several times before coming up with a translation. The visualisation provided by the translation progression graphs (as exemplified by Figure 2) revealed that S2, S8 and S12 did in fact read systematically through the whole ST before starting to translate it, thus apparently engaging in extensive initial orientation. This type of behaviour is illustrated by the translation progression graph for S2's Text A shown in Figure 2, where the continuous string of blue circles starting at 0 ms (bottom-left corner) and ending around 40,000 ms (top-left corner), just before the first key is pressed, indicates systematic reading of the ST before starting to produce the translation.
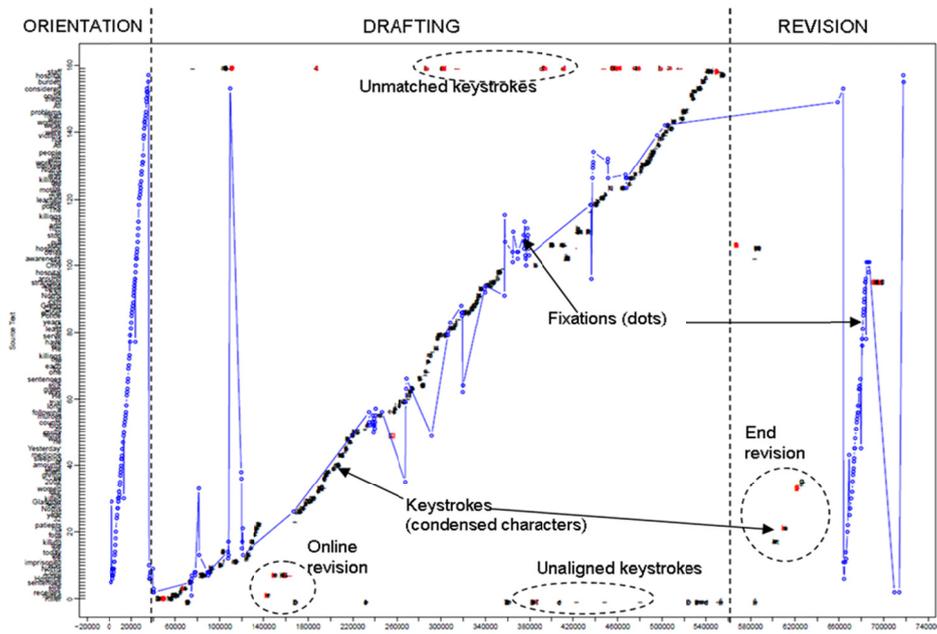
Figure 2: Translation progression graph for S2, Text A. The X-axis shows time in ms, and the Y-axis shows the ST (from 1 to approx. 160 words). The small dots indicate fixations, and the lines between them are eye movements. The TT keystrokes are represented as condensed characters.

Only the above-mentioned three translators carried out systematic initial orientation, as illustrated in Figure 2. In the majority of cases, the translator either started immediately (categorised as *head-starters*), or read the first couple of words or sentences, and then pressed the first key (*quick planners*). Some translators scanned the text rapidly (*scanners*). Overall, most translators only considered a limited amount of context before they started translating the text, and rarely the whole source text.

The categorisation of translators with regard to initial orientation or other types of behaviour (as described below) was based on the researchers' interpretation of the eye-tracking and keylogging data represented in the translation progression graphs. In the example in Figure 2, the categorisation was easy to make, whereas in other cases it was less obvious. For instance, distinguishing between 'quick planners' (Appendix B) and 'scanners' (Appendix D) was sometimes difficult, because both were characterised by some fixations, but only few fixations on the ST before the first keystroke. Yet, the distinguishing characteristic was that scanners had sporadic fixations at different places in the ST, whereas quick planners typically read the first couple of sentences in the ST before commencing the translation.

When we matched the classifications made qualitatively on the basis of our interpretations of the translation progression graphs (see Figure 2) with the purely quantitative measure of time spent before the first keystroke (see Figure 1), it turned out that, with one exception, all of the 14 head-starters spent between 4 and 10 seconds on initial planning; the 7 quick-planners and scanners spent between 10 and 20 seconds before they pressed the first key, again with one exception, and the three systematic planners spent between 30 and 60 seconds on reading through the text. Figure 2 presents an example of a systematic planner, and examples of head-starters, quick planners, and scanners are given in appendices B-D.

5.2   Online ST orientation

Online ST orientation refers to the translators' behaviour with respect to ST reading during the translation drafting phase. We looked at where in the ST the translators' eyes were fixated while a given word or phrase was being produced in the TT.
We distinguished between fixations on ST words which were about to be translated (looking ahead), and fixations on ST words that had already been translated (looking back).

5.2.1 Looking ahead

When people read aloud, there is a lag, termed the eye-mind-span (Just & Carpenter 1980), between the eyes and the mind, which enables us, for instance, to produce two or three words after the lights in a room are turned off and our eyes can no longer see what is being read (Staub & Rayner 2007: 329). Thus, in a simple copying task where subjects rewrite a text in the same language, the copyist will typically look two to three

words to the right[6] of the word being retyped, according to the TYPIST model developed by John (1996).

The average look-ahead for the translators in this experiment was approximately four words (mean: 4.28, median: 3.90), suggesting that translators generally look for slightly more context than typists performing a simple copying task. Most ST fixations were in the area between two and six words to the right of the word being translated. Thus common to all translators was a tendency to look beyond the current word, suggesting that looking/planning ahead may be a universal feature of the translation process. This does not imply that the translators never looked at a ST word while simultaneously producing an equivalent in the target language (TL), but all translators had most fixations to the right of the word which was about to be translated. Reading some words ahead in the ST as a separate activity *before* starting to produce TT seems to support translation models (see Section 2 above) suggesting a sequential processing pattern of ST reading and comprehension followed by TT formulation (e.g. Gile 1995; Danks & Griffin 1997), although (mental) TT formulation may very well already occur while the ST is being read, as suggested by Danks and Griffin (1997) and Carl & Dragsted (2012). Typing *while* looking ahead in the ST suggests that comprehension and production take place in parallel rather than as two sequential activities. Thus, the data do not offer clear support to one translation model, but rather suggest that the processing pattern varies from one individual to another.

Again, large individual differences could be identified with respect to reading ahead, as illustrated by Figure 3.
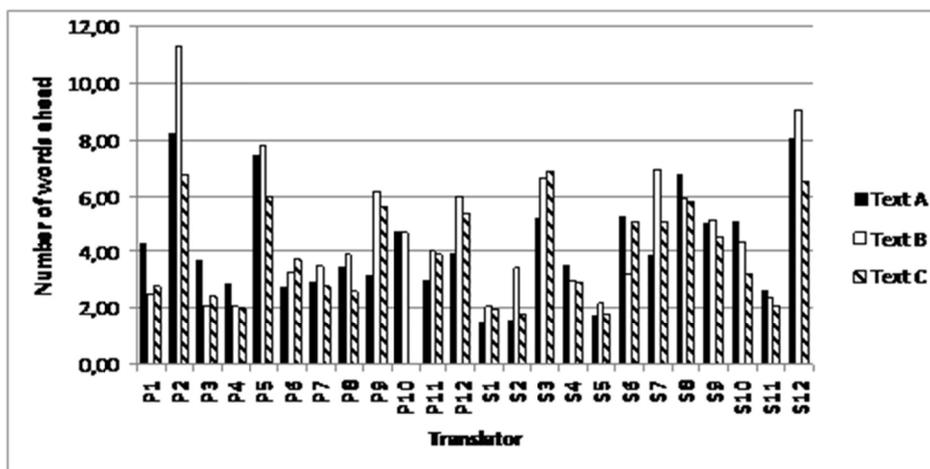
Figure 3: ST fixations ahead of the word being translated (mean)

While we found some variance in individual planning behaviour across the three tasks, standard deviations were generally below or just around 1. Thus, translators with a tendency to look far ahead in the text did so fairly consistently across all tasks, and

translators who focused on the close context of the word or phrase being translated similarly exhibited this behaviour regularly. For example, P2 and S12 had fixations far ahead in the ST in all three tasks, whereas S1 and S5 generally appeared to focus their attention on a narrower context. The level of text complexity, at least the way it was measured in this study (see 4.2 above), did not appear to have an effect on the translators' ST reading behaviour, signified by the lack of a clear relationship between text and number of words ahead. For instance, there was no tendency for translators to look further ahead in the most difficult text (text C) than in the easier texts. This corresponds with the findings in Jensen's (2011) study (which used the same texts and complexity measures) where text complexity was not found to have any significant effects on cognitive load and attention.

The differences between the translators' individual reading patterns across the three tasks led us to suggest a division of online planning behaviour into three different categories: broad-context planning, narrow-context planning and sentence planning.

Broad-context planners oriented themselves in a broad context, with fixations sometimes far to the right of the word or phrase which was currently being translated. They either attended to a sentence further down in the text or read long stretches of text, sometimes several sentences, following the current position of translation. Broad-context planning behaviour is illustrated by the translation progression graph in Appendix B, where the translator, throughout the translation task, moved her eyes far ahead of the word or phrase being translated. The translation progression graph in Appendix B represents the most common type of broad-context planning behaviour, where the translator first reads long stretches of text and then produces the translation. Another type of broad-context planning behaviour was observed in one translator who read ST and produced TT more or less in parallel, but whose ST fixations were consistently about five words ahead of the position where TT was being produced. However, translators who read ST and produced TT in parallel were usually narrow-context planners (see below).

Some of the fixations far ahead in the ST may be random. Since translators constantly had to move their eyes from the bottom window of the screen, where the translation was being typed, to the top window, where the ST was displayed, their eyes may sometimes incidentally 'stumble' on ST words when moving up or down on the screen, leaving a single or a couple of fixations at a random place in the text. However, even such apparently random fixations may reflect a translator's preference for broad-context planning – and may not be completely random after all. This has not been analysed in the present study, but might be worth investigating further in future studies. The classification with respect to online planning was made by qualitatively analysing the translation progression graphs but, as was also the case with the initial orientation classifications above, there was a clear relationship between the qualitative interpretations of the graphs and the quantitative measure of the number of words ahead; see Figure 3 above. Translators identified qualitatively as broad-context planners had an average read-ahead of five words or more, with the exception of two translators

who looked only 4.7 and 4.2 words ahead on average. In all, ten translators were categorised as broad-context planners.

Characteristic of *narrow-context planners* was that they seemed to focus on a narrow context of no more than a few words ahead of the word being translated. An example is given in Appendix C. Narrow-context planners did occasionally have single fixations far ahead of the current position, but these did not appear to be systematic. A major part of the fixations were on or very close to the word currently being translated, as illustrated in Appendix C, where fixations (dots) frequently overlap with keystrokes. Compared with broad-context planners, narrow-context planners more frequently engage in parallel processing where ST comprehension and TT production co-occur. Strongest support for the sequential processing model (see above) is thus found in broad-context planning, whereas narrow-context planning seems to suggest that ST comprehension and TT production take place more simultaneously.

Again, we found a relationship between translators classified (qualitatively) as narrow-context planners and the quantitative measure of read-ahead (Figure 3) in that all of the 12 translators identified as narrow-context planners had read-ahead measures below 5.

Apart from the broad-context planners and narrow-context planners, the data also revealed that two translators had a clear preference for planning one sentence ahead and could be characterised as systematic *sentence planners*. These translators read a full sentence and then translated it afterwards, as exemplified in Appendix E (S1, text C). Sentence planners could only be identified on the basis of qualitative analyses of the translation graphs; yet, both of the sentence planners read less than 5 words ahead on average (1.9 and 4.5 respectively).

5.2.2 Looking back

Let us now turn to fixations on already translated ST words, i.e. cases where the translator is in the process of translating a word or phrase at one place in the text, but is looking at words which have been translated previously. Strictly speaking, such regressions are not required by the production process; yet they appear in all the progression graphs and thus constitute a feature shared by all translators. Some consistently exhibit *backtracking* behaviour.

There are several possible explanations for why backtracking fixations should occur. Some fixations are likely to be random and caused by the translators' eyes travelling back and forth on the screen and incidentally landing in a 'wrong place', or, as suggested by Jakobsen (2011) in his six-step translation micro-cycle, the gaze shifts from the TT back to the ST, and the ST word which has just been translated is read again before moving on to the next segment. Other fixations are probably triggered by TT monitoring (which was not tracked in this experiment), where translators read their output and check it against the ST to make sure that the translation is correct.

Looking back may also be the result of translators searching for clues in previous ST words or sentences, in order to be able to continue production, i.e. they attempt to understand and translate current words by revisiting previously translated text. Thus, backtracking behaviour could be caused by production problems (Tirkkonen-Condit 2005; Krings 1986a, 1986b), which trigger the need for deeper understanding (and consequently re-reading) of the ST (Carl & Dragsted 2012).
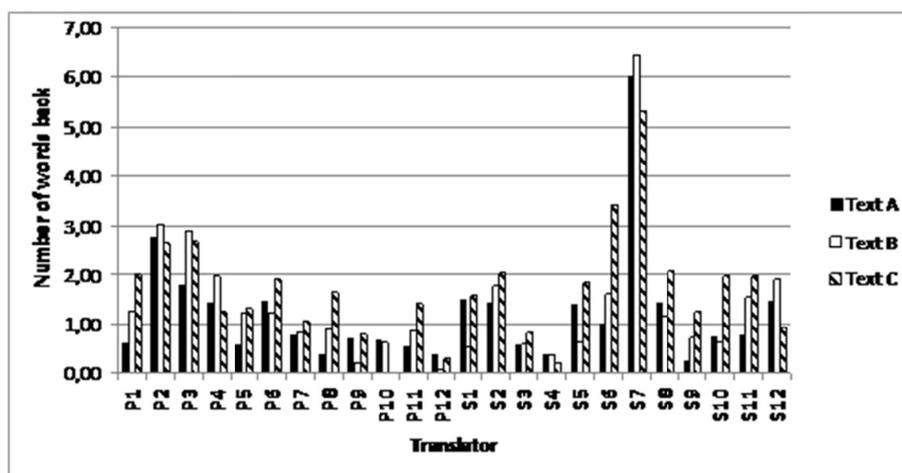
Figure 4: ST fixations looking back from the word being translated (mean)

Six of the 24 translators consistently, i.e. across all three tasks, looked back in the ST, whereas the majority only sporadically and apparently fairly randomly reread previously translated ST words. An example of a systematic *backtracker* is given in Appendix F (top) and contrasted with an example of a translator with no (or hardly any) backtracking (bottom). The backtracker had a large number of regressions to already translated ST words, especially towards the end of the drafting phase.

Again, there is a correlation between the qualitative analyses on which the classification was based and the quantitative measure of fixations looking back from the word being translated (Figure 4). For translators who exhibit backtracking behaviour, the measure is consistently above 1.5, whereas for the rest of the translators, it is consistently below that figure.

5.3   Revision/editing

In line with classifications from writing research, we divided revision/editing activities into two broad categories: online revisions, i.e. revisions carried out during the drafting phase, and end revisions, carried out after the drafting phase.

Online revisions were calculated as the number of deletions during the drafting phase, whether these were associated with the correction of typos, rephrasing of words,

phrases or sentences or change of word order, etc. All translators made revisions while drafting, but the amount of online editing varied from an average of 27 deletions in the translator with the lowest number of deletions across the three texts to an average of 134 in the translator with the highest number.
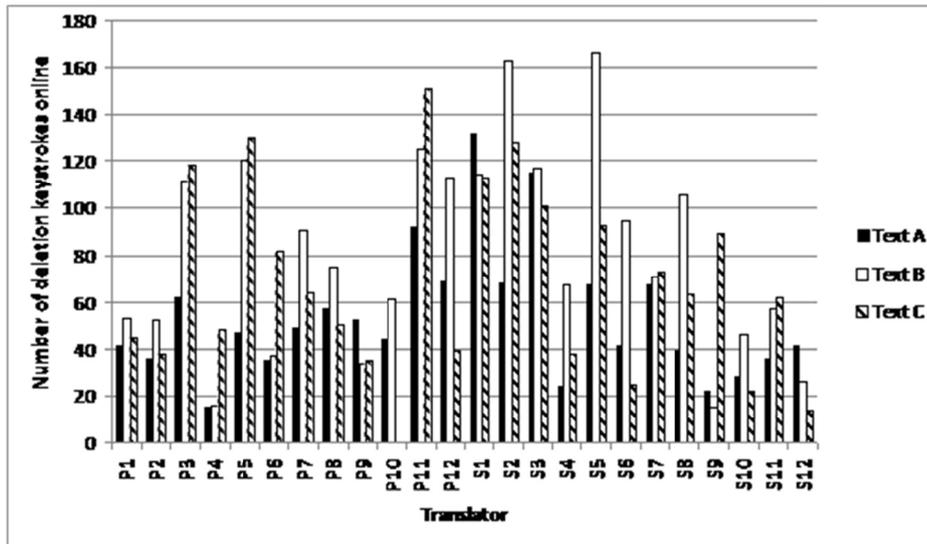
Figure 5: Number of deletion keystrokes made during drafting

Again, for many of the translators there was a tendency for the number of revisions to remain fairly constant across the three tasks. For instance, the translator with the lowest average (S12) had 41, 27 and 14 deletion keystrokes respectively in the three texts, whereas the translator with the highest average (S2) made 108, 164 and 129 eliminations respectively. However, we also found some variation across the tasks, and notably more than half of the translators performed most online revisions in text B (supposedly the medium-complex text).

As for *end revision*, only some of the translators performed corrections after the drafting phase. A possible reason for this is the time constraint condition. As mentioned in 4.2 above, some of the texts were translated under a time constraint (see section 4.3 and Jensen 2011, 94ff for details). Although in most cases the translators still managed to finish their translations, this may have affected the end revision phase. Notably, two of the translators (S6 and S4) did not finish their translations under the time constraint. This explains why these two translators performed no end revision in texts B and C respectively, but did make corrections at the end in the other two texts.

Eight translators (P7, P8, P9, S3, S5, S7, S9 and S11) made no deletions during end revision in any of the three tasks, and most translators consistently made few deletions, i.e. in the range of 5-10, after the drafting phase. However, even translators who made no or few revisions after the drafting phase could in principle still have reviewed their

translations without this leading to modifications of the TT. This would be signalled by increased time and gaze activity in the post-drafting phase, thus suggesting that a more accurate measure of the end revision effort is the time spent after the drafting phase relative to the time spent during drafting.
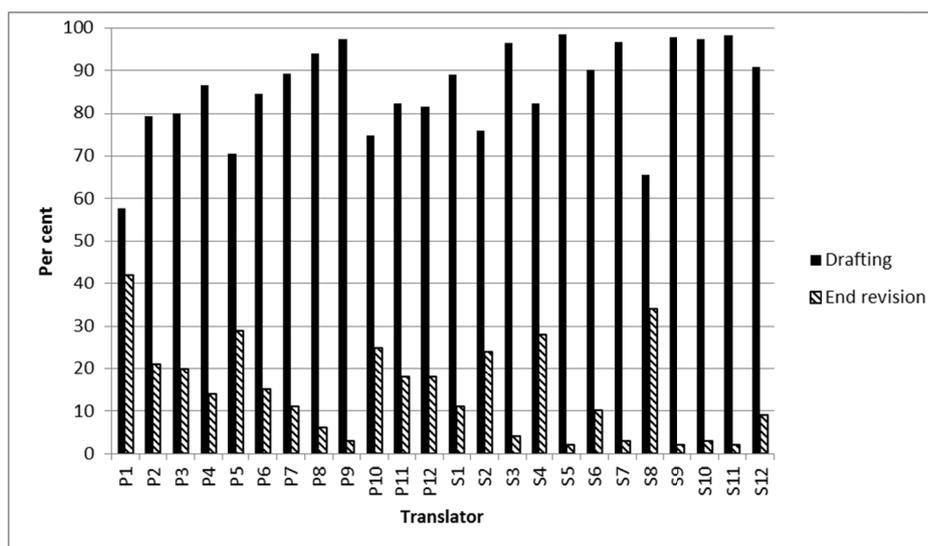
Figure 6: Ratio of drafting time and end revision time (average for all three texts)

As illustrated by the graph in Figure 6, we find a clear tendency among the translators to spend more time on the drafting phase than on the end revision phase, which is not surprising. Yet, as is apparent in Figure 6, eight translators (P1, P2, P3, P5, P10, S2, S4, and S8) spent as much as 20 per cent or more (in one case as much as 42%) on end revision. Not surprisingly, the same translators had a fair number of deletions during the end revision phase (range 4-34, mean 12.7). Somewhat unexpectedly, however, four of the eight end revisers also had a large number of online deletions, i.e. higher than the average of 68, and could thus best be classified as *constant revisers* (some of whom were most likely unskilled typists), whereas the rest of this group were categorised as *end revisers*, and translators who spent less than 20 per cent of their time on end revision were classified as *online revisers*.

6.   Discussion and conclusion

On the basis of analyses of gaze activity and keystrokes, we have arrived at categorisations of translator behaviour during initial orientation (into head-starters, quick-planners, scanners and systematic planners), during drafting (into narrow-context planners, broad-context planners and sentence planners as well as into translators with or without consistent backtracking behaviour), and during revision (into online revisers,

end revisers and constant revisers). We have found support in the data that translator behaviour remains relatively constant across texts of varying complexity, and that one may thus postulate that translators are characterised by individual translator profiles which are independent of text complexity (hypothesis 1), and possibly also of other external factors. For instance, we might characterise a translator, in terms of translator profile, as being a head-starter, a narrow-context planner, a backtracker, and an online planner.

In order to arrive at more comprehensive translation styles, we were interested to see whether translators with a particular type of behaviour on one dimension tended to exhibit a certain kind of behaviour on one or more of the other dimensions – for instance, whether head-starters tended to be narrow-context planners or end revisers, whether systematic planners tended to be broad-context planners, etc. Despite ambiguities, we observed a number of common behavioural features supporting the formulation of translation styles (hypothesis 2):

- 11 out of 12 narrow-context planners were either head-starters (9) or quick-planners (2), and 9 out of 14 head-starters were narrow-context planners
- 2 of the 3 systematic planners were also broad-context planners, and all 3 scanners were either broad-context planners or sentence planners
- 4 of the 6 backtrackers were narrow-context planners
- scanners and systematic planners, i.e. translators who spent time on initial planning, also carried out revision at the end (either as end revisers or constant revisers)

The shared features tentatively suggest a categorisation into translators with a predominantly local vs. a predominantly global focus: local orientation is generally characterised by head-start or quick-planning in the initial planning phase and narrow-context planning in the drafting phase, whereas a more global orientation is characterised by systematic planning or scanning in the initial planning phase and broad-context or sentence planning in the drafting phase.

Moreover, several translators with a general tendency towards local orientation during initial planning and drafting also had a tendency to prefer online revision as opposed to more globally-oriented end revision. Eight of the narrow-context planners were also online revisers, and all of these were at the same time either head-starters or quick planners. This group thus seems to constitute a category of translators with an overall preference for local orientation, which appears to be similar to Van Waes and Schellens's (2003) *non-stop writer* and *first draft writer* categories, or Chandler's (1993) *watercolourists* and *bricklayers* (see above).

Systematic planners and scanners were usually (in five out of six cases) also broad-context planners or sentence planners, and all but one carried out revision at the end, either as end revisers or constant revisers. These translators could be characterised as having a tendency towards global orientation, and seem to have most in common with Van Waes & Schellens's (2003) *second draft writers* or Chandler's (1993) *oil painters*, although, given the time they spent on reading/planning online, and, in some cases, on

extensive revision also in the drafting phase, they did not necessarily produce the first draft quickly.

We have so far disregarded the distinction between students and professionals in our analysis, but we initially hypothesised that translation style would be a predictor of experience (hypothesis 3). The data did not provide strong support that this was the case, but we did find certain tendencies characterising each of the groups. In particular, there appeared to be a difference between the two groups in the initial planning phase. Most of the professionals (82%) were head-starters, whereas all three systematic planners were students. Three of the four quick-planners were students. Generally, students carried out more initial planning than the professionals. Note that this contradicts earlier findings (Jakobsen 2002) showing that professionals have longer initial planning phases than students.

We found a tendency for professionals to carry out more end revision: three were end revisers and two were constant revisers, whereas there was only one end reviser and two constant revisers among the students. However, it should be noted that the time constraint factor in the experimental design may have had an impact on the participants' behaviour with respect to revision. In particular, students, who can generally be assumed to have been affected more by the time constraint than the professionals, may have omitted the end revision phase, and to a lesser extent also online revision, because they were pressed for time.

Although the tendency is not strong, there seems to be a preference among professional translators for local orientation in the initial planning phase and during drafting (82% head-starters and 64% narrow-context planners), whereas they take a more global perspective in the revision phase. Several students carried out more initial planning, and 55% were either broad-context planners or sentence planners. It may seem counter-intuitive that professionals would be more locally-oriented than students. However, local orientation during initial planning and drafting does not necessarily imply that the translators did not consider the text as a whole or that they worked with it in a fragmented manner. Local orientation behaviour may suggest that, due to their translation expertise, professional translators are able to produce TT more quickly, and without referring to more than the immediate context of what they are translating, unless a production problem occurs. This seems to be consistent with the translation models proposed by Krings (1986b) and Tirkkonen-Condit (2005) (see also Carl & Dragsted 2012). Students, on the other hand, are more insecure and therefore have a tendency to look for more ST context to test their meaning hypotheses (Gile 1995) and generate a deeper understanding of the ST, in order to overcome production problems (Carl & Dragsted 2012). This production mode seems to tie in with the sequential translation model proposed by Gile (1995), while also allowing for an interpretation in line with Danks and Griffin's model, which suggests that the translator does not necessarily comprehend the ST fully before starting to formulate the TT (Danks & Griffin 1997).

In conclusion, we have found that the method of combining eye-tracking and keylogging data in translation progression graphs has provided us with useful insights into shared features and individual characteristics in translators, and patterns of interaction between these characteristics in different phases of the translation process. Presenting typing and gaze data in translation progression graphs offers the possibility of investigating translators' profiles on the basis of visual representations of their production process, thus providing us with a very useful first impression of translators' behavioural characteristics. These can then be supplemented with quantitative analyses. With this first attempt at defining translation styles using eye-tracking/keylogging technology and translation progression graphs, we have tested a method which seems to offer a good potential for exploring translation styles. In particular, it would be interesting to look further into correlations between different behavioural characteristics and relate these to established models. For example, a follow up study might systematically investigate the relationship between orientation in the ST (broad vs. narrow context planning) and processing mode (sequential vs. parallel processing). Finally, knowledge about translation styles may eventually feed into translation software design, taking individual processing patterns and levels of expertise into account.

Notes

1. We are grateful to PhD, Assistant Professor, Kristian T. H. Jensen, for allowing us access to translation process and product data collected in connection with his PhD thesis (Jensen 2011).

2. Krings identifies five main sets of translation strategies: comprehension of SL text segments, retrieval of target language (TL) equivalents, monitoring of equivalents, strategies of reduction (of for instance the metaphorical character of a SL text item), and decision-making strategies where the translator consults general, text-independent translation strategies (Krings 1986b:268ff).

3. Retrieved Nov. 2010 from http://www.tobii.se

4. It should be noted that these gaze-to-word mappings are subject to some uncertainty caused by the inaccuracy of the hardware and software as well as external factors, such as pupil and light conditions. In previous studies, the accuracy of the GWM tool has been reported to be between 65 and 88% (Jensen 2008; Dragsted & Hansen 2008).

5. In many instances, Danish and English can be aligned at word level. E.g. killed the four women was usually translated into *dræbte de fire kvinder*, and alignments could be made word for word (killed -> *dræbte*; the -> *de*; four -> *fire*; women -> *kvinder*). In other cases, for instance when translating fixed expressions, idioms and discontinuous strings, alignments were made at phrase/clause level.

6. This applies to languages which are read from left to right. In languages such as Hebrew that are read right to left, fixation spans are to the left of the word (Staub & Rayner 2007).

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Appendix A: Experimental texts

Text A

Source: *The Independent* (4 March 2008)

Average production time: 6 minutes and 22 seconds

Hospital nurse Colin Norris was imprisoned for life today for the killing of four of his patients. 32 year old Norris from Glasgow killed the four women in 2002 by giving them large amounts of sleeping medicine. Yesterday, he was found guilty of four counts of murder following a long trial. He was given four life sentences, one for each of the killings. He will have to serve at least 30 years. Police officer Chris Gregg said that Norris had been acting strangely around the hospital. Only the awareness of other hospital staff put a stop to him and to the killings. The police have learned that the motive for the killings was that Norris disliked working with old people. All of his victims were old weak women with heart problems. All of them could be considered a burden to hospital staff.

Text B

Source: *Daily Telegraph* (12 February 2008)

Average production time: 7 minutes and 18 seconds

British families have to cough up an extra £1,300 a year as food and fuel prices soar at their fastest rate in 17 years. Prices in supermarkets have climbed at an alarming rate over the past year. Analysts have warned that prices will increase further still, making it hard for the Bank of England to cut interest rates as it struggles to keep inflation and the economy under control. To make matters worse, escalating prices are racing ahead of salary increases, especially those of nurses and other healthcare professionals, who have suffered from the government's insistence that those in the public sector have to receive below-inflation salary increases. In addition to fuel and food, electricity bills are also soaring. Five out of the six largest suppliers have increased their customers' bills.

Text C

Source: *The Times* (13 February 2008)

Average production time: 7 minutes and 8 seconds

In a gesture sure to rattle the Chinese Government, Steven Spielberg pulled out of the Beijing Olympics to protest against China's backing for Sudan's policy in Darfur. His withdrawal comes in the wake of fighting flaring up again in Darfur and is set to

embarrass China, which has sought to halt the negative fallout from having close ties to the Sudanese government. China, which has extensive investments in the Sudanese oil industry, maintains close links with the Government, which includes one minister charged with crimes against humanity by the International Criminal Court in The Hague. Although emphasizing that Khartoum bears the bulk of the responsibility for these ongoing atrocities, Spielberg maintains that the international community, and particularly China, should do more to end the suffering.

Appendix B: Example of initial quick planner and broad-context planner, who reads a couple of sentences initially and looks far ahead into the ST during the drafting phase (S10, Text B)
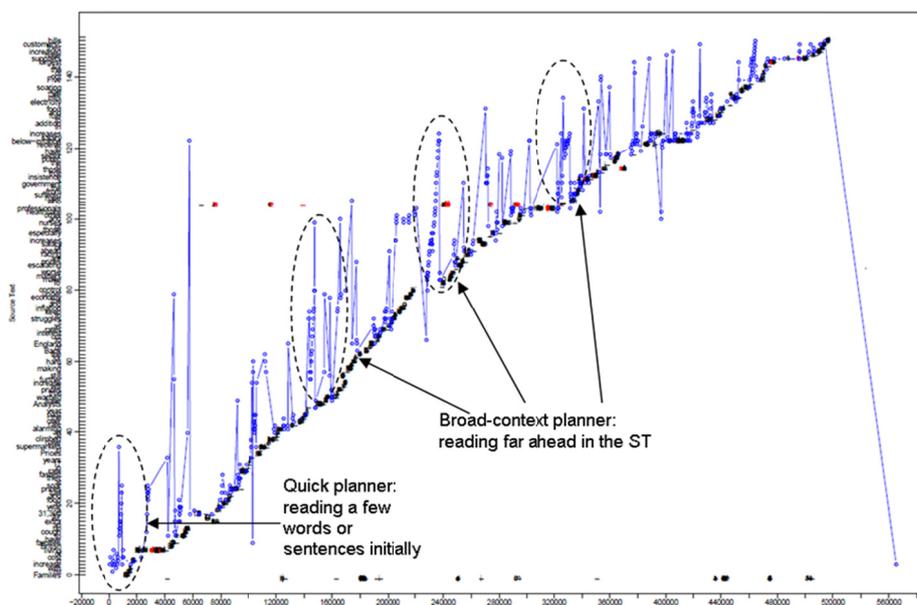
Appendix C: Example of initial head-starter and narrow-context planner, who starts translating right away and reads no more than a few words ahead of the word being translated (P6, Text B)
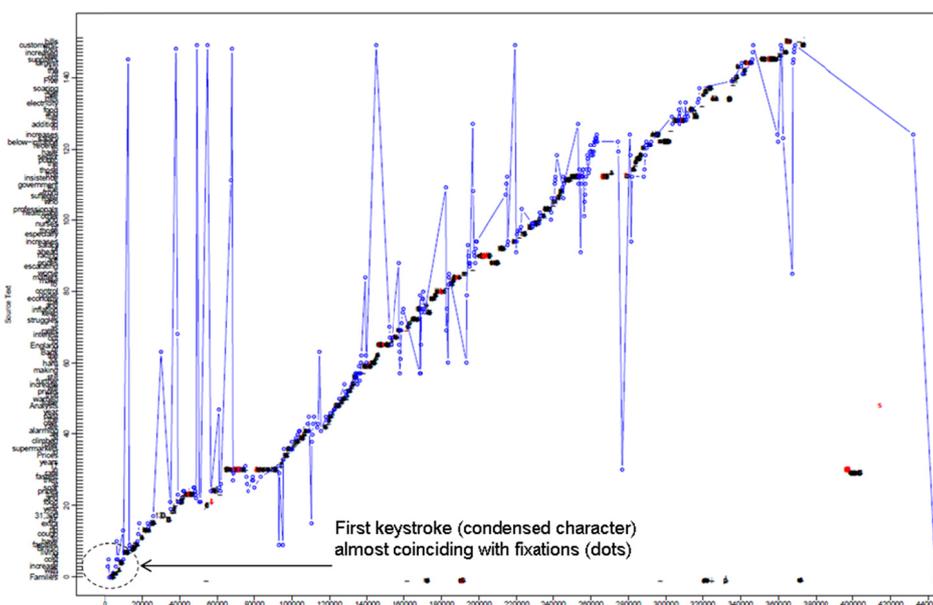
Appendix D: Example of initial scanner, who has some 'sporadic' fixations in the ST before starting to translate (P10, Text A)
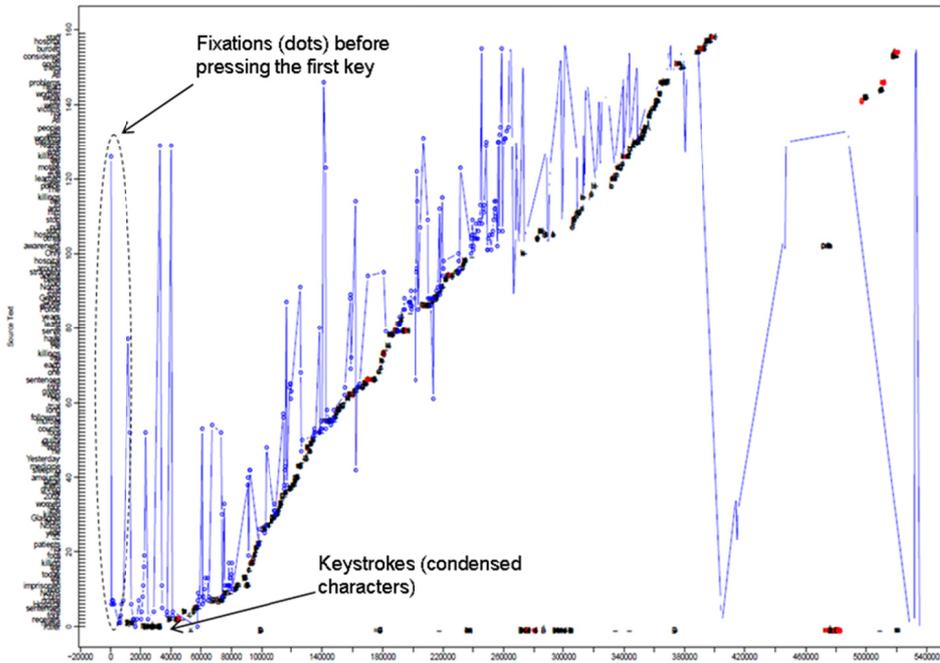
Appendix E: Example of sentence planner, who systematically reads one sentence ahead in the ST before starting to translate it (S1, Text C)
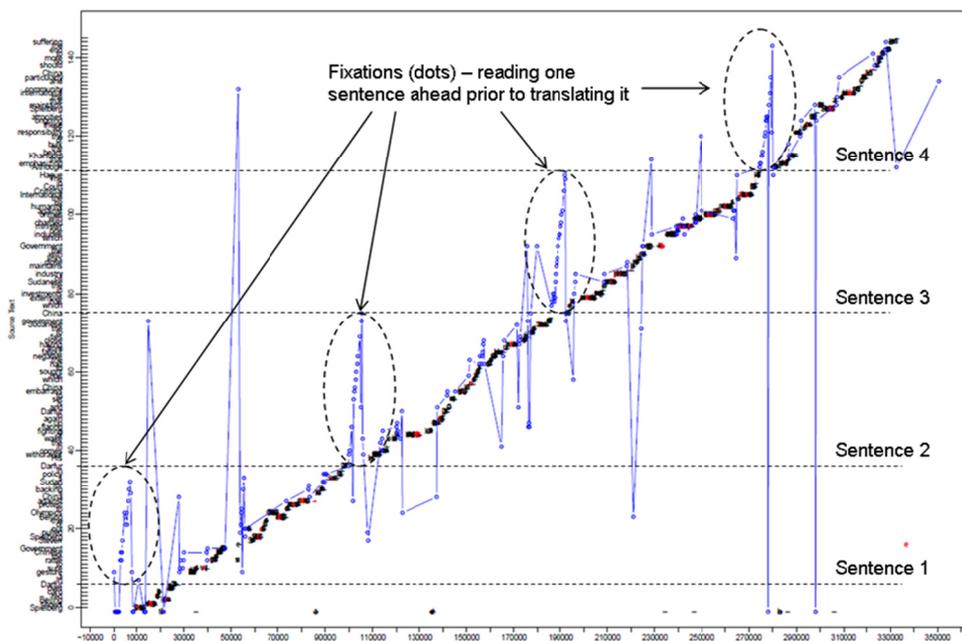
Appendix F: Example of backtracking (top) with many fixations on ST words which have already been translated vs. no backtracking (bottom) with very few fixations on already translated ST words.