Digital Humanities and Empirical Human Translation Process Research Past, Present and Future Perspectives

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Computers are useless.
They can only give answers - Pablo Picasso

Abstract

The paper traces some results from earlier experiments and analyses in the field of human translation process research (TPR). Some of these results – obtained with key-stroke logging and introspection – are corroborated by newer experiments where sophisticated tools like eye-tracking as well as cluster and mapping techniques are used. As more translation process data are available and better analysis tools are developed, we are also able to go beyond cognitive models of human translation processes and develop fine-grained translation process models. The success of TPR in the future will be measured by the insights gained and they will be instrumental for the design of better interfaces for human-computer interaction (HCI) in translation. We anticipate that at least parts of TPR will increasingly turn into an engineering discipline, with many interesting insights for (digital) humanities.

Introduction

According to Wikipedia (as of 26th July 2011) digital humanities is the "digitalization and analysis of material related to the traditional disciplines of the humanities". It "combines the methodologies from the traditional humanities disciplines [...] with tools provided by computing". The goal is to overcome linear narration in scholarly documents and to create dynamic texts that are more than merely papers. Digital humanities fosters an integration of novel forms of data visualisation, data retrieval, computational analysis, the application of multimedia, internet and interactive technology and tries to apply this in scholarly activities of traditional arts and humanities. In some parts of the humanities, like TPR, computer tools are welcome because they add rigor to the investigations.

One of the differences between the *humanities* and natural *sciences* has traditionally been that the former discipline asks questions and that results are based on theories and arguments, while the latter one is based on hypotheses and provides answers based on empirical evidence – although not necessarily to the same questions. With *digital humanities,* this division seems to get out-dated, at least with respect to some parts of the traditional humanities like, for example, corpus linguistics and translation process research. As human behavior is being recorded and digitized and answers to the question ”What does it mean to be human?” are now increasingly being computed rather than argued. On the one hand, this technological turn calls for more formalized methods and for applied knowledge to solve practical, computational problems. On the other hand, digital humanities transforms (parts of) the humanities into an engineering discipline, which will radically change our living and working conditions.

Twenty years ago computational linguistics was often considered to be part of the humanities and computers were applied to verify or consolidate linguistic theories. Today computational linguistics is primarily a language engineering discipline, based on empirical research and catered towards finding computational solutions to automatize language processes and to develop more advanced language technologies. Google (translate) and facebook are now a part of our daily lives and our preferences on the internet, peer group and on-line behavior is constantly monitored and statistical user profiles are generated. Due to the fact that technology has changed our lives, we are now also faced with new questions that were unknown before. By living in a virtual world it is, in fact, the users who “answer questions ...”--- while the statistical analysis of the reactions produces finer-grained questions --- “... that we were not even aware we could ask” (cf. call for papers of this conference). In contrast to earlier research, and by reversing Picasso's introductory citation, it is now the computer that suggests to us a number of (most likely) questions in the form of possible choices, while the users answer them explicitly or implicitly by the way they behave.

We envision a similar development for digital translation process research (DTPR). Computer-based analysis techniques have been applied in empirical translation studies for about 15 years. Digitization of human typing behaviour is used in combination with other methods, like introspection, and combined with an evaluation of the target text.

As with computational linguistics, we observe increased formalization of the field and assume that (parts of) DTPR will eventually turn into an engineering science. Computer-based tools will be more extensively used in the centre of interest while the human aspect may disappear more and more.

Empirical TPR with Translog

Empirical translation research has increasingly focused on translation processes from a cognitive perspective. In the

beginnings of TPR, for example, by Krings (1986), Lörscher (1992) and Tirkkonen-Condit & Jääskeläinen (2000), user data could only be elicited via traditional methods of introspection like questionnaires, think-aloud experiments (TA) or retrospection.
Around the 1990s, most texts and most translations were typed on computer keyboards, and software was developed to log the writing process (all keystrokes, pauses and changes), for example ScriptLog (Holmqvist et al, 2002), Proxy (Pacte group), Translog (Jakobsen and Schou, 1999 and Inputlog (Leijten/Van Maes, 2006)). This can be regarded as the beginning of digital translation process research (DTPR). With these tools a complete log can be created of all the keystrokes made in producing a text, including typos, pauses, deletions, changes, mouse clicks, cursor movements. Key stroke logging was combined with introspection, usually with TA. Several larger translation process projects were carried out with keystroke logging combined with retrospection and post-process dialogues.
In this kind of TPR several aspects of translators' behaviour were investigated, like for instance, the segmentation of the translation process, aspects of time, translation under time pressure, translation problems and search strategies to solve these problems, decision taking, units that translators identify and focus on, the temporal and/or contextual structure of those activities – in projects comparing inter- and intrapersonal variation.
Within CRITT[1], we have developed a combined method and data acquisition software, Translog[2], with which translators' activities (keystrokes and eye-movements) can be recorded simultaneously. Translog separates the screen into a source text window and a target text window. While the source window works in a read-only mode and plots the target text, translators type their translation into the target window. Keystrokes and (since 2011 also gaze activities) are recorded during the translation sessions and can be replayed for inspection and analysis in a replay mode.
This tool is now the most widely used tool of its kind (Jakobsen, 2006). Over the past years, CRITT has also collected a substantial amount of translation process data from numerous translation sessions. The analysis of these data has given rise to grounded translation models and a novel understanding of the underlying human translation processes (Hansen 2002; Mees and Göpferich, 2009). We will give examples of the application of digital methods and show some results.

A holistic longitudinal study

In a holistic longitudinal study, *From student to expert (*Hansen 1997; 2002; 2003; 2005; 2006; 2010; 2011), several experiments and control experiments were carried out with Translog in combination with retrospection. Additionally pre-process and post-process questionnaires and a post-process dialogue as well as revision tests of self-revision and other-revision were carried out.

[1] CRITT is the "Center for Research and Innovation in Translation and Translation Technology" at Copenhagen Business School, which aims at building up new knowledge of translation and communication processes and providing a basis for technological innovation in this field.

[2] www.translog.dk

Translation was regarded as a complex individual mental act of intercultural communication. Translation tasks had a clearly defined realistic purpose and the target text receivers were defined in a translation brief.
The original goal of the longitudinal study was identifying what it is that characterises successful translators.
In Hansen (1997: 207), it was submitted that translators have their individual competence pattern (ICP) which can be recognized and identified in their translation products and also in their behaviour during their translation processes.
In the first part of the longitudinal study, the subjects carried out individual experiments of translation into both directions, from German into Danish and vice versa. As the goal was drawing competence patterns of *successful* translators, it was necessary always also to evaluate the processes and the final products and to take the quality of the revisions during the processes into consideration.
Parameters were thus *profile parameters* like, among others the subjects' individual backgrounds, their translator training and additionally their comments during the retrospection and clarifications and explanations during the dialogue; *product parameters* were the quality of the target texts and of the revisions during the process, and also the types of errors made. The pure digital process data were:
- the time management during the processes, segmentation into phases and pauses as well as the position and length of the pauses
- cursor movements and revisions
- the use of aids, if registered on the computer

These digital data were combined in several constellations with each other and with the introspection data and the results were triangulated, like for example:

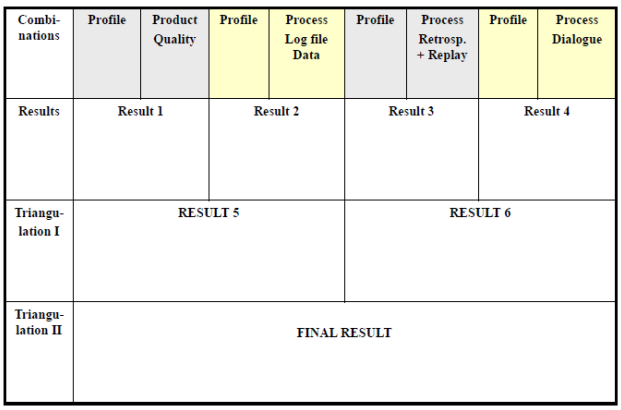

Figure 1: Combinations and Triangulations

Figure 1 is a model demonstrating how combination and triangulation (only results are triangulated) can be used to control a holistic study. Result 1 comes from the combination of the subject's profile data (individual background) with the quality of the evaluated product whereas result 2 emerges from a combination of the same subject's profile data with his/her time management, e.g. segmentation of the process in phases and pauses as well as key-strokes, changes and revisions. These two results can be triangulated, for example in order to explore if

successful translations can be combined with special behaviour during the process.

In the projects of this kind of holistic process research, focus is on the problems the translators paid attention to, their manner of solving problems and taking decisions, i.e. their intentions, attitude, strategies, behaviour and their ability to control their process and product.

The fundamental idea of the application of introspection methods is that in an attempt of in-depth understanding and in order to find causal relationships, it is necessary to *ask* the subject. In this kind of translation process research, an assumption is that a human-being who experiences a phenomenon is the best to report on his/her experience and perception. However, introspection data are subjective data.

The advantage of digital tools is that additionally to the introspective data they provide objective, reliable, quantitative data. Position and length of phases and pauses, cursor movements and revisions are registered in a log-file, and the process can be replayed. With the "replay function" of Translog showing the writing process dynamically on the screen (see Figure 4), it is possible to use the tool as a kind of retrieval cue for the retrospection.

But apart from changes and revisions, computer logging primarily shows aspects of time. There is still no or little information about what translators are reflecting upon. It is still not possible for the researcher to really know what is going on in the subject's mind.

The first experiments of the students' translation processes in 1997, 2002 and 2004 made evident that several translators show a similar behaviour and use the same strategies – their interpersonal results, however, are still totally different. Small personal aspects, like a special attitude to the task or earlier experiences, can have a decisive influence on the quality of the product.

These first experiments also confirmed a hypothesis that there is no relation between the manner of segmentation of the process (into phases and pauses) and the quality of the product (Hansen 2002: 45). An unexpected observation was that about 50% of the translators had their individual segmentation pattern. In several experiments with different text types and translations into both directions, the subjects' segmentation of the processes into phases and pauses did not change considerably (*ibid*.: 38f).

Phases were in accordance with Krings (1986: 178), divided preparation phase, writing phase and a revision phase. With respect to pauses, it was their position (just in front of a sentence = orientation pause; in a sentence = internal pause; just after a sentence = control pause) and the length (short pauses and long pauses of more than 30 seconds) as well as the number of all kinds of pauses which was investigated (Hansen (2002: 34; 2003: 36).

The experiments in the first part of the longitudinal study also revealed causes of less successful translation processes, several sources of disturbances (SD's), for example, disadvantageous attitudes or habits, awkward strategies, different kinds of manias, e.g. extensive cross-checking, lack of control for self-revision as well as fundamental misunderstandings caused by their earlier translator training. Via the Translog log-files it could be revealed that some participants reformulated sentences several times though already their first solution was correct. Combinations of the quantitative (digital data) and the qualitative introspection data, and triangulations of the results, were necessary in order to find causes and explanations for less successful behaviour. Often the participants already during the retrospection realized how they could improve their translation processes – in some cases, the post-process dialogue could be used to encapsulate the fundamental reason for a problem or to let the subject discover and explain the causes of a problem him/herself.

TPR with Translog revealed, for example, that about 45% of the 47 subjects used reverbalization as a strategy. Reverbalization means that a sentence of the source text is reformulated in the source language – then the second version of the sentence is translated. There are several reasons for using this strategy and for translators who are able to control their own translations it can be a useful strategy – for others who easily lose control or who don't understand semantic nuances – this strategy is a typical source of errors (Hansen 2006: 196ff).

In several cases digital research with Translog where quantitative and qualitative data are combined, gives unexpected results – answers the "unaskable". An example:

Process segmentation sometimes gives hints with respect to the translation competence. Hansen (2006: 149ff) describes observations of a kind of "natürliches Pausengefälle" which means that depending on the difficulty of a text passage, the translators' log-files show that they usually need longer pauses when they meet reception- or production problems than when translating less problematic passages. This "usual segmentation pattern" could be observed for 30 out of 47 subjects when translating into their L2, German, and for 39 subjects when translating into their L1, Danish. *Deviations* from this usual segmentation pattern could be observed in two situations: 1) some good translators were able to translate difficult passages automatically, without needing long pauses, and nevertheless their translation product was evaluated as good; 2) other translators had the same length of pauses in all passages and their product was poor. They did not seem to realize the difficulties or showed difficulties all over the process.

Another unexpected answer to the "unaskable" was given by the combination of the quantitative data with the qualitative data revealed a discrepancy between talking and doing. Some of the subjects said during their introspection that they had taken the target text receiver's presuppositions and the communication situation into consideration or that they had used the strategy of reduction. Their log-files clearly showed something else. There seems to be a discrepancy between what translators think they do and what they really do (Hansen 2006: 192ff). In these cases a clarifying post-process dialog is useful.

10 years later

Ten years after the first experiments with Translog, in 2007 a group of 28 of the earlier subjects – now professionals – agreed to participate in new experiments. The experiments were carried out nearly exactly in the same manner as in 1997 – but now at their working places and with new texts (as they can remember their earlier translation problems). Still searching for the profile of the

successful translators, the data of the four best translators were more closely analysed who had shown the best target texts in both directions and who had also had the best results in the revision tasks.
Based on the results from 2002 where it was confirmed that there is no correlation between a special segmentation pattern and the quality of the product, the phases and pauses were again focussed on – and caused by the observations that in the earlier experiments about 50% of the subjects showed consistency in their individual pattern of segmentation, the hypothesis of the existence of "individual translation styles" was investigated once more – this time with the same subjects as professionals. Focus was on time management, corrections, revisions and reformulations. The intention was to observe intra-individual variance over time; this can be demonstrated by an inter-individual comparison. The parameters looked at were:

- time management
- key-strokes per minute
- Corrections and changes while writing a word
- Online revisions in the drafting and revision phase
- Reformulations of whole sentences or passages

Here are some of the surprising results which show that translators obviously already had found their individual translation style at the end of their study and that they still keep this style with few modifications – also after 10 years as professionals (Hansen 2011).

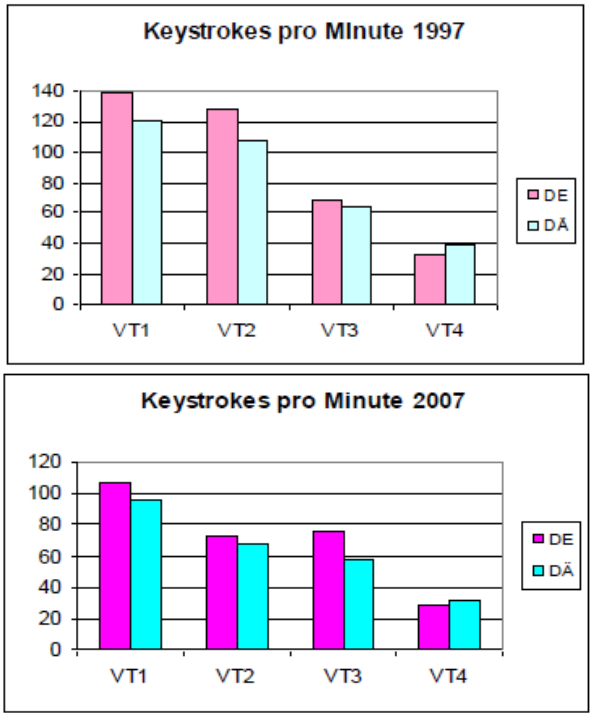

Figure 2: Writing speed into L1 and L2

Figure 2 shows process data, the participants' writing speed in translations into both directions: Participant 4 (VT4), for example, writes in 2011 still slowly when translating into both directions (just as in 1997) whereas participant 1 (VT1) still writes quickly in both processes (just as in 1997).

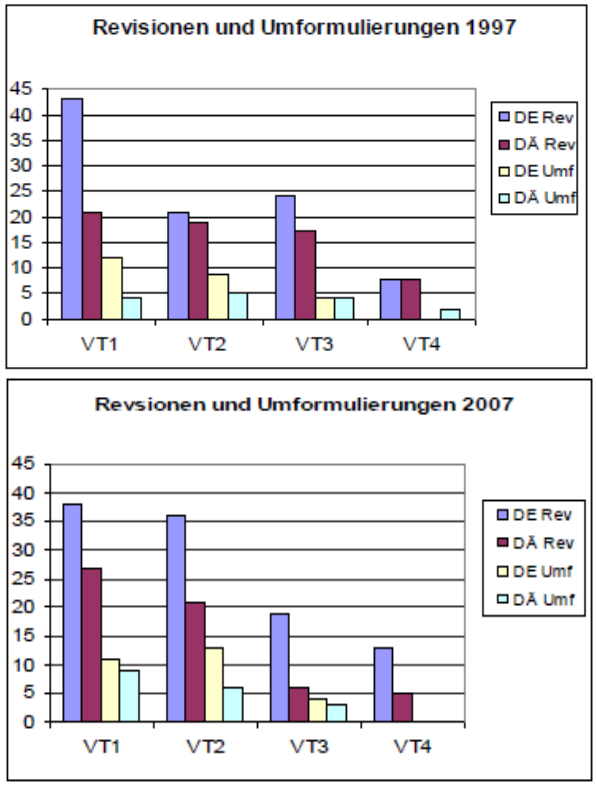

Figure 3: Number of revisions and reformulations

In Figure 3, the number of revisions (Rev) and reformulations (Umf) of 1997 and 2007 is compared. Again both directions are shown. Also here it is obvious that the participants have their individual translation style. Participant 4 (VT4) shows fewer revisions than the others and he has only a few reformulations – different from, for example participant 1 (VT1), and this has not changed during the 10 years.
Based on these results, future translator training should be a *differentiated* education and individual conditions and patterns should be taken into consideration.

Quantification and visualization

Some of these findings were corroborated by recent studies of User Activity Data (UAD), carried out at CRITT, investigating keystrokes in combination with eye movements (Carl 2008; Carl 2011). Adding eye tracker allows us to understand where translators look on the screen while translating, from which we can infer Translator types. Techniques have been developed to cluster single gaze samples into fixations and to map fixations onto the likely words that are being fixated (Šparkov 2007). Other techniques are used to map single keystrokes onto the ST words for which they form the translations. Figure 4 shows a replay situation in which a translator has typed the Danish translation of the third English sentence (top) into the bottom window. Gaze activities during the translation of the sentence (highlighted in blue) are marked as red dots (left eye) and green dots (right eye)[3].

[3] Gaze activity was recorded with a Tobii T120 at a sample rate of 60Hz. Each green and red dot represents, thus, approximately 7-8 ms.

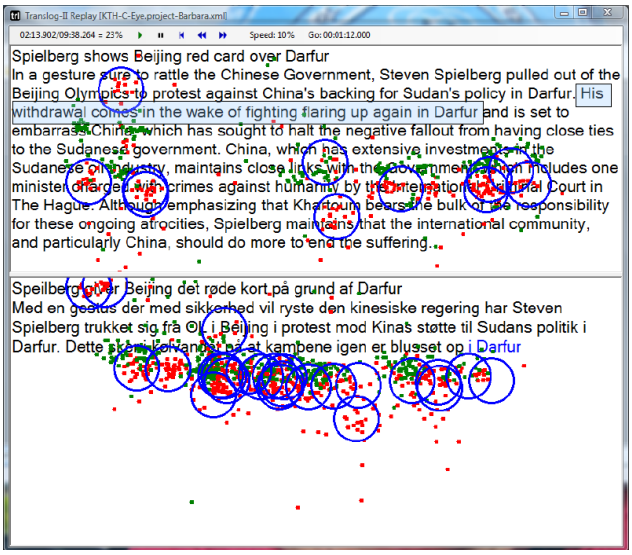

Figure 4: Replay screen in Translog-II

A number of observations can be made: Much more gaze activity can be seen on the target text then on the source text. There are many stray gaze samples, and the main detected gaze activity is *not* always at the positions of the words which are being translated.

The translation progression graph in Figure 5 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 intervals where the translator watches the keyboard or reads the target text (TT). The translation progression graphs show only reading behaviour on the ST, since our software can only register and map gaze movements on the source text window. Due to the fact that translators frequently had to move their eyes from the keyboard or the target window on the bottom of the screen to the top of the screen, where the source text was displayed (see Figure 4), some of the fixations in the source text may be random.

The gaze-data is synchronised with the keyboard data and can be plotted in translation progression graphs. A *translation progression graph* (Perrin, 2003) represents the gaze and typing data in time. Translation progression graphs show where pauses and deletions occur, and how keystrokes and gaze activities are distributed over time. It gives a general picture of how the translation develops, by relating each activity to the ST unit which is being translated.

Carl et al. (2011) analyze 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 specializing in translation between Danish (L1) and English (L2). They observed differences and similarities in the translators' working styles, and identified the traditional three translation phases (Krings 1986): initial orientation, translation drafting and final revision.

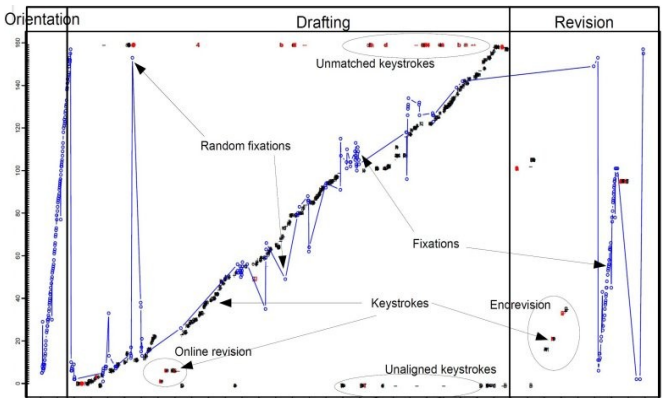

Figure 5: Translation progression graph

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

- *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

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.

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

In another study Carl and Dragsted (2011) find that Translators usually look only a few words ahead into the ST from the position which they are currently translating.

At some points extensive reading behaviour can be observed, signalling more serious translation problems. These problems seem to be triggered through translation production problems, rather than difficulties in ST understanding, which supports a claim that was already made 15 years earlier. Gile (1995) finds that often the translator "only realizes there is a problem when trying to read the first target-language version".
However, this observation may be biased on the kind of source text but also on the language pair to be translated. In translation processes from German to Danish, often long pauses are needed to solve reception problems.
DTPR gives us today the possibility to visualize and compare translation process data in an unanticipated way. Figure 6 shows the keystroke rhythm from three translators. The horizontal X-axis enumerates the source text words while the vertical Y-axis plots the relative length of inter-key pauses by which the translations were typed. Higher values represent slower typing speed (i.e. longer pauses) and lower values shorter inter-key delay.

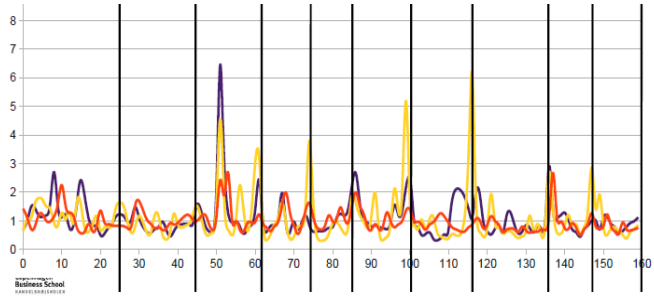

Figure 6: Overlayed keystroke rhythm of three translators

The graph shows where each of the three translators type smoothly and where longer pauses occur. It also shows that at some places all translators behave in a similar manner, i.e. slow down or accelerate their typing speed, while at other places each translator behaves differently. The vertical bars indicate sentence boundaries in the source text. It could be expected that translators slow down at those boundaries to prepare for the translation of the next sentence, but this seems to be only a part of the explanation. Around word #50 all translators seem to face some translation problems in the middle of a sentence where they all slow down, while the sentence boundary around word #25 does not seem to trigger a particular typing delay.

From (D)TPR to HCI

We observe a shift from more cognition based TPR with combinations of qualitative and quantitative data to quantitative user modelling (translation styles and translation preferences).
While introspection is an important method to uncover the nature of the basic psychological and cognitive translation processes which allow us to establish *cognitive competence models of translation*, the synchronisation of keyboard logging and eye-tracking gives us today the possibility to confirm, complete and corroborate earlier observations about the translators' behaviour, and open a possibility to *model translator performance*. Digital data also gives the possibility for advanced visualization to highlight individual differences in translation styles. The following list of questions illustrates these two developments in TPR:

Cognitive competence model of translation

- What mental processes are involved in natural language translation?
- What are the translation phases and translation strategies?
- How is attention and effort distributed in translation processes?
- Do translators proceed in units and what are the shape(s) of these units?
- How much ST understanding is required before a translation can be produced?
- How are the translation processes of experts different from novice translators?

Translator performance model

- Can individual competence patterns of translation be identified?
- What is the inter- and intra-personal variance in these patterns?
- Are there typical behavioural patterns during the translation of more or less difficult texts?
- Where do translators look in the text?
- Are there behavioural patterns that are better/more appropriate than others?

In combination with longitudinal studies we are also able to confirm observations of constant behaviour in individual translators over long stretches of time (see Hansen 2011). This knowledge can today be instrumental for the design of interfaces for human-computer interaction (HCI) in translation. Increased digitization in combination with, advanced computer-assisted translation (CAT), translation memories and machine translation systems calls for in depth studies on human-computer interaction in translation.
While today most of the TPR is based on manual from-scratch translation, future research will look more into HCI. On the one hand, the translation industry needs to find computer-assisted solutions to enhance translation speed and to lower translation costs. On the other hand TPR will investigate to what extent translation processes can be formalised and to verify predictions from theoretical considerations.
Machine translation and CAT tools are becoming more used/useful, but fully automatic translation is only functional in limited domains (weather forecast, METEO). Computer assisted translation (translation memories) is everyday practice for most professional translators, and some TPR attempts have been started to investigate translation practice (e.g. a project of Sharon O'Brian). Kremer et al. (2011) investigate how non-professional translators can profit from phrase translations generated for machine translation. For the future, we anticipate that this kind of research will gain importance in line with a catalog of questions as the following ones:

Human-computer interaction in translation

- How do translators use CAT tools?
- Can cognitive and user models of translation be adapted to the CAT scenario?

➢Are the translation processes for computer assisted translation different from those without CAT?
➢What additional factors need to be studied in a human-computer interaction scenario in translation?
➢Which translation aides are most suited for which type of translator and for which type of text?
➢When does computer interaction become a burden for translators?
➢How should translation aides be visualised on the screen so that they best support the processes?
➢How can the different digital tools be improved and combined?

Conclusion

The paper has re-traced digital translation process research (DTPR) from its beginning in the 90s up-to-now. Until now, translation process research has sought to establish cognitive models of human translation, while recent empirical and digital research strands aim at a different kind of modeling more fine-grained user performance.

TPR has only in few instances been concerned with human-computer interaction (HCI), i.e. computer assisted translation (CAT), and this despite the fact that CAT tools are increasingly used by professional translators.

In the not-too-far future novel CAT systems will be developed which put the translator in front of a computer screen on which a large number of translation options and translation resources will appear. The translator can then chose from these proposals and compose or edit a translation. TPR methods and models will be instrumental to design and evaluate interfaces of such advanced HCI in translation.

TPR has produced a number of basic research questions and generated statistically grounded answers from the process data. A set of additional DTPR methods and complementary tools for eliciting and data analysis are needed as those new translation support tools emerge. They will have to take the human and the machine translation processes into account and investigate their interaction. Increasingly, questions will be produced and answered based on the technological possibilities and the suitability of CAT tools for the human translator.

References

Carl, M. (2010). Towards statistical modelling of translators' activity data. *International Journal of Speech Technology*, 12(4). http://www.springerlink.com/content/3745875x22883306/.

Carl, M., Dragsted, B., and Jakobsen, A. L. (2011). A Taxonomy of Human Translation Styles. In *Translation Journal* 16(2): http://translationjournal.net/journal/56taxonomy.htm

Hansen, G. (1997). "Success in translation." *Perspectives. Studies in Translatology* 5.2: 201–210.

Hansen, G. (2002). "Zeit und Qualität im Übersetzungsprozess." *Copenhagen Studies in Language* 27. 29–51.

Hansen, G. (2003). "Controlling the process. Theoretical and methodological reflections on research in translation processes." In Alves, F. (ed.) *Trinagulating Translation*. Amsterdam & Philadelphia: John Benjamins. 25–42.

Hansen, G. (2005). "Experience and emotion in empirical translation research." *Meta* 50–2, 511–521.

Hansen, G. (2006). *Erfolgreich Übersetzen. Entdecken und Beheben von Störquellen.* Tübingen: Attempto, Francke, Narr.

Hansen, G. (2010). "Integrative description of translation processes". In: Shreve, G.M. and Angelone, E. (eds). *Translation and Cognition*. Amsterdam & Philadelphia: John Benjamins. 189–213.

Hansen, G. (2011). "Viele Wege führen zum Ziel: Eine Langzeitstudie zum persönlichen Übersetzungsstil." Amsterdam & Philadelphia: John Benjamins. (forthcoming)

Holmqvist, K., Johansson, V., Strömqvist, S., Wengelin, Å. (2002). "Analysing reading and writing online." In Strömqvist, S. (ed.) *The Diversity of Languages and Language Learning*. http://www.scriptlog.net/about.asp

O'Brien, S. (2008). "Processing fuzzy matches in Translation Memory tools: An eye-tracking analysis." Copenhagen Studies in Language 36, 79–102.

Krings, H.P. (1986). *Was in den Köpfen von Übersetzern vorgeht.* Tübingen: Narr.

Van Maes, L. and Leijten, M. (2006). "Logging writing processes with Inputlog." In Van Maes, L., Leijten, M. and Neuwirth, D. (eds). *Writing and Digital Media*. Oxford: Elsevier, 158-165.

Lörscher, W. (1992). "Investigating the Translation Process." *Meta*, XXXVII (3):426–439.

Jakobsen, A.L. und Schou, L. (1999). "Translog documentation." *Copenhagen Studies in Language* 24: 149–184.

Jakobsen, A.L. (2006). "Research methods in translation – Translog." In Sullivan, K. P. H. and Lindgren, E., (eds) *Computer keystroke logging and writing: Methods and applications*, volume 18. Oxford: Elsevier, 95–105

Mees, I. M., Alves, F. and Göpferich, S., (eds) (2009). *Methodology, Technology and Innovation in Translation Process Research*, volume 38. Copenhagen: Samfundslitteratur.

Perrin, D. (2003). "Progression analysis (PA): Investigating writing strategies at the workplace." *Pragmatics*, 35:907–921.

Špakov, O. (2007). GWM – the Gaze-to-Word Mapping Tool, available online at: http://www.cs.uta.fi/~oleg/gwm.html (abgerufen am 21. Juni 2011).

Tirkkonen-Condit, S. & Jääskeläinen, R. (eds) (2000). *Tapping an Mapping the Process of Translation and Interpreting*. Amsterdam & Philadelphia: John Benjamins.

Gerhard Kremer, Matthias Hartung, Stefan Riezler, Sebastian Pado (2011). *Phrase Table Support for Human Translation*, Contrastive Linguistics, Translation Studies, Machine Translation – what can we learn from each other? Pre-conference Workshop, Hamburg