On the Systematicity of Human Translation Processes

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While translation careers and the translation profession become more globalised and more technological, we are still far from understanding how humans actually translate and how they could be best supported by machines. In this paper we attempt to outline a method which helps to uncover characteristic steps in human translation processes. Based on the translators' activity data, we develop a taxonomy of translation styles, which are characteristic for different kinds of translators. The taxonomy could serve to inform the development of advanced translation assistance tools and provide a basis for a felicitous and more grounded integration in human machine interaction in translation.

Introduction

The translation profession is in a situation of transformation, triggered through technological achievements in the area of machine translation and computer assisted translation. Questions have to be answered concerning the development of "Translation Careers and Technologies" as the profession becomes more globalised and more technological. We believe that a better understanding of the human translation processes can inform the development of advanced translation assistance tools and provide a basis for more successful interaction between the human translator and the technology. It may also be instrumental for the development of tools for translator education.

In this paper we attempt to outline a method which helps to uncover characteristic steps in human translation processes. While there has been some research to investigate the systematicity in the translation product (e.g. Steiner, 2001), we are only beginning to understand and formalise the processes that take place during human translation.

With respect to the translation product, a qualified human translator will, for instance, systematically produce syntactically correct and faithful translations. In their training and professional lives, translators develop translation strategies (i.e. a systematicity) which leads to a systematically more coherent, predictable and confident output than that produced by MT. Besides the systematicity in the translation product, we argue that there is also systematicity in human translation processes.

Empirical human translation process research started in the 1980s (Lörscher 1991, Krings 1986) and since then has developed in a direction which analyses, describes and models translator behaviour, using eye-tracker and keyboard logging devices (Jakobsen, 2003). While eye movements give a picture of how

meaning is constructed from a string of source text symbols, typing behaviour reflects how the meaning is constructed in the target language.

In this paper we will give an overview of our current research to describe types of translator behaviour based on translators' activity data, and draw some conclusions concerning the specific kind of human-computer interaction that is characteristic of contemporary translation. We aim at establishing a repository of patterns of translation behaviour to describe translation styles. An empirically grounded cognitive model of translation will help not only understand translation activities, but also to design targeted translation assistance.

As our investigation is grounded in activity data, we will first report the experimental setting and the visualization tools used. We will then identify characteristic styles of translator behaviour based on a qualitative and quantitative assessment of translators' activity data, and finally draw some conclusions that the findings might have on the technological development.

Experimental setting

We report on translation experiments which included 12 professional translators with at least two years' experience, and 12 MA students at the Copenhagen Business School (CBS), all of them specialising in translation between Danish (L1) and English (L2).

Three texts were presented to the participants in the keystroke logging program Translog User (Jakobsen and Schou 1999), which displays the source text (ST) in the top window of the screen, and enables the translator to produce the target text (TT) in the bottom window. The participants did not have Internet access and were not allowed to use dictionaries or other similar support, since this would produce a large amount of irrelevant data (for our purpose), and distort the timings and process data that we were interested in.

Process data consisted of eye-tracking and keystroke logging data from all the texts. 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 source text at word or phrase level.

The combination of aligned source and target texts with eye movement and keystroke logging data enabled the presentation of *translation progression graphs* (Figures 1 to 4) showing relations between translation product and translation process data in time (Carl and Jakobsen, 2010). Thus, we were able to see, for instance, whether the translator was looking at a ST word while producing a translation of it, whether he/she was looking at another ST word somewhere else in the source text, and so on.

The translation progression graph in Figure 1 shows a fragment of 700 seconds in which an English ST of 160 words was translated into Danish. The graph shows the distribution of ST fixations on the 160 ST words and the keystrokes by which the TT was produced. Blue circles represent fixations on the ST, black dots TT insertions, and red dots TT deletions. Note that there are longer stretches of time with no gaze activities (i.e. no blue circles). These are likely to be times when the translator was looking at the keyboard or reading the

target text (TT). The translation progression graphs only show reading behaviour on the ST, since the software used in the experiment only registered and mapped gaze movements on the source screen. Due to the fact that some TT words could not be aligned to any ST word, there are a number of *unaligned* keystrokes. There are also *unmatched* keystrokes, which could not be associated with any of the ST words.

Figure 1 shows several translation phases: *initial orientation*, *drafting* and *revision*. In this paper we characterise translators according to (1) how they initially orient themselves in the ST, (2) how they plan translation drafting, and (3) whether they prefer online revision or end revision. The combination of a translator's behavioural characteristics in these three phases may serve to formulate different translator styles.

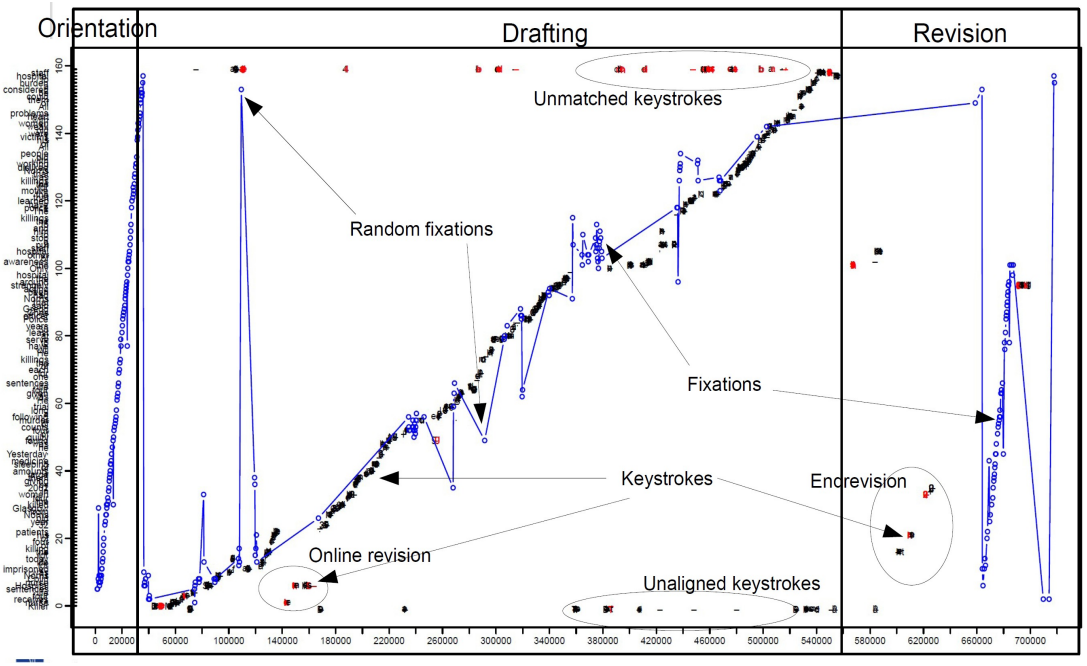

Figure 1: The translation progression graph shows time in ms on the X-axis, and the Y-axis shows the source text (from 0 to approx. 160 words). The small dots in the graph indicate fixations, and the lines between them are eye movements (saccades). The black and red characters are the TT keystrokes.

Initial orientation

Initial orientation in the ST involves the translator's reading of the ST before starting to produce the translation. We knew from previous studies that the extent of initial orientation may vary. Some translators prefer to systematically read the whole source text before they start translating, some translators skim the text very briefly, and some translators just read the first couple of phrases or sentences before starting to type, or they simply go straight ahead with target text production with hardly any preliminary ST reading.

Initial orientation may be calculated as the amount of time spent before writing the first character[1]. On average, the 24 translators spent 3.3 per cent of total task time on initial orientation across the three texts, and most of them spent less than 10 seconds (in all tasks), which includes the reading required for producing the first translation segment of target text. In general, translators have a tendency for the initial orientation phase to be of approximately the same duration across all three tasks, but substantial individual differences were observed. In particular, three of the translators spent a long time on initial orientation before they started translating the text. The visualisation provided by the translation progression graphs revealed that these three translators systematically read through the whole source text before starting to translate it. This type of behaviour is exemplified by the translation progression graph in Figure 1, where the continuous string of blue circles starting at zero ms (bottom-left corner) and ending around 40,000 ms (top-left corner), just before the first key is pressed around 40,000ms, indicates systematic reading of the ST before typing was started.

Only three translators carried out systematic reading during initial orientation. In the majority of cases, the translator either started translating right away (head-start) or read the first couple of words or sentences, and then pressed the first key (quick planning). Some translators skimmed the text rapidly (skimming). Generally, the initial orientation phase seems to be oriented towards limited context and not the whole text.

Reading during drafting

Translators also differ with respect to ST reading and planning while translating. We looked at where in the ST the translators' eyes were fixated while translating a given word or phrase. First of all, a distinction can be made between fixations on words which were about to be translated (looking ahead), and fixations on ST words that had already been translated (looking back).

Looking ahead

When people read aloud, there is a lag, termed the eye-voice-span by analogy with the celebrated eye-mind span (Just and Carpenter 1980). The eye-voice span is a measure of how far the eyes are ahead of what is articulated at any point in time. If the lights in a room are turned off and the eyes can no longer see what is being read, we are still able to produce two or three more words (Staub and Rayner 2007: 329). Similarly, in a simple copying task, where subjects were asked to rewrite a text in the same language, the copyist typically looked two to three words to the right[2] of the word being retyped (John 1996).

The average look-ahead for our translators was around four words (mean: 4.28, median: 3.90), suggesting that translators generally look for slightly more

[1] This is not a perfectly accurate calculation. The first keystroke is likely to be preceded by a short period of 'local' preparation that should ideally count as part of the drafting phase.

[2] 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 and Rayner, 2007)

context than typists performing a simple copying task. Most ST fixations were in the area between 2 and 6 words to the right of the word being translated. Thus all translators in the study shared a tendency to look beyond the current word. A certain amount of forward planning is a general feature of the translation process. This does not imply that the translators never look at a ST word simultaneously with producing an equivalent in the TL, but all translators had most fixations to the right of the word being translated.

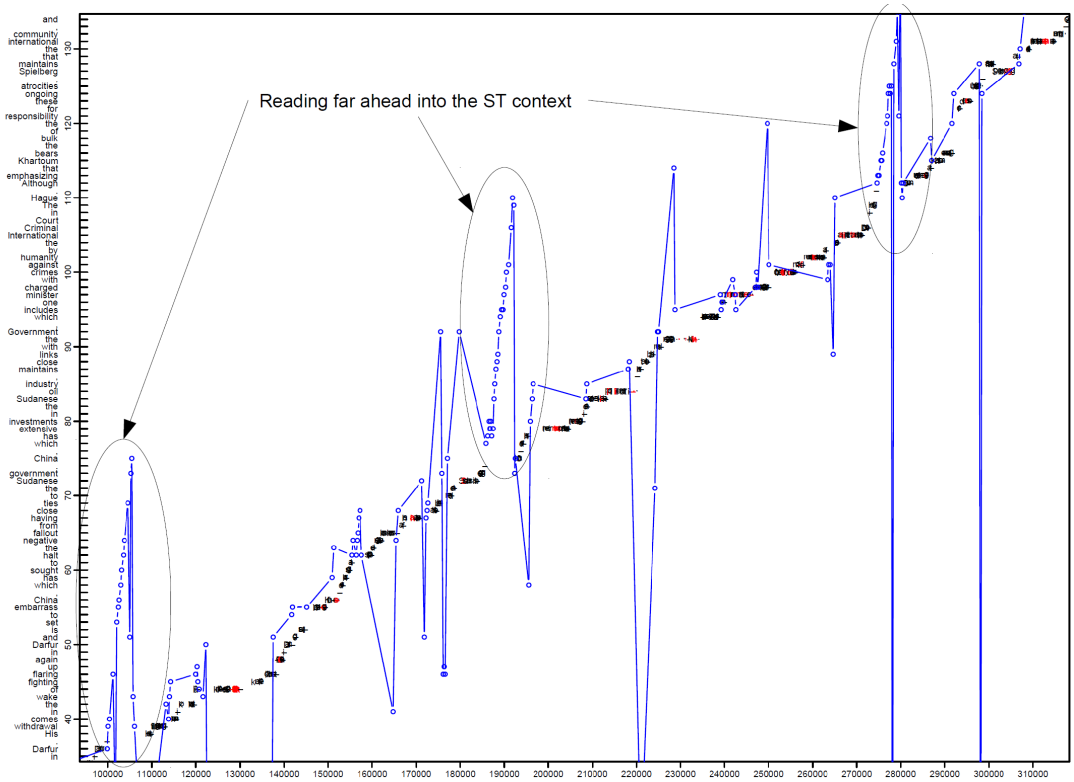

Figure 2: Large context planning: source text fixations ahead of the word currently being translated

We found some variance in individual planning behaviour across the three tasks, but standard deviations were generally below or just around 1. The level of text difficulty did not appear to have an effect on planning behaviour, signified by the lack of a clear correlation between text and the number of forward words viewed. Translators with a tendency to look far ahead in the text did so fairly consistently across all tasks, and translators who focused on the near environment of the word or phrase being translated similarly exhibited this behaviour regularly. Online planning behaviour can thus be divided into two different categories: large-context planning and small-context planning.

In ***large-context planning***, translators are oriented in a broad context, with fixations sometimes far to the right of the word or phrase which is currently being translated. For instance, the large context planners may attend to a sentence

further down in the text or read long stretches of text, sometimes several sentences, immediately following the current position, as in Figure 2.

Some of the fixations far ahead in the source text may be random. In the experimental setup we used, translators frequently had to move their eyes from the bottom window of the screen, where the translation was typed, to the top window of the screen, where the source text was displayed. Therefore the eyes may sometimes incidentally have 'stumbled' when moving up or down on the screen, leaving a single or a couple of fixations at a random place in the text

There turned out to be a strong correlation between the qualitative analyses of the graphs and the quantitative measure of the number of words read ahead. Translators identified qualitatively as large context planners had an average read-ahead of 5 words or more (on average for all three texts), with the exception of two translators who looked only 4.7 and 4.2 words ahead on average. Ten translators were categorised as large-context planners.

It is characteristic of ***small-context planning*** that the translators focus their gaze on a small context of no more than a few words ahead of the word being translated. An example is given in Figure 3. Even if small context planners may seem to have some leaps ahead, these are not very systematic, and the translator does not read longer sequences further ahead in the text. Rather, a major part of the fixations are on or very close to the word currently being translated. Here the fixations (blue circles) frequently overlap with the keystrokes, which indicates that ST fixation and typing of TT equivalent occur simultaneously.

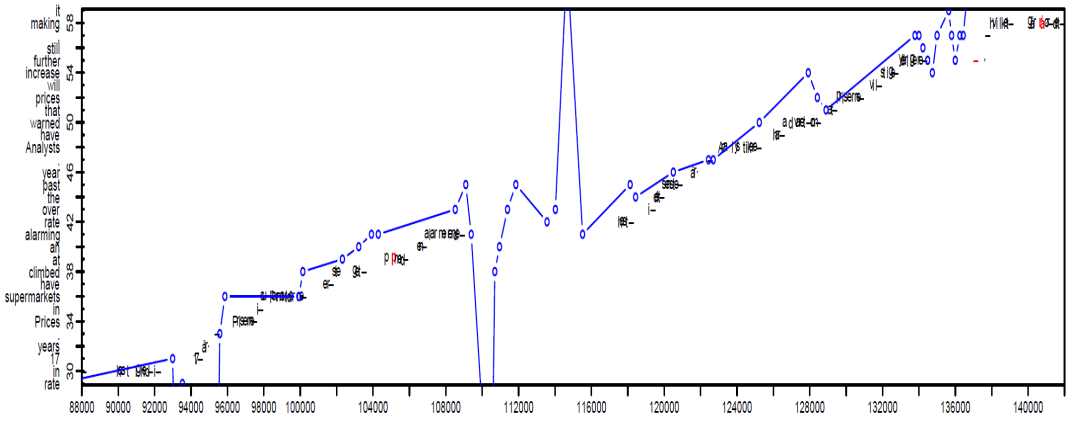

Figure 3: Small context planner, looking only a few words ahead (with some random regressive/progressive fixations)

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

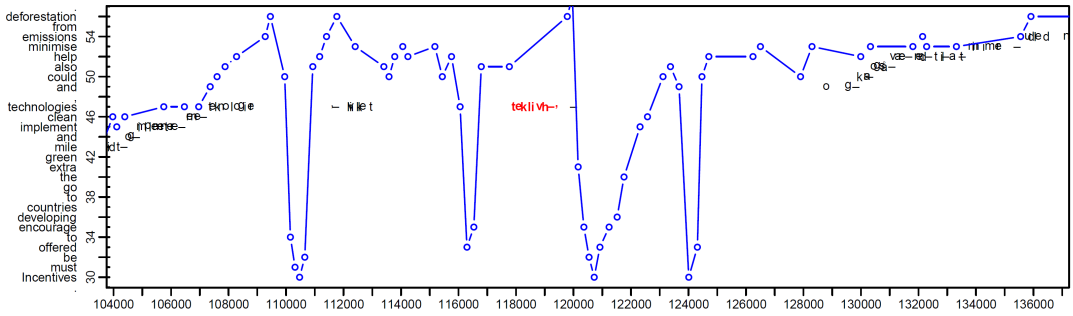

Figure 4: Source text fixations looking back from the word being translated

Looking back

We will now turn to fixations on ST words which have been translated, i.e. 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.

Looking back may be triggered by TT monitoring where the translator reads his or her translated output and compares it with the ST input to check that the translation was correct, or it may be associated with the translator searching for clues in previous ST words or sentences in order to be able to continue production, i.e. they attempt to understand and reproduce words currently being translated by revisiting previously translated text. Our classification of translator behaviour as ***backtracking*** or ***non-backtracking*** is concerned mainly with the latter behavioural feature of consistently rereading sequences of previously translated ST, because it signals a broader orientation perspective on the translation.

Although the data showed that all translators had some regressions to previously translated ST words, there was no indication of this behaviour generally characterising the translation process. Six of the 24 translators consistently, i.e. across all three tasks, looked back in the ST whereas the remainder only sporadically and fairly randomly, it seems, reread previously translated ST words.

There is a correlation between the qualitative data on which the classification was based, and the quantitative measure of fixations looking back from the word being translated. For translators who exhibit backtracking behaviour, the mean number of words backtracked is consistently above 1.5, whereas for the rest of the translators, it is consistently below.

Revision/editing

Revision/editing activities can be divided 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 text elimination keystrokes during the drafting phase, irrespective of whether these were associated with the correction of typos, rephrasing of words, phrases and sentences, or with change of word order, etc.[3] All translators made corrections while drafting, but the amount of online editing varied from an average number of 27 text elimination keystrokes to an average of 134.

Again, for many of the translators there was a tendency for the number of revisions to remain fairly consistent across the three tasks. For instance the translator with the lowest average had 41, 27 and 14 deletion keystrokes respectively in the three texts, whereas the translator with the highest average made 108, 164 and 129 eliminations respectively. However, we also found some variation across the tasks.

As for ***end revision***, only some of the translators made corrections after the drafting phase. Eight translators had no text elimination keystrokes in any of the three tasks, and most translators consistently made few deletions, i.e. in the range from 5-10, after the drafting phase. Even so, some of the translators made an effort after the drafting phase, signalled by time and gaze activity, to review their own target text. In some cases no or few corrections were in fact made, resulting in the low number of text elimination keystrokes after the drafting phase in some translators. Thus, it seemed that a better measure of end revision would be to measure the time spent after the drafting phase (end revision) relative to the time spent during drafting as described below.

We find a clear preference among the translators for allocating more time to the drafting phase than to the end revision phase. Yet, eight translators spent a considerable 20 per cent or more of the overall translation time on end revision. Not surprisingly, the same translators had a fair amount of text elimination keystrokes 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 text elimination keystrokes, i.e. higher than the average of 68, and their behaviour could thus better be classified as ***constant revision*** behaviour, whereas the other translators in this group exhibited ***end revision*** behaviour. Behaviour in translators who spent less than 20 per cent of their time on end revision could be classified as ***online revision*** behaviour.

Conclusions

Based on empirical data, we have observed differences and similarities in the translators' working styles, and classified translation types according to the observable behaviour. We have identified three translation phases: initial orientation, translation drafting and final revision.

1. Initial orientation: functions as an initial text planning phase. Several types of behaviour can be distinguished:

[3]See Carl et al. (2010) for a discussion on short and long distance revisions of the same text material.

- *systematic initial orientation*: the translator systematically reads through the ST before translation.
- *skimming*: the translator skims the ST rapidly before translation
- *quick planning*: the translator reads the first couple of words or sentences, and then presses the first key.
- *head start*: the translator starts translating right away

2. Translation drafting: the phase in which the actual translation is drafted. We distinguish several translation styles:
   - *large-context planning:* the translator reads text sequences, sometimes whole sentences, far ahead in the source text.
   - *small-context planning:* the translator frequently fixates the word being typed or a couple of words, but rarely a whole sentence ahead.
   - *backtracking:* the translator has a tendency to re-fixate ST words which have already been translated
   - *non-backtracking*: the translator does not systematically re-fixate ST words which have already been translated

The translators may show traces of different kinds of behaviour during drafting, but the data provide evidence for an overall preference for one of the two kinds of planning ahead (small context or large context planning) as well as a preference with respect to looking back at previously translated ST words. The two types of planning behaviour may or may not be combined with backtracking.

3. Revision: this phase serves to review the text and refine translation choices. Three types of revision can be distinguished:
   - *online revision*: the translator revises the text during the drafting phase
   - *end revision*: the translator spends 20 per cent or more of his/her time on end revision
   - *constant revision*: the translator spends more than 20 per cent of translation time on end revision, but at the same time makes a large number (above average) of online revisions.

Development of translation tools could benefit from incorporating knowledge of human translation behaviour and translator styles.

Given the separation into translation phases, and their different function in the translation process, it might be helpful to design separate tools that support translators in their specific need during these phases. Repeated expressions, term translation, or passages that are difficult to translate may be of interest in the initial orientation phase and tools could be designed to highlight these occurrences during this phase.

According to behavioural preferences in the translation phases, different online assistance tools might help translators who work, for instance, as small-, or large-context planning. Translation completion tools might be more helpful for small-context planning, whereas translation memories or machine translation post-editing might be more acceptable for large-context planning.

Previous research has shown that professional translators and novices generally exhibit different translation behaviour (Jääskelainen 1988, Jensen 2001, Jakobsen 2003, Tirkkonen-Condit 2005). Preliminary investigations suggest that professional translators tend to be characterised by head-starting, small-context planning, and end-revising, while student translators more frequently perform systematic initial orientation, large-context planning and online revising (Carl and Buch-Kromann, 2010). Future studies will investigate this preliminary finding in more detail.

Also, it has been reported that expert translators are less enthusiastic about automated translation assistance than student translators (Koehn, 2009). It is unclear why this might be the case, and how translation assistance could be designed to help all translators alike, but developing customised translation tools taking account of different translation styles seems could be a direction to pursue.

Better cognitive models of translation have to be developed, since experiments to design and evaluate such CAT tools are extremely labour intensive to develop and to test. As Knight et al. (2007) point out, "the combination of small usability studies and cognitive modeling [may help to] make an informed decision about critical aspects of a User Interface".

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