



A retrospective and prospective view of translation research from an empirical, experimental, and cognitive perspective: the TREC network

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Abstract. The aim of this paper is to discuss some developments in empirical translation research with an experimental and cognitive perspective. The focus is on the activities and research of the network TREC (Translation, Research, Empiricism, Cognition). The network was formed in 2011, funded by the Spanish Ministry of Economy and Competitiveness and led by PACTE (Universitat Autònoma de Barcelona). It consists of translation scholars and research groups united by their common interest in empirical and experimental research, particularly in relation to the cognitive operations that underlie the task of translating.

The paper first gives a short general overview of research on translation as a cognitive activity and outlines the objectives of the TREC network. The network members, representing universities from Argentina, Brazil, Denmark, Finland, Ireland, Norway, Spain, Sweden, Switzerland, the UK, and the USA, then present their most important contributions to cognitively oriented research (topics, methods, results). Finally, some conclusions are drawn and perspectives for future research are outlined.

Keywords: translation, cognition, empirical-experimental research, process-oriented translation studies, networking

1. Research on translation as a cognitive activity

Studies concerning translation as a cognitive activity date back to the late 1960s. Borrowing from neighbouring disciplines, such as cognitive psychology, psycholinguistics, expertise studies, and cognitive science, these studies have ranged from speculative and phenomenological theoretical modelling to empirical

and experimental studies. Research has focused mainly on the translation process (e.g., phases, unit of translation and segmentation patterns, problem solving and decision making, and strategies) and on the competences necessary to translate – translation competence and its acquisition – as well as on traits of translators’ expert performance and applications of this research to translators’ training.

The first attempts to study translation as a cognitive activity can be attributed to the Interpretive Theory of Translation and the seminal work of Seleskovitch (1968, 1975) and Lederer (1973, 1976); cf. also Levy’s proposal (1967) of studying translation as a decision process within a game theoretical framework. Over the past decades, the interest in the study of translation as a cognitive activity has grown exponentially. Several models of the translation process have been proposed: Bell (1991), building on cognitive science, artificial intelligence, and systemic functional linguistics; Gutt (1991) and Alves (1995), using the framework of relevance theory; Kiraly (1995), drawing on psycholinguistics and sociology; Wilss (1996), building on cognitive psychology; Gile (1995), using an effort model approach to the study of interpreting. Various models of translation competence also appeared in the same period, such as the models proposed, among others, by Bell (1991), Neubert (1994), Cao (1996), Hurtado Albir (1996), Presas (1996), Hansen (1997), PACTE (1998), and Risku (1998).

The evolution of empirical and experimental research in translation can be divided into three phases (Alves & Hurtado Albir, 2010). In the early 1980s, empirical research on written translation processes started, drawing primarily on think-aloud protocols (Ericsson & Simon, 1984) for data elicitation. Using this technique, the pioneering work of Krings (1986) spearheaded the first phase of translation process research. Further works by Königs (1987), Jääskeläinen (1987), Gerloff (1988), Tirkkonen-Condit (1989), Séguinot (1989), Lörcher (1991), Kussmaul (1991), Fraser (1993), Kiraly (1995), and Alves (1995), among others, gave impetus to experimental research in translation.

A second phase began in the mid-1990s, with researchers aiming at more systematic descriptions and accounts. A multi-methodological perspective (triangulation), stemming from the Social Sciences and other related disciplines, introduced the use of various data elicitation tools to “locate” the process of translation from different yet complementary vantage points. Interviews, retrospective protocols, questionnaires, and psycho-physiological measurements were other tools used. The second phase is marked by the development of the key-logging software *Translog* (Jakobsen & Schou, 1999) and the use of different software packages (*Proxy*, *Camtasia*, etc.) with screen recordings to capture process data, which, being beyond the scope of the key-logging software, were not previously available. These new tools created the conditions for more robust analyses of larger sets of data. Subsequently, the impact of translation technology, mainly the use of translation memory systems, also attracted the attention of researchers (Dragsted, 2004).

In the mid-2000s, a third phase started with the incorporation of eye-tracking data to the triangulation approach in experimental research. O’Brien (2006a) is one of the first studies, combining eye-tracking and translation technology. This was followed by a series of studies that used eye-tracking data to corroborate assumptions not yet proven by key-logged data (e.g., Alves et al., 2009; Jakobsen & Jensen, 2008).

Recently, a new trend in empirical-experimental research has been emerging as a result of the increasing interaction between humans and machines in the translation industry. This trend, introduced by Krings’s (2001) pioneering work, paved the way to a fourth phase in the evolution of research which draws on computational linguistics, studies of human-computer interaction, and speech

recognition to study, for instance, the impact of post-editing tasks on human cognitive processes (Balling et al., 2012).

It can thus be claimed that empirical and experimental research has come of age and is now in a position to use different data elicitation techniques as a way of capturing the process-product interface in translation. However, research still borrows more than it can lend to neighbouring disciplines (O'Brien, 2013). Therefore, it is important to develop a specific methodological framework for the study of translation as a cognitive activity. To that extent, further work is needed to consolidate our research and to strengthen the interdisciplinary exchange, thus making lending equally important as borrowing. Furthermore, effort needs to be put into validating instruments of data collection, refining experimental designs, using larger and more representative samples, and fostering the replication of studies, allowing for validation or falsification of previously found results. Studies would then have a much greater power of generalization.

2. The TREC Network

TREC (Translation, Research, Empiricism, Cognition) is a network of translation scholars and research groups united by their joint interest in empirical and experimental research, particularly in research related to the cognitive operations that underlie the task of translating. TREC was initiated in September 2011 by the PACTE group through funding from the Spanish Ministry of Economy and Competitiveness (Project FFI2010-11995-E; principal investigator: Amparo Hurtado Albir).

TREC is currently formed by 13 research groups carrying out empirical and experimental research in translation; 17 universities from 11 different countries (Argentina, Brazil, Denmark, Finland, Ireland, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States of America) are involved. TREC aims to foster research on translation as a cognitive activity and to enhance comparability across studies in empirical and experimental translation research. The main thematic goals of the network are:

1. To promote exchange and transfer of knowledge about empirical and experimental research in translation process, translation competence, translation competence acquisition, and expertise in translation.
2. To foster cooperation among different research groups working under the empirical-experimental paradigm.
3. To optimize the use of methodological resources as well as technological tools to collect data for research.

The aim of this paper is to present an overview of the TREC network, its members, their research interests, complementarities and differences, what the network has achieved so far, and the challenges that lie ahead for the network and for the whole field of translation as a cognitive activity.

3. TREC members and their contributions to cognitive-oriented research

3.1 Retrospective views of the research of the groups

In this section, the members of the TREC network give short overviews of their research. The texts are presented under the name of the research team/university

and organized chronologically, according to when cognitive-oriented research started in each institution.

Itä-Suomen yliopisto (University of Eastern Finland (UEF)), Finland. In 1984, translation process research was imported from the AILA World Congress in Hamburg to the then Savonlinna School of Translation Studies, University of Joensuu, by Professor (Emerita) Sonja Tirkkonen-Condit. The first studies were similar to other pioneering work, with the fairly general aim of finding out what happens in the translation process, using think-aloud protocols as data and translation students as subjects. The first phase can be characterized as generating ideas and hypotheses as well as digging deeper into the main method of data elicitation at the time, i.e., think-aloud (Jääskeläinen 1999; Tirkkonen-Condit & Jääskeläinen, 2000). First attempts were also made to identify, for example, what role affective factors play in translation, how particular linguistic items are handled by translators, and how translators manage uncertainty.

On the whole, much of the research has focused on three broad topics: methodology, empirical testing of models and hypotheses, and conceptual analyses. For example, Tirkkonen-Condit's interest in the processing involved in translating Finnish clitic particles resulted in proposing the unique items hypothesis, which has subsequently been refined and tested in relation to translation universals (e.g., Tirkkonen-Condit, 2004). Tirkkonen-Condit (e.g., 2005) also tackled the issue of literal translating and the Monitor Model, finding empirical evidence to support the assumption that translation tends to proceed literally until a point at which literal translation no longer functions; at that point, the Monitor initiates a search for better solutions. Conceptual analyses have attempted to take apart and operationalise, e.g., *translation strategy*, *professional translator*, and *expertise*.

While research has been largely based on individual projects, Finnish researchers have been actively creating international networks with process researchers, thereby promoting research collaboration. In 1996, at the AILA World Congress in Jyväskylä, Finland, a loose and informal research network called the "Process Team" was founded (see Tirkkonen-Condit & Jääskeläinen, 2000). The pioneering scholars involved have contributed to establishing translation process research as a legitimate field of research in Translation Studies, striving for clarity and rigor in research.

In the past ten years much has changed in the research environment; in 2007, Professor Tirkkonen-Condit retired, and in 2007-2009, the Savonlinna School of Translation Studies was relocated to the Joensuu campus and integrated in the Department of Foreign Languages. In 2010, the former universities of Joensuu and Kuopio merged to form a new University of Eastern Finland. After the administrative turmoil, the University of Eastern Finland is better able and better equipped to focus on research. There are interesting PhD projects underway, dealing with, for example, pause behaviour and cognitive rhythm in translation vs. monolingual writing, and the development of translation competence. A great many questions remain to be investigated, from TAP methodology to the nature of translators' expertise (Jääskeläinen, 2011).

Aston University, Birmingham, UK. Scholars working in Aston started exploring students' translation strategies with small-scale process studies focusing on aspects such as the role of world knowledge in comprehending and translating texts (Schäffner, 1991) and the influence of personality traits on translation performance (Hubscher-Davidson, 2009). Driven by the need to understand why students with apparently similar profiles translate source texts in many different

ways, Aston researchers have investigated empirically the performance of student translators for over twenty years. During this time, research on the translation process has increasingly reflected the need to take account of insights from other disciplines in order to fully understand translators' individual differences and working practices. Over the years, theories and concepts from the following disciplines have been used to approach the study of the translation process: conceptual metaphor theory (Schäffner & Shuttleworth, 2013), ethnography (Hubscher-Davidson, 2011), intuition and emotional intelligence (e.g. Hubscher-Davidson, 2013a, 2013b). Recently, the scope has been expanded by conducting large-scale studies taking into account what impacts the translation process of professional translators (e.g., affective factors), while still maintaining a strong interest in individual translator behaviours and attitudes.

Stockholms universitet (Stockholm University), Sweden. In 1993, Birgitta Englund Dimitrova started the project "Semantic change in translation – a cognitive perspective," funded by the Swedish Research Council for the Humanities and Social Sciences. It focused on the role of the translator's mental semantic representation in the process, by studying, on translation process data, how semantic changes of various kinds come about, or not, in the process. This project's research environment turned into a rallying-point for a number of subsequent translation research projects with a process orientation, mainly at Stockholm University but also at Uppsala University. These projects have analysed translation and/or interpreting data from a number of language combinations: English-Swedish, German-Swedish, French-Swedish, Russian-Swedish, French-German. Research has been carried out by senior researchers, PhD students, and MA students.

Swedish process-oriented research comprises to a large extent individual projects, designed and carried out predominantly by individual researchers, according to their own interests, but with inspiration and influence from other studies, Swedish and international. The research environment, with its possibilities for discussion (and supervision of PhD students) has been instrumental in the work.

Most projects combine the process and product perspectives, with the analysis of textual aspects being a prominent and integral part of the process study, and where the study of the process has explanatory aims. The predominant research methodology has been think-aloud protocols, combined in some studies with key-logging.

The nature and development of experience and expertise in the translation and interpreting process is targeted in several projects, with different research designs: cross-sectional (Englund Dimitrova, 2005; Künzli, 2003), or a combination of cross-sectional and longitudinal (Tiselius, 2013). Swedish process researchers pioneered the study of revision (both self-revision and other-revision) as part of the translation process (Englund Dimitrova, 2005; Künzli, 2003). Some projects focus on the cognitive processes of interpreting (Englund Dimitrova & Hyltenstam, 2000; Tiselius, 2013).

The projects have yielded a number of book-length publications, three of which have been published in Benjamins Translation Library (one monograph, one conference proceedings volume, and one edited volume (Alvstad et al., 2011). Furthermore, there have been four PhD dissertations, published as monographs by the respective universities, two MA theses, and a substantial number of articles in different publications.

Plans for the future include work on textual and process aspects of print interpreting (Norberg), on the correlation between an individual's (textual)

translator style and process profile (Englund Dimitrova), and on children as interpreters (Tiselius).

A complete bibliography of Swedish process-oriented research can be downloaded from <https://su-se.academia.edu/BirgittaEnglundDimitrova/Bibliographies>.

KenTra, Kent State University, USA. KenTra is the result of synergies and collaborations between Greg Shreve, Erik Angelone and Isabel Lacruz at the Institute for Applied Linguistics at Kent State University. Its origins can be traced to collaborations between Greg Shreve and researchers in experimental psychology in the 1990s (Danks et al., 1997). Its work began in earnest when Erik Angelone joined the Institute in 2007, followed by Isabel Lacruz in 2010. Rooted in empirical and experimental approaches, KenTra's research explores translation processes through cognitive, psycholinguistic, and pedagogical lenses.

Early research was based on observational studies aimed at developing an understanding of the role of expertise and meta-cognition in uncertainty management during translation, probing how translators engage in problem solving, and optimising process-oriented translator training. Methodologies included self-reports from translators, such as think-aloud protocols, and behavioural observations through screen recordings. It was found that professionals tend to engage in meta-cognitive bundling, with uninterrupted problem recognition–solution proposal–solution evaluation sequences serving as an indicator of efficacy (Angelone, 2010).

Since 2010, there has been a surge of activity in experimental research. Efforts have been focused on understanding the nature and locus of mental effort expended by translators during written translation, sight translation, and post-editing; and identifying mental representations of language that are unique to translators. Eye-tracking measures were used to investigate how translators responded to different levels of syntactic complexity during sight translation. The process of producing written translations of the same materials was analysed using a key-logger. Syntactic complexity was found to be more disruptive for sight translation than for written translation (Shreve et al., 2010).

Understanding the effort involved in post-editing machine translations is important not only in developing effective training programs for effective post-editing, but also in helping machine translation program developers to improve their products. Key-logging experiments uncovered an apparent relationship between cognitive effort and pause patterns during post-editing. An important finding was that short pauses are a key indicator of cognitive effort (Lacruz et al., 2012).

Most bilinguals are not trained as translators. So, just as monolinguals and bilinguals have different mental representations for language, it can be expected that translators will show unique traits in their mental representation of the languages they work with. Very recent reaction time experiments provide evidence that this is indeed the case: translators' lexical decision time patterns for cognates and false friends were different from those of bilinguals, indicating that these types of words have different underlying representations for translators (Lacruz, 2014).

In the future, KenTra will continue to conduct empirical and experimental research in hopes of gaining a more nuanced understanding of mental representations involved in all aspects of the translation process; and will also investigate best practices in process-oriented translator training.

PACTE, Universitat Autònoma de Barcelona, Spain. The PACTE (Process in the Acquisition of Translation Competence) research group at the Universitat Autònoma de Barcelona was founded in 1997. Its research aims to improve curriculum design for trainee translators, with special emphasis on designing competences, progression in learning, and assessment. The framework for PACTE's research draws on three bases: cognitive and experimental translation research; the didactics of translation; and the use of technologies applied to translation research. The research has been planned in four phases: investigating Translation Competence (TC); investigating the Acquisition of Translation Competence (ATC); levelling TC (establishment of different degrees of acquisition); and assessing competences. The first two phases have been carried out, data analysis from the second phase (ACT) being nearly complete.

In the first phase (TC) of the research, data concerning the knowledge and behaviour of professional translators was compared with that of foreign language teachers with no experience in translation. After exploratory tests and a pilot study, the final experiment was conducted in 2005-2006 with 35 professional translators and 24 foreign language teachers (PACTE, 2009, 2011). In the second phase (ATC), a simulation of a longitudinal study was carried out with 130 trainee translators (PACTE, 2014).

PACTE's research is carried out from two complementary perspectives: cognitive and textual. For cognitive studies, software programs (Proxy and Camtasia) are used, together with direct observation and questionnaires. The studies of translated texts focus on prototypical translation problems (rich points) for which categories have been established and criteria for acceptability determined. Electronic corpora are also used for analysis. Thus, a multi-methodological approach is used, combining both qualitative and quantitative methods.

From a conceptual point of view, PACTE has developed a holistic model of TC (PACTE, 2000, 2003) and a dynamic model of ATC (PACTE, 2000, 2014). The results confirm that TC is made up of different sub-competences that are interrelated; that the sub-competences specific to translation are Knowledge of Translation, Instrumental, and Strategic; and that the most important is the Strategic sub-competence. From a methodological point of view, PACTE's research has contributed to the design and validation of data-collection instruments (problems questionnaires; a knowledge of translation questionnaire; the use of rich points in texts; direct observation charts); the use of software (Proxy and Camtasia) in translation research; customized templates for data analysis; models of statistical analysis for different variables; and the use of electronic corpora to study translated texts.

In the near future, PACTE plans to complete the ATC research and begin work on levelling TC in order to establish different degrees of acquisition, as it exists in other disciplines (i.e., foreign language teaching). Later on, the results obtained will be used to research the assessment of competences (indicators, instruments, tasks) during translation competence acquisition.

CRITT, Copenhagen Business School, Denmark. The CRITT Centre at Copenhagen Business School was started by Professor Arnt Lykke Jakobsen in June 2005 with a three-year grant from the CBS President. From 2014, it will be headed by Professor Michael Carl.

CRITT (Centre for Research and Innovation in Translation and Translation Technology) aimed from the start at building new knowledge of translation and communication processes and providing a basis for technological innovation within translation process research. The special focus was on developing a

methodology for translation process research (TPR) using key-logging (e.g., Jakobsen & Schou, 1999; Jakobsen, 2011), and later a combination of key-logging and eye-tracking as the principal tools for recording user activity data (UAD). The central hypothesis was that analysis of behavioural UAD could yield improved understanding of the cognitive processes of translating (reading ST; mapping ST meaning onto TT text; typing and visually monitoring TT production; coordinating reading, typing, and monitoring activity) and would allow computational modelling of translation.

The principal research instruments have been Translog for key-logging and Translog II (since 2011) for key-logging and eye-tracking. Three different eye-trackers have been used: Tobii 1750 (2006-2009); Tobii 60/120 (since 2009); and EyeLink 1000 (since 2011). The main machine translation application is an implementation of the machine translation engine Moses. A variety of statistical methods (e.g., linear mixed-effects regression models using R) have been employed. Machine learning, various computational training techniques, and computer modelling are also in use. Finally, from 2013, speech recognition is included as a new input method in dictation, translation, and post-editing experiments. As of 2013, an attempt is being made to collect all these methods aimed at handling *big data* under the label *Data Analytics*.

The EU FP6 Project EYE-to-IT (2006-2009) aimed at integrating key-logging, eye-tracking and EEG for intensive monitoring of translators' activity. An application enabling gaze-based translation support was successfully developed.

In 2008, CRITT obtained World Class Research Environment status at CBS, which gave the centre a 5-year grant (2009-2013) to carry out a suite of projects aimed at combining human translation process research, computer modelling, machine translation, tree-bank annotation, and business application.

A number of nationally funded projects, e.g., one on "Speaking your translation" using dictation and speech recognition, and one on "Text comprehension and formulation in translation hybrids," were also successfully completed between 2009 and 2013.

Late in 2011, the EU FP7 Project CASMACAT (Cognitive Analysis and Statistical Methods for Advanced Computer Aided Technology) was started. The project aims to develop an interactive MT-supported translation workbench that adapts to the user's translation style.

With the inclusion of speech recognition expertise, an overriding vision is to create speech-to-speech translation apps for several language pairs. A further aim is to develop intelligent, adaptive, interactive post-editing workbench solutions (e.g., Balling et al., 2012). See also Göpferich et al. (2008) and Mees et al. (2009).

For other publications, please browse <http://bridge.cbs.dk/platform/?q=staff>.

LETRA, Universidade Federal de Minas Gerais, Brazil. In the late 1990s, Adriana Pagano, Celia Magalhães, and Fabio Alves created the Centre for Translation Studies (NET) at the Federal University of Minas Gerais (UFMG), Brazil. Their aim was to develop a combined product-process oriented approach to carry out empirical-experimental research in translation. The publication of Alves et al. (2000) spearheaded the application of research results in teaching.

Translation process research at UFMG first used the software Translog to track the unfolding of text production in translation, later integrating screen logging (Camtasia) and retrospective protocols into the research methodology. Supported by the notion of triangulation in translation (Alves, 2003), this gave rise to a paradigmatic change in the way research was carried out at UFMG. The Centre for Translation Studies was renamed LETRA, the Laboratory for

Experimentation in Translation, reflecting the vision to work as an experimental laboratory. Two corpora, CORDIAL and CORPRAT, were created. While the former was concerned with standard corpus-linguistics oriented analysis of the translation product, the latter aimed at using translation process data, stored in a database, to generate further insights, raise new hypotheses, and provide more robust evidence to support or refute claims about the translation process. This new line of research at LETRA was consolidated with the publication of Alves et al. (2005).

From the mid-2000s, LETRA has investigated the use of CAT tools in the translation process, focusing on the impact of translation memory systems on translators' cognitive processing. In 2008, LETRA added eye tracking to its triangulation approach. With this tool, the technological angle in research grew in scope, and it was only natural that a computational approach would be blended into the triangulation paradigm. This occurred with the development of LITTERAE (Alves & Vale, 2011), a web application designed to annotate translation process data using the rationale of corpus linguistics. LITTERAE enables the alignment of the translation product found in target texts with key-logged process data, thus integrating all interim renditions produced by translators in the course of the translation process and providing a tool for analysis of micro/macro translation units (Alves & Gonçalves, 2013). Looking into the future, LETRA will investigate human-machine interactions in the post-editing of machine-translation output. Over the last two decades, LETRA has trained over 20 PhD students. The majority of them have subsequently made their way into institutions of higher education in Brazil. Thus, a new generation of Translation Studies scholars, trained by LETRA, is now in place at several universities in Brazil, and translation process research has become stronger throughout the country.

Gentt Project, Universitat Jaume I, Spain. The Gentt (Textual Genres for Translation) research group, based at the Universitat Jaume I in Spain, has been working on the application of the concept of *text genre* as a conceptual and methodological tool to analyse, from a multilingual perspective, different fields of specialized translation and communication. Since the beginning of the Gentt project in 2000, the research has gradually shaped a definition of the concept of text genre by taking propositions from systemic functional linguistics, genre theory applied to translation, and sociology of professions (García Izquierdo, 2009).

Taking as the starting point the three perspectives (formal, communicative, and cognitive) that form the definition of genre, Gentt has focused on the study of the formal and communicative aspects, although some research on the cognitive perspective of genre has also been carried out, particularly regarding its relation with the acquisition of *translation competence* (Borja et al., 2009; Montalt et al., 2008). Formal aspects have been researched by describing, systematizing and analysing specialized genres from the medical, legal and technical fields (Ezpeleta Piorno, 2012; García Izquierdo, 2009), and communicative aspects have been approached by incorporating the needs and insights of the professionals and experts who work with the genres under study (García Izquierdo, 2009; García Izquierdo & Conde, 2012).

In terms of research methodology, both qualitative and quantitative methods have been used. Regarding quantitative methods, corpus analysis and exploitation techniques as well as computer linguistics applications have been used. These methods have been combined with qualitative ones, that is, focus groups, interviews, and surveys, in order to discover the most significant socio-

professional aspects of the communicative situations under study. Current research of the Gentt group has incorporated action research, by which active participation of researchers in the situation under study is required.

The main achievement of the group has been the development of an electronic document management system, the Corpus Gentt 3.0 (with previous versions Corpus Gentt and Corpus Gentt 2.0), with which textual and contextual information of more than 450 genres and subgenres in five different languages can be retrieved. Other recent contributions that derive from the Corpus are the JudGentt and MedGentt platforms, which are documentation management systems for legal and medical translators, respectively.

Future work will focus on an action research project and its transfer to the real world within two specific contexts and sample populations: legal and judiciary freelance and in-house translators, and cancer patients from different public hospitals and patient associations in the Valencian Community (Spain). The aim is to identify the needs for (multilingual) written resources, study the quality (and quantity/diversity) of the existing resources, and design and propose new ways to disseminate written information (systematize communication).

PETRA, coordinated by Universidad de Las Palmas de Gran Canaria, Spain.

The group Expertise and Environment in Translation (PETRA, Spanish acronym) is a loose circle of researchers from several Spanish translation schools who share some basic views on the field. In more than one way, it is closer to a think tank than to a regular research team. PETRA unofficially started out in the year 2000 with the overarching goal of developing a cognitive translatology, i.e., an interdisciplinary effort to explain translation and interpreting activities through empirical research and from the point of view of the human mind. PETRA's point of departure was a rejection of the classical cognitive paradigm, with the aim of successively enriching the referential framework by exploiting common ground of situated cognition, embodied cognition, distributed cognition, and extended cognition (Muñoz Martín, 2010a, 2010b).

At the beginning, PETRA set out to study as many aspects of the translation process as possible, while attempting to streamline some common core approaches to research design, including subject and text profiling (extraneous variables), previous typing period (baseline), test repetition (reliability of measurements), length *and* frequency to determine pause relevance (weeding out confounders), blind product cross-evaluation (rater and inter-rater reliability), and statistical and ecological validity checks. Non-invasive, observational data-collection methods were also favoured, such as Translog combined with a second key-logger to capture computer activities outside Translog, text analysis, pre- and post-test questionnaires, and standardized tests, such as WAIS3 and TOEFL.

With such a research apparatus, PETRA members studied the effects of time pressure on the behaviour of translators and the quality of their products, problem-solving strategies, the role of memory when translating, natural translation (contrasts between untrained bilinguals and translation trainees and professionals), translation evaluation, and comprehension processes, to name but a few topics. Many of PETRA's research projects were replicas of previous studies, often followed by second rounds with variations on the designs, since the main concern has been to devise a coherent theoretical framework to set a clear direction and to interpret data (De Rooze, 2003).

In this decade of work, PETRA's initial positions have evolved. For instance, current thinking is that studying translation routines may yield more results than focusing on problem solving. Quantitative research and qualitative research are now considered complementary, so that both are necessary to study the cognitive

aspects of translation. Introspection is now seen as a valuable source to discern how subjects construct what happened in their minds while at task, because that has a major influence on behaviour (Martín de León & Presas, 2011; Presas, 2011). Currently, PETRA members are working on text profiling, the role of culture as an extraneous variable in empirical research, and the influence of implicit beliefs both on translators' behaviour and on their results.

Universitetet i Oslo (Oslo University), Norway. The starting point was a grant (2002-2005) from the Research Council of Norway enabling the setup of EXPERTRANS, a European network for process research in translation using data from professional translators' concurrent TAPs and key-logging. The next step was the EYE-to-IT project (2006-2009): a research project in translation and cognition within the 6th Framework Programme, Future and Emerging Technologies. Motivated by recent technological developments and new theoretical insights in cognitive linguistics, this project integrated key-logging, eye-tracking, and EEG measures in a series of experiments with professional translators and bilinguals, in order to study cognition and translation (see http://folk.uio.no/antin/DataOslo_Team_research_2006-2010.pdf.)

The first goal of the Oslo research team was to study cognitive mechanisms in translation related to time simulation in text processing (i.e., mental simulation of movement in different speeds: slow, neutral, fast), visualization techniques, polysemy in and out of context, and conceptual metaphors and metonymies. Results regarding time simulation (Rydning & Janyan, 2008) show that movement speed indices in text influence heart rate during both comprehension and later stages of word processing during reading and translation. The study of polysemy (Rydning & Lachaud, 2010) showed that context reduces ambiguity during comprehension and increases creativity during production, and that expertise improves translation quality. The study of conceptual metaphor comprehension (Rydning & Lachaud, 2011) showed that primary conceptual metaphors are processed faster than complex conceptual metaphors, that conceptual clarity is higher, and that brain dynamics and active areas differ.

The second goal was the study of the effect of prompting on transcoding performance (Lachaud, 2012). Here, results show that prompts increase transcoding speed and accuracy of false cognates but not of non-cognates, independently of relation type (lexical vs. semantic), but depending on the amount of traits related to the target (lexical only or semantic only = a little; both lexical and semantic = more).

The third step (2010-2013) dealt with how information is re-categorized in translation (Behrens, 2014). Controlled process studies are planned for investigating *restructuring in translation*, with the main research question being whether information units are kept in their ST form and positions whenever possible in target texts, even when that strategy does not yield optimal translations. Preliminary results from a multi-translation corpus show the variability in target solutions, with a particular view to translators' difficulties/creativity in restructuring information for optimal translation.

Researchers at Oslo University are probing further into the challenges of translating figurative language containing cultural references that need to be renegotiated in the target language. The main focus is on the cases of metaphors, demetaphorization, metonymies, and the combination of metaphors and metonymies into metaphonymies (Rydning, 2012). Research design for restructuring studies is being spelled out for experiments using a new eye-tracker with Translog II. One relevant question relates to syntactic priming and considers

to what extent possible alternatives in the syntax of the target language affects processing.

Dublin City University, Ireland. Process research at Dublin City University (DCU) and within its dedicated research centre – the Centre for Translation and Textual Studies – focuses primarily on the domain of translation technology, including machine translation, post-editing, interaction with translation memory and terminology management tools, crowdsourcing, game localization, and volunteer translation or post-editing.

The initial focus on process research stemmed from an interest in the cognitive effort involved in post-editing machine translated output, and, particularly, on whether the application of controlled authoring rules to source content destined for machine translation would reduce post-editing effort. Tools such as screen recording and key-logging (Translog) were deployed to investigate this research question. This quickly led to an interest in the use of eye-tracking to measure cognitive effort in interaction with both machine translated output and human translated output proposed from translation memory systems. At the time, machine translation was on the increase and an important question emerged about how post-editing effort compared with the effort of editing fuzzy matches.

While researchers at DCU are still interested in the cognitive dimensions of editing TM and MT matches, attention has more recently been given to end user interaction with translated output. Using eye-tracking methods, among others, they have undertaken a number of projects that investigate the cognitive impact on end readers of raw machine translated content and post-edited content. This measurement effectively involves measuring the usability of translated content, by monitoring reading processes and how people use instructional material to complete tasks. Moreover, focus has also shifted to researching translators' interaction with the tools they are often required to use. Many translators have been surveyed on their satisfaction levels with translation technology, especially in relation to how such technology supports post-editing, and this has resulted in recommendations for improved user interfaces that better support both the translation and post-editing tasks.

In addition, DCU researchers work with a group of developers in designing and testing mobile translation interfaces. Further research projects have included the measurement of cognitive effort in subtitled films, TV shows, and games; analysis of motivation and success of volunteer post-editors in online technical forums and in social networking sites; and the interaction of users with an online terminology database for Irish. DCU publications include Doherty & O'Brien (2014), Moorkens & O'Brien (2013), and O'Brien (2006a, 2006b, 2011).

Zürcher Hochschule für Angewandte Wissenschaften (Zurich University of Applied Sciences), Winterthur, Switzerland. It was a colleague's publication of a seminal article on journalists' writing processes (Perrin, 2003) that first prompted this group to explore whether the same approach could be used to study translation processes. In 2006, a large-scale study was launched at the institute to investigate the development of translation competence. Adopting a multi-method approach, it set out to capture information about student translation processes as non-invasively as possible, by combining observations of the workplace, interviews, questionnaires, computer logging, screen recordings, and retrospective verbalizations. The study's scope was subsequently broadened to include professional translators at their workplace in the SNSF-funded "Capturing Translation Processes" project (2009-2012).

The project focused on identifying indicators in the translation process that seem to be related to competence level. Examinations of resource use indicated potentially important discrepancies between students and professionals (Massey & Ehrensberger-Dow, 2011). Beginners may have the competence to search for information but do not necessarily recognize when they should, while advanced students are more likely to recognize translation problems and search more purposefully for the information they need. Most professionals use a wider range of resources and are more discerning about their use for specific problem types.

In addition, professionals were found to orient themselves more quickly to translation tasks, translate source text titles sooner, produce target text faster, research less, revise more, and pause more than beginners and advanced students do. The results also suggested that professionals have a wider repertoire of strategies to cope with translation problems, and a clearer self-concept of their roles (Ehrensberger-Dow & Massey, 2013). They adapt their approach in response to the challenges presented by a particular text, whereas most students seem to find it difficult to depart from familiar patterns.

Many of the insights gained from this research are being incorporated into diagnostics, teaching, and curriculum design at the institute (Massey & Ehrensberger-Dow, 2014). Examining short translation processes or even process extracts seems to provide evaluators with very useful information both on candidates' potential and their training needs. The apparent increase in metacognition fostered by exposure to one's own, peer, and professional processes has led to a greater process orientation in the design of the undergraduate, graduate, and CPD curricula.

Observations of disturbances in workplace processes also made it clear that understanding of professional practice could be strongly supported by examining external influences and constraints (Ehrensberger-Dow & Massey, 2014). As a result, "Cognitive and Physical Ergonomics of Translation" was launched in 2013, an interdisciplinary project combining perspectives from translation studies, occupational health, usability testing, and language technology. It is expected that the input from professional translators and other findings from this project will provide valuable insights into the physical, cognitive, and organizational ergonomic factors impinging on professional translation work.

Universidad del Aconcagua, Argentina. Process-oriented research at Universidad del Aconcagua started in the year 2006 and can be characterized by two distinctive stages. The first one embraced two initial projects, in which the main focus was to find the right data elicitation methodology for observing the translation process. The combination of key-logging, cued recall and post-task questionnaires under the paradigm of data triangulation proved to be the right answer, as it helped researchers comply with ecological validity while maintaining accuracy and reliability parameters. This methodology provided the best of the quantitative world as well as the qualitative one, leading directly into the student's process (descriptive phase) and the underlying reasons for the choices made (explanatory phase). Data analysis was grounded in PACTE's translation competence model (2003).

The second stage focused on the dual role of the translator as both reader and text producer of linguistic material that not only presents propositional meaning but also signals the writer's attitude towards his/her own discourse and the audience of the text.

The first project drew on theories about subjectivity in language. The current project builds on metadiscourse, which provides a more robust model for

understanding the interpersonal resources writers use to present their propositional material as well as guide and engage the reader throughout the text.

The results show a clear tendency towards “neutralization”, i.e., translation students tend to concentrate too much on the transference of propositional meaning of the text, mistranslating metadiscourse, especially those markers signalling attitude. Furthermore, there is some evidence of a possible link between poor use of instrumental sub-competence and errors in the translation of metadiscourse. For this reason, the ongoing project has a twofold objective: to establish the relation between instrumental sub-competence and the decision-making process leading to the translation of metadiscourse, and to explore students’ implicit or underlying theories on translation, which may explain this “neutralization” tendency.

The four research projects have resulted in a number of publications at a local level (Giozza & Gatti 2009, 2012), the possibility of sharing them through TREC’s webpage, and presentations at congresses in Brazil and Argentina. At an institutional level, results have shed light on our students’ cognitive processes and the reasons behind their translation errors and difficulties, thus raising metacognition awareness among both teachers and students, and leading to the revision of current translation teaching practices.

3.2 Concluding Remarks

The preceding presentations showcase a wide variety of projects, methods, and approaches, developing from small-scale research at one university in the 1980s to today’s initiatives, which often comprise diverse teams of researchers. At present, some groups are loosely formed entities, based primarily upon the participating researchers’ individual research interests and considerations stemming from the research environments familiar to each researcher. However, at several universities, researchers have been successful in obtaining funding and have been able to create research groups based on such support. This has led to important technological developments of new research tools and their integration in cognitive research in translation.

The theoretical frameworks embraced by different groups reflect the interdisciplinary character of translation studies, and of the cognitive-oriented paradigm. Naturally, Translation Studies is the common core of the research. However, theories, concepts, and methods have also been inspired by such diverse areas as cognitive psychology and psycholinguistics, cognitive linguistics, ergonomics, studies on intuition, writing research, and machine translation, to name but a few.

In terms of research methods, there are some prominent tendencies. Several TREC members began their cognitive-oriented research with a single method (often TAPs), then either discarded it for one or more others, or enhanced it through *triangulation* by combining it with one or more other methods. Many moved from TAPs to more non-invasive methods, such as key-logging, in order to enhance ecological validity.

Certain themes have been explored by several groups. The most prominent one is characteristics of the translation process of individuals with different levels of (professional) translation experience. This has been the topic of several studies, the general purpose being to find out how translation processes among professionals differ from translation processes among non-professionals (usually translation students, but also, to some extent, professionals and/or students from other fields than translation). Models of translation competence and its acquisition have been proposed. Mental representations for the translators’ languages and cognitive effort in the translation process have also been studied. Several

members attest to the importance of the results of their cognitive-oriented research for curriculum development in translator training programs at their universities.

Other topics that have been or are being addressed are textual features (of the source text), such as metaphors and their translation, and implicitness of various kinds in the source text.

As part of its network activities, TREC has developed a website (<http://pagines.uab.cat/trec/>) with a database with information about projects and publications of TREC members on the investigation of translation as a cognitive activity. The website also contains a section of resources for empirical and experimental research in translation. A section on metadata about projects carried out by TREC members (Hvelplund & Carl, 2012), covering research designs, subject profiling, criteria for data analysis, etc., is currently being developed. The database will enable the comparability across different language pairs of disparate subject profiles and text genres. This website and its infrastructure is an important asset for future cooperation, both within the network and with other researchers interested in translation and cognition. The many commonalities in methods for data collection and analysis between the different members of the network will be significant to achieve this. From a conceptual point of view, collaboration among TREC members can help unify and clarify the different terminologies used in research on translation as a cognitive activity, e.g., by identifying common conceptual aspects within the different theoretical frameworks used by TREC groups, thereby enhancing conceptual consensus.

As shown in section 3.1, future plans by the groups share common threads and reflect the evolution of cognitive-oriented research in Translation Studies. At the methodological level, increased use of both qualitative and quantitative information to throw light on all aspects of translation as a cognitive activity can be expected. Triangulation of eye-tracking data with other modalities, such as key-logging data, monitoring of electrical activity in the brain, and more qualitative introspective reports, derived for example from the think-aloud methodology or retrospection, will give much richer information than data collection based on a single paradigm. In cognitive research in translation at large, data collection is also likely to be carried out on a much larger scale than before, as online tools for data extraction and manipulation, such as those under development by some of the groups, become more readily available, and data sharing becomes commonplace.

In view of what has been said in the preceding sections, there is great potential for future work on issues related to validating instruments of data collection, refining experimental designs, using larger and more representative samples, and fostering the replication of studies. For example, while some attempts have been made to refine designs and replicate studies (such as the Alves et al. (2011) attempt to replicate Jakobsen & Jensen's (2008) study), there are many other avenues that remain to be explored. These could include improving a potential compatibility between software such as Translog-II and Inputlog (Van Waes, 2014), increasing the interface between key-logging and eye-tracking software (Carl, 2011), as well as enhancing the dialogue between reading/writing research with research on translation as a cognitive activity (Dam-Jensen & Heine, 2013). Such examples give just a glimpse of the scope for possible future investigations in which TREC members could play an important role, together with other researchers with an interest in translation and cognition.

So far, most TREC members have focused on research drawing on the empirical-experimental paradigm, but new directions are being explored. For example, investigating translation as embodied action also seems to be a promising avenue within the scope of the TREC network (Muñoz Martín, 2010a,

2010b). In addition, emergent, communicative needs in cross-language communication and the various types of new agents in translation offer increasingly important research challenges for the network. Another fundamental aspect for research development is related to the application of results arising from basic research into translators' training. Finally, as a result of a more integrated collaboration, TREC members have the potential to engage in dialogue between translation studies and expertise studies and, thus, contribute to a more precise definition of expertise as applied to translation. Such attempts will most likely strengthen collaboration across disciplines, a desirable goal not only to strengthen the discipline *per se*, but also to increase interdisciplinary exchange.

The next few years promise to be of extraordinary interest and accomplishment for the TREC network in particular and the translation and cognition community in general.

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