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Cognitive approaches to translation

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25.1 Introduction

Cognitive approaches to translation studies are driven by three interrelated aims: to understand the structure and organization of the capacities of cognitive agents involved in processes of translation, to build better theories and models of translation, and to develop more efficient methods and programs for translator training. Meeting the goals of such a broad agenda requires the fusion of different theoretical and experimental tools, involving fields such as cognitive psychology, linguistics and artificial intelligence (AI). The current landscape of research programs that investigate the cognitive underpinnings of translation is therefore both varied and constantly developing, and covers exploratory studies that aim to carve out the very problem space for cognitive approaches to translation through to large-scale projects that promise helpful technological innovations.

In Section 2, which forms the bulk of the chapter, I describe and analyse five of the key research domains within this complex area, focusing on meaning, competence, expertise and emotion, before turning to the important and emerging area of machine translation and AI.

In Section 3, I address the question of how the field of cognitive aspects of translation should be conceptualized. My analysis shows that, unlike some ‘hard’ sciences, cognitive research is not driven by a ‘master’ theory, in this case of the psychological capacities involved in the translation process. Instead, it seems that cognitive approaches to translation are better conceptualized as a family of projects based on multiple theories that are differentially relevant for studying the translation process. Cognitive approaches, I argue, are dynamically organized around specific problems or questions that have been shaped by previous research, by well-established cognitive hypotheses and by the current theoretical and practical interests of the discipline of translation studies.

25.2 A varied landscape of cognitive approaches to translation

Broadly construed, the explanatory task of cognitive approaches to translation is to offer an account of how translators are able to create, transform and communicate meanings in various contexts by manipulating and interacting with different types of texts (Malmkjær 2012;
Malmkjær and Windle 2012). By expanding existing cognitive models of language processing and comprehension, as well as of general human capacities like learning, problem solving and decision making, cognitive scientists provide theoretical insight and practical recommendations concerning translators’ choices and behaviours. Cognitive models are used to guide answers to specific theoretical and practical research questions. How are meanings assigned to specific situations and texts? Are there language or cultural universals that can serve as a basis for translation? Do machine translation programs inform us about how human translation works or do they provide an alternative that overcomes some of the limitations encountered by human translators? What kind of tools best help translators in their problem solving and decision making processes?

In order to generate good explanatory answers to these questions, existing models of cognitive capacities are calibrated and tested against relevant data. In addition to introspection, cognitive researchers deploy a host of empirical methods to collect and analyse data about the translation process. Some of these include EEG measurements, theoretical analysis, think-out-loud protocols of individual language learners and translators and of groups of translators, participant observation, tracking/logging the translation process on computer screens and eye-tracking during translation tasks. While first and second-generation cognitive studies typically work with data collected via a single empirical method, third-generation studies triangulate multiple sources of data to calibrate and confirm particular models of the cognitive capacities involved in the translation process. In addition, third-generation studies have started to combine data from translation process observation with data gathered from translation product analysis and corpus-based translation studies.

In what follows, I survey several examples of current cognitive research on translation. These short case studies will serve to illustrate (i) the differences between first, second and third-generation cognitive studies of translation, and (ii) the roles that theoretical models and specific research questions play in determining and organizing cognitive approaches to translation.

25.2.1 Cognitive perspectives on meaning in translation

Cognitive approaches conceive of the process of translation broadly as requiring that the same or similar meanings are carried from the source language to the target language. This makes theories of meaning central to explaining what cognitive capacities are involved in the translation process and how they are modulated by various physical, cultural and social factors. The variation in cognitive approaches to translation starts in how they conceptualize the notion of meaning itself. Cognitive models differ in what they take to be the locus of meaning: some models assume that meanings are the sort of things that belong to texts, to languages and even to neural patterns, while others assign meaning to specific socio-cultural interactions.

Such theoretical perspectives on the notion of meaning are associated with broader cognitive paradigms that comprise specific models of cognitive capacities, e.g., reasoning, problem solving and decision making. There are three major frameworks or paradigms that have been imported from the field of cognitive science to translation studies: the information processing, the neural networks (or connectionist) and the situated and embodied cognition frameworks (Risku 2012). Each of them implies different ways of thinking about how meaning is created and manipulated through different cognitive capacities during the translation process.

The information processing paradigm views translation as a matter of manipulating symbols in accordance with a set of well-specified rules. Relying on the analogy of a digital computer, this paradigm models human minds as manipulating and transforming internal
mental symbols or representations. Mental representations are thought to be the bearers of meanings and to have causal roles in shaping human reasoning capacities and behaviours. A landmark in the development of symbolic approaches to meaning has been the introduction of componential analysis to Chomskyan generative grammar by Fodor and Katz. *The Structure of a Semantic Theory* (1963) proposed a model of meaning combining a structuralist method of analysis, a formalist system of description and a mentalist conception of meaning. Although the Katzian model is no longer the standard in contemporary semantic analyses, its lasting influence comes from the introduction of two key ideas in linguistic theorizing: the requirement of describing the structure of lexical meaning in the context of a formal grammar and the issue of the psychological reality of meaning (Geeraerts 2015: 2–3). The first idea contributed to the emergence of two contemporary ways of formalizing the semantics of natural language: computational semantics and formal semantics. The second idea has generated different theoretical positions (on a spectrum from permissive to restrictive) concerning the issue of the independence of linguistic capacities (and linguistic knowledge) from other cognitive capacities (and world knowledge).

More specifically, both ideas have informed cognitive models of translation. For instance, equivalence theories view translation primarily as a task of comparing and matching linguistic and/or mental representations (e.g., Catford 1965; Nida and Taber 1969/1982; House 1977; Snell-Hornby 1988). In broad outline, these approaches seek to establish and to represent formally general rules that govern the process of transferring meanings from source to target language (Panou 2013). Some of their most salient differences concern the issue of whether the linguistic capacities involved in the translation process (or word-knowledge) should be treated as independent or interconnected with other cognitive capacities (world-knowledge).

However, equivalence theory approaches to translation share in part the challenges that have been levelled against the adoption of the information processing paradigm in cognitive science more broadly. For instance, in light of an increasing number of cognitive studies, the symbolic computationalist framework has been criticized for offering too idealized a picture of human reasoning abilities. Rather than relying solely on semantic characteristics of mental representations, cognitive scientists have proposed that human cognitive functioning depends on emotionally loaded exemplars drawn from experience.

The emerging alternative framework models human cognitive capacities in terms of neural networks. This framework places a double emphasis on the experiential and culturally constructed nature of cognitive categorizations and on the constraints imposed by the biological brains whose function is to support and maintain specific cognitive capacities. That is, the neural networks or connectionist framework assumes that world knowledge based on individual experiences plays a key role in cognitive processes like understanding, learning and decision making. Also, against the classical symbolic view of cognition, connectionist models assume that knowledge is not stored in discrete data structures; rather, knowledge is said to be implemented across patterns of neural activation. Thus, instead of thinking of cognitive processes in terms of specific symbol-manipulating algorithms, the connectionist paradigm suggests that neural networks ‘learn’ to recognize regularities in the environment by having access to novel inputs and by exploiting existing connections between their nodes. It follows that the meaning of words is learned in concrete interactions with the environment at a sub-symbolic level. The observed stability of meaning is the result of repetition of certain types of situations and interactions between the world and the cognitive system. Nevertheless, according to connectionist models, meaning is a constantly changing construct.

Prototype theory is one class of theories of the translation process that has been influenced by the connectionist framework. Prototype theory postulates that the translation process
consists of the manipulation and transformation of experienced-based units of thought. These units are referred to as frames, scripts, schemas, scenes or scenarios. For instance, Vannerem and Snell-Hornby (1986) used the notions of scenes and frames to explain the experiential basis of text analysis and production in translation. Their model emphasized that the understanding and production of texts requires understanding the particular translation situations, which in turn determines specific expectations about the meaning and style of the source and target texts. Thus, rather than reproducing meaning structures (symbols) from one language to another, the task of a translator is better conceptualized as one of offering possibilities for the construction of meaning. According to prototype theory, translators do not just follow rules in a task of symbol manipulation, but rather engage in a complex task of integrating situation-specific inputs and internal-individual or culture-specific models (schemas, scenarios, etc.).

The connectionist paradigm thus facilitated the development of models which capture the dynamic nature of meanings manipulated in the translation task. But while prototype theory approaches accounted for the role of experience as a factor in translators’ performance, they have also been criticized for neglecting (or downplaying) the social and artefact-mediated aspects of the translation task (Muñoz Martín 2010). This criticism of the sub-symbolic models of meaning and translation process made room for a third theoretical paradigm of cognitive models.

The situated and embodied cognition paradigm tries to integrate the physical, social and cultural factors that lie outside human minds and which play key roles in how cognitive capacities develop and are applied in different situations (Clark 1997). Instead of explaining cognition in terms of the recognition, reconstruction and use of mental representations or neural patterns, the situated/embodied view conceptualizes cognition in terms of an interaction between agents and their psycho-social environment. With respect to the problem of meaning, this framework entails that one cannot localize meaning on paper or in the brain, and that one should view it as a product of interaction with a particular environment. The implications of this way of viewing meaning for translation studies include: (1) placing more emphasis on the role of personality traits, emotional features and social skills of translators and (2) taking into account the structure of translators’ communities and translators’ training in understanding translators’ behaviour and choices (Kiraly 2000; Risku 2010).

Describing the translation process in terms of problem solving and decision making has encouraged symbolic and connectionist models that seek to explain: (1) how agents overcome the problems encountered during different types of translation tasks, (2) the differences between the performance of expert and novice translators and (3) micro and macro strategies and methods that might work best for overcoming the processing difficulties met during the translation process. The situated/embodied paradigm, on the other hand, brings to light the unconscious and ‘non-problematic’ aspects of the translation process, such as experts’ ability to interact with novel texts, how personality traits of the translator affect the product of the translation process or how the affective elements implicit in a translation context impact the end result. As a result, the situated cognition paradigm has encouraged cognitive researchers to take into account these aspects in explaining the concept of translation competence and expertise (Muñoz Martín 2010; Risku 2010).

The problem of meaning in translation generates a rich collection of models of the cognitive capacities involved in the different stages of the translation process and the internal and external factors that modulate this process. As I showed in this section, these models can differ with respect to the theoretical assumptions they make about human minds in general and the specific cognitive factors involved in the translation process. Despite this diversity, I argue there is an underlying unity to cognitive approaches to translation. Before addressing the issue
of how to think about this unity, the following subsections will further exemplify the research questions raised by cognitive models of meaning in the translation process.

25.2.2 Translation competence

The question of whether translation, as a process which involves the manipulation and transformation of meanings, requires a special type of psychological competence has proven to be a fruitful research problem at the intersection between translation studies and psycholinguistics. Theories of meaning and language acquisition, as well as cognitive models of the social and cultural factors that might impact the agent’s performance in translation tasks, have flourished in the past years.

For example, the PACTE project at the University Autonoma de Barcelona focuses on the development of the translation competence of both language students and experienced professional translators. Their model of translation competence comprises several submodules: the bilingual competence submodule, the extra-linguistic competence submodule, the strategic and instrumental competencies submodules, the knowledge about the translation process submodule, as well as other psycho-physiological components. The predictions yielded by the PACTE model have been tested via two longitudinal studies comparing the knowledge and skills of experienced translators with those of foreign language teachers with no experience in translation and with those of trainee translators, respectively. The outcome is a dynamical model of the translation process in which all the cognitive submodules interact in a way that integrates declarative knowledge (know-that) and procedural knowledge (know-how). In addition, PACTE’s experimental results indicate a more substantial contribution of procedural knowledge to the improvement of the quality of translation (Hurtado Albir et al. 2014; Hurtado Albir 2017).

A similar process-orientated longitudinal study is at the basis of the TransComp project at the University of Graz. Following the development of translation competence in undergraduate translation students, the project offers the opportunity to translation researchers to model the acquisition and development of expertise, or experienced professionalism, in the field of translation. Building on the PACTE model of translation competence, the TransComp researchers posit six distinct capacities whose development leads to translation expertise: communicative competence in the source language and the target language, domain competence, and tools and research competence, translation routine activation competence, psychomotor competence and strategic competence. Measuring creativity indicators such as uniqueness, optional shift and novelty, their longitudinal study showed that the quality of translation is correlated with achieving a cognitive balance between creative problem solving and automaticity of the translation process (Göpferich, Jakobsen and Mees 2009; Göpferich, Bayer-Hohenwarter, Prassl and Stadlober 2011). While further cognitive research is required to test the empirical predictions of projects such as PACTE and TransComp, these early findings provide a ‘proof of concept’ for the contributions of cognitive approaches to the problem of expertise in translation.

25.2.3 Expertise in translation

While translation competence is analysed in terms of several other cognitive capacities, expertise in translation is conceptualized as (1) a permanent state of mastery reached after a substantive amount of practice or as (2) a process which takes place at the upper limit of translation competence. The latter perspective emphasizes the continuity between translation competence and expertise rather than the extensive amounts of practising hours required in order to reach a certain level of expertise.
More generally, cognitive research has yielded a series of categories for differentiating multiple types of expertise at work in the translation process. For instance, while some studies distinguish between translation experts and experienced non-experts, others focus on the cognitive differences between routine experts and adaptive experts. These distinctions are important because they also reflect the theoretical interest in identifying the multiple factors, such as work experience, cultural background, linguistic competence and the level of understanding of the expectations and needs of the target audience that might influence what counts as expertise in different translation contexts (Siren and Hakkarainen 2002).

In addition, these more fine-grained expertise research categories have been used to interpret the surprising findings of several empirical studies showing that expert translators do not always produce high-quality translations. One way of understanding these results is with the help of the categories of routine and adaptive experts. When an expert translator applies a routine translation approach to a novel (non-routine) task, the results might be suboptimal. The less successful translators might fall in the category of routine experts that have difficulty in adapting to novel translation tasks. In other contexts, the suboptimal results are due to the fact that the experimental translation task falls outside the professional domain in which a translator is an expert. This points to another relevant distinction between expertise and professionalism which has been applied to the field of translation.

Some cognitive studies pursue a more in-depth analysis of the process view of translation expertise and of its consequences, in particular with respect to the so-called automaticity question. The latter refers to the common assumption that novices have to work hard at a translation task while experts select and process the relevant information quickly and effortlessly. Cognitive research on the different stages involved in the translation process challenges this assumption, revealing the fact that given the same translation assignment experts would typically work harder and invest more time in the decision making stage of the translation. The automaticity question is a growing topic of research in cognitive psychology, indicating that we are still some way from having any definitive answers. However, the emerging models suggest that the effect of automaticity might be a robust pattern in the translation process. Thus, investigating the ‘translation does not get easier’ phenomenon may help refine further expertise research categories and inform translation training programs.

For a more concrete illustration of the expertise research agenda, consider the work of the network EXPERTISE coordinated by Andin F. Rydning at the University of Oslo (2001–5) and comprising a number of translation researchers and cognitive scientists from all over Europe. Members of this research network published numerous reports discussing various aspects of translation expertise. Several of these studies used Thinking Aloud Protocols (TAPs) to investigate the cognitive dimensions of translation expertise. This method requires that the translators involved in the study verbalize their translation procedures and decisions, which are subsequently analysed in parallel with their written translations. While the use of TAPs has raised a number of serious concerns and objections, it has also been argued that the methodology can yield valid data if certain conditions are met during data collection and analysis (Ericsson & Simon 1984/1993; Künzli 2009). In a series of studies, Alexander Künzli has relied on TAPs to investigate the factors which directly influence the comparative evaluation of the performance of different groups of translators: expert translators and translation students (Künzli 2001), technical translators and routine translators (Künzli 2004). These preliminary studies established that linguistic background and specialist domains are key in determining expertise performance in a specific translation task. Whether and how the effect of these factors can be modulated by other contextual elements is a growing topic in translation research.
Another class of studies aimed at integrating the results of TAPs with other methods used in translation process research such as eye-tracking methods and computer keystroke logging in order to explore further the features of translators’ expertise. In a series of Translog studies of experts and novices, Arnt Jakobson has triangulated these different perspectives on the translation process and succeeded in validating three important aspects of translators’ expertise (Jakobsen 2003, 2005, 2011). First, he established that experts spend more time on initial orientation and final revisions. Second, experts are capable of processing longer units or segments. Finally, they have superior speed potential. In addition, Jakobson’s findings can be shown to provide further support for Künzli’s hypothesis that peak performance is possible only in domains in which translators are specialized.

Expertise research, and translation process research more generally, aims to identify and explain not only the cognitive but also the affective elements involved in the translation process. Thus, the problem agenda of expertise research has recently been extended by contributions from affective cognitive science, which further refine the questions and associated hypotheses about the emotional aspects of translation.

25.2.4 Emotion in the translation process

Research linking emotion to translation studies can be divided into two main strands. The more prominent strand focuses on the question of how to translate emotive language or emotional material, while the less developed component of this research agenda concerns the emotions evoked in translators and interpreters. Nevertheless, an increasing number of translation process studies point to the relevance of the latter strand of research for understanding the factors that influence translator performance as well as translator training. Thus, while not a traditional research problem in translation studies, the investigation of the emotional aspects of translation, using the resources (models, theories, methods) from affective studies, has the potential to complement current hypotheses about the organization and dynamics of how translators operate and even of how they gain expertise in a particular domain.

As noted in the previous section, a translator needs to not only to be a competent linguist, but also to know how to mediate effectively between cultures, to understand a target reader’s needs and expectations in order to be able to communicate a source author’s message in a successful way to target readers or to a target audience (in an interpreter’s case). Being able to recognize and communicate one’s own and other people’s emotions guarantees a more successful inter-cultural communication, and thus should count as an important skill for translators and interpreters. These latter aspects of a translator’s competence are part of what personality psychology investigates under the label of emotional intelligence.

Current research on the emotional aspects of the translation process points to the existence of a robust link between creativity, emotional intelligence and translators’ performance. For example, Davou (2007) focuses on the interaction of cognition with emotion in the processing of textual material. The study explores the link between creativity and emotion, suggesting that creativity is a product of the interaction between different emotional stimuli that are sent simultaneously and are capable of triggering multiple thoughts and cognitive processes. Thus, observed differences in levels of creativity among translation students or even professional translators might be explained in terms of the different emotional interpretations that the same text generates for each of them. This hypothesis seems to be supported by previous empirical observations that successful translators are typically emotionally engaged individuals who derive personal and contextual meanings from texts and create interpersonal relationships with source text authors and target readers (e.g., Boase-Beier 2006; Jääskeläinen 1999).
Different texts are also likely to elicit different emotional responses from translators, so that a legal translation will not have the same potential for emotivity as translating a love poem. Because of this, the role that emotional intelligence plays in the process will vary across translation tasks.

One fairly obvious implication of this line of research into the emotional aspects of the translation process is that the translation of texts with high emotive potential is likely to be more successfully undertaken by an emotionally intelligent translator, while texts with low emotive potential do not have the same requirement because they rely less on the ability of the translator to regulate and manage emotions. This prediction can be tested in experimental studies, which in turn will yield additional refinements of the emotional involvement hypothesis.

Similar exploratory studies have already begun to investigate the relationship between levels of emotional intelligence and individual differences among the performance of interpreters, as well as translators. Focusing on the performance of signed language interpreters, Karen Bontempo designed two studies of Auslan/English interpreters that made use of multiple psychological measurements such as self-efficacy, negative affectivity and self-esteem (Bontempo and Levitke-Gray 2009). Her findings suggest that personality, and more specifically affective traits, have an impact on interpreters’ perceptions of competence – that is, how confident they are during the interpretation or translation process. This in turn is seen as a factor that modulates the individual’s capacity to carry out a specific interpretation task. In particular, emotional stability or an individual’s ability to manage difficult life events and emotions has been shown to be a good predictor of interpreter competence. A series of subsequent studies, conducted by Bontempo and collaborators, points to a more general hypothesis according to which individual personality differences correlate to translation outcomes. In Bontempo and Napier (2011), the researchers compared personal variables such as interpreting experience and professional qualifications with opinions about linguistic skills and competence, as well as with some self-reported personality traits. The findings show that personality modulates not only self-perceptions of translation competence but also interpretation outcomes. The researchers concluded that non-cognitive criteria should be explicitly addressed and incorporated in translators’ and interpreters’ education programs (Bontempo and Napier 2011; Bontempo, Napier, Hayes and Brashear 2014).

Rosiers, Eyckmans et al. (2011) have also used self-report measures of student translators and interpreters to investigate the relationship between levels of linguistic self-confidence, motivation and language anxiety. Their comparative study of translating and interpreting students yielded a series of differences between the two groups. They found that interpreting students rate their communicative competence higher than translation students, who in turn experience more language anxiety than interpreting students. While this study does not target explicitly the emotional traits involved in the translation process, it identifies a series of personality characteristics and attitudes that impact the translators’ and interpreters’ performative behaviours.

Affective research in the process of translation is still in its exploratory stage. The studies briefly reviewed earlier suggest how psychometric measures can be used to shed light on translation creativity and competence. Future generation studies in the field of translation are likely to benefit from incorporating more non-cognitive (affective) concepts and measures in their empirical and theoretical work. It is also expected that pursuing the link between emotion and translation would yield more efficient translators and interpreters training programs.

### 25.2.5 Machine translation

We have seen that cognitive approaches can contribute to translation studies by articulating specific models of the various cognitive and non-cognitive aspects of the human translation
Another area of cognitive science, namely AI, focuses on the human cognitive capacities involved in translation to design and build technologies that can serve as external aids in the translation process. A series of AI projects aims to use knowledge about how the human mind and brain operate during translation tasks to construct artificial devices that would assist occasional, novice, routine and professional translators and interpreters. Thus one way to understand the broad problem agenda of machine translation (henceforth MT) is in terms of its engineering aim to develop various computational tools that may assist or even perform automatically different translation tasks. In what follows, I will briefly review some of the main research directions pursued in this field, pointing to the difficulties and limitations that MT projects have encountered along the way in their more than 60 years of history (Way 2010; Hutchins 2012).

The difficulty of making translation an automated (or semi-automated) process by designing and building an appropriate computer program is closely tied to the ways in which we conceptualize the process of translation itself. As we saw in the previous sections, translation involves an understanding of the meaning of the source text (or speech) followed by a culturally and pragmatically appropriate rendering of the given text in the target language. Abstracting away from the many factors that influence and modulate the various stages of the translation process, a simpler representation of the translation task from an AI perspective includes selecting the correct sense of each individual word and identifying the right relationship between the words as captured in the syntax of the source language. But even this simplified representation of the translation problem generates a series of hard challenges for machine translation. Three of the most common issues are lexical ambiguity, syntactic ambiguity and cultural variation. I will briefly review these challenges to MT before introducing the main methods used to overcome or avoid them.

The problem of lexical ambiguity affects what is typically conceived as the first stage of the machine translation process, namely word-sense selection. Many words have multiple meanings. These include true homonyms as well as polysemous words with more or less closely related meanings. In addition, the morphological inflections characteristic of some languages are a further source of lexical ambiguities for computer-based translation programs. Even when words from the source text are not lexically ambiguous in these ways, the translation task can still be affected by this problem if the target language contains more than one word with an appropriately related meaning. Various strategies can be used to simplify the word selection task and choose the appropriate corresponding word in the target language. Still, these strategies need to take into account another source of trouble: syntactic ambiguity. *Eating cakes can be satisfying* is an apparently innocuous sentence which can pose serious problems to an MT program. Sometimes the source and target languages allow for the same types of syntactic ambiguities, in which case the MT program might get away with not solving the syntactic ambiguity in the first place. But very often computer-assisted translations need to go through a post-editing process to check for mistakes generated by such cases of syntactic ambiguity. Finally, another common problem for an MT program is the selection of the appropriate style and register for a particular translation. While this rarely poses a problem to experienced human translators, computers make more mistakes in picking up the appropriate level of detail, register and style for a pair of languages. These problems motivate the development of rigorous evaluation and post-editing protocols that accompany computer-assisted translations.

There are two mainstream approaches that have emerged in MT research and which try to tackle the sort of translation problems listed earlier: rule-based approaches and statistics-based approaches. While basic research favours statistics-based MT methods, the majority of commercial MT systems are still based on some version of the rule-based approach. This
preference reflects the fact that the rule-based approach is more robust – that is, it is easier to maintain. On the other hand, improving and perfecting the translation outputs of these systems is more resource-demanding. That is, they require both more time and more expert knowledge than statistics-based MT systems. The advantage of the latter method is that MT systems can be developed more quickly, although it is not entirely clear how they can be fine-tuned. I will return to this issue later.

An MT program based on a rule-based approach starts by analysing the individual words in a sentence. Dictionary look-up identifies the part of speech of the word and lists possible candidate translated meanings. Then the MT program seeks to determine the internal structure of each sentence, identifying syntactic relations and trying to solve lexical and syntactic ambiguities contained in the source text. If the program parses a complex sentence, it will focus on identifying its ‘building blocks’ at the expense of its overall structure. This explains why sometimes the partial output of MT commercial systems can seem to be on the right track and then completely fall to pieces.

The key idea behind the statistics-based approach is that a computer program can learn how to translate by parsing and analysing large amounts of data from previous translations and then computing statistical probabilities which inform the choice of translation for a new input. The statistical method in MT research relies on the existence of huge amounts of what is called bilingual corpora data. The analysis of this data is typically divided into two parts. In the first part, the program builds the translation model. That is, it analyses the data and estimates probabilities for correspondences between individual words and phrases in the two languages. This counts as the program learning word correspondences between the two languages. The second part of the program consists in learning the target language model by computing probabilities that certain word-sequences are legitimate in the target language. The two models constitute the ‘facts’ that the computer ‘knows’ about the source and target languages.

The actual translation task is performed by the third component of the MT system which is known as a decoder. Its function is to take the input sentence, evaluate the various probabilities for all the individual words and phrases in the translation model, and then put these through the target language model to yield the most probable translation according to the systems’ learned statistical distributions. The success of the MT systems based on this approach depends to a large extent on the quality of the data on which the programs are trained. One surprising feature of these statistical MT-systems which depend on the features of the available training data is that they may not produce the same translation for two very similar sentences. This gives rise to further research questions about the comparative evaluation of the translation outputs of a rule-based MT system and a statistical MT-system (Somers 2012).

One recent success story of the statistics-based approach to MT is the radical transformation and improvement of the Google Translate program. Based on an audacious ‘neural-translation’ research idea, the new program behind Google Translate uses hierarchically nested neural networks to learn statistical probabilities from massive amounts of bilingual corpora data. The main breakthrough of the Neural Machine Translation (NMT) approach is that it manages to reduce both training time and translation inference time with no cost for the quality of the output translation (Wu et al., 2016; Johnson et al., 2016). Moreover, the researchers working on the NMT program promise that further developments to the system will not be epistemically opaque and will increase the translation performance of the system much faster than with traditional rule-based MT systems. They also require minimal changes in the old architecture supporting the Google Translate program, thus avoiding the hardware costs that made some of the previous statistics-based approaches unappealing from a commercial perspective.
Researchers behind the NMT project have also claimed that their research approach provides a way of bridging the gap between human translation and machine translation (Wu et al., 2016). Although we cannot do justice to this broad problem in this review, it is important to clarify one misleading interpretation of this statement. Although the neural network approach is inspired (loosely) by the functioning of biological brains (Minsky and Papert 1969), the proposal is not that human brains and minds operate in a similar way to the ‘Google brain’, which parses massive amounts of data and computes statistical probabilities to improve both the speed and quality of its translation outputs, but rather, the models that constitute the NMT program are best thought as being inspired by how human brains operate. The hierarchical organization of the neural networks used in this MT project roughly resembles the nested and modular architecture of the brain, while the learning rules used by the system are more sophisticated versions of the Hebbian rule of synaptic plasticity. These general principles have encouraged researchers to describe the statistical process behind NMT as a bridge between neurobiological and AI research. That is, not only is neurocognitive research thought to provide useful resources for the improvement of the quality of NMT results, but advancements in the latter are expected to yield novel insights about the functioning of the brain.

Ongoing projects explore the potential lessons that the success of NMT might have for understanding the cognitive processes involved in human translation, but the final story will very likely be more complicated than saying that the ‘Google brain’ is a faithful mirror of how human brains operate in the translation process. Just as with the problem of comparing human intelligence and machine intelligence, the relationship between AI and cognitive psychological research into translation cannot be settled by merely identifying the two or by a definitive pronouncement of the demise of one or other of them.

25.3 The organization of cognitive approaches to translation

Cognitive studies of translation constitute a varied landscape of research questions and methodological strategies which seems to challenge the attempt to offer a systematic account of their contributions to translation studies. The overview offered in Section 2 supports this mosaic-like conceptualization of the field. The question is whether this topical and methodological diversity should simply be taken as a symptom of the field’s current immaturity or as a more intrinsic characteristic that is likely to endure.

Traditional philosophical discussions of the structure of scientific theories (Oppenheim and Putnam 1958; Kuhn 1996) associate the maturity criterion for a scientific field with the existence of a ‘master’ theory or set of theoretical principles which guides its development and organization. The physical and the biological sciences are candidates for this theory-driven view of mature sciences. According to this view, the plurality of cognitive models (e.g., symbolic, connectionist, situated) of the cognitive capacities involved in the translation process is the result of the immaturity of a field that is still on the lookout for a stable theoretical framework. Such a framework would articulate the laws or stable regularities that govern the cognitive processes relevant for the analysis of the translation process.

On descriptive grounds, though, this theory-driven picture appears to offer an inadequate perspective on the organization and potential unity of cognitive approaches to translation. To begin with, recent discussions in philosophy of science suggest that the theory-driven picture of science is a poor guide for understanding even how some branches of the physical and biological sciences have developed and are currently organized. Waters (2007), Love (2013, 2014) and Sullivan (2016a, 2016b) have proposed that scientific fields as diverse as microbiology, developmental biology and cognitive neuroscience are not organized around any
master biological theory. According to the perspective defended by these philosophers, the 
structure and progress of these well-established scientific domains should be analysed in terms 
of the clusters of research questions that one finds presented in textbooks and research journals. 

For instance, theoretical models from cellular, molecular and evolutionary biology inform 
answers to explanatory questions in developmental biology. Challenging the stability or 
importance of the field as a whole on grounds of a lacking ‘master’ theory of development 
rests on the problematic assumption that all fields of scientific inquiry should conform to the 
same maturity criteria. Given the methodological diversity that characterizes science as a 
broad intellectual enterprise, such uniformity is unlikely and may, perhaps, even be damaging 
to the development of certain fields (Waters 2007; Love 2013). Thus, adopting a theory-
inform ed and question-based perspective on science requires challenging the idea that there is 
only one way to think about scientific investigation and allowing the articulation of more 
‘local’ criteria of scientific success. 

Extending this perspective to cognitive approaches of translation, I propose that the absence 
of a unified theory points to a question-based way of thinking about the organizing structure of 
the field as being the most productive (Koralus and Mascarenhas 2013). The core idea is that the 
organization and dynamics of cognitive research in translation studies is driven by the existence 
of stable and broad domains of interrelated questions or problem agendas (Waters 2007). That 
is, cognitive studies of translation are organized by multiple questions clustered into problem 
agendas which are approached with the theoretical and methodological resources made avail-
able from different areas of cognitive science, including linguistics, psycholinguistics and AI. 

One place to start unpacking this erotetic structure of cognitive studies of translation is in 
the textbooks, companions and handbooks which synthesize the knowledge accumulated in 
this area of research and present it in a way suitable for transfer to novices (e.g., Baker 2011; 
Baker and Saldhana 2008; Bassnett 2002; Gentzler 2001; Malmkjær & Windle 2012; Munday 
2008; Pym 2010/2014; Venuti 2012). A survey of such collections reveals a series of inter-
related questions about the agency involved in the translatorial action, the role of the translator 
as a cultural mediator, the roles and consequences of the multimodality of the translation 
process, the pragmatic and semantic theories of meaning developed for understanding different 
types of translation, the analogies and disanalogies between human and machine translation 
(MT), the cognitive roles and effects of the processes of translation evaluation and revision, the 
cognitive models used for translation training, and so on. 

These and other additional themes have been explored within the different disciplines that 
constitute the field of cognitive science. Researchers with different backgrounds have approa-
ched these questions at various levels of abstraction and by taking into account different degrees 
of variation in the translation phenomena they take as their targets. Most of current research is 
also seeking to establish connections between the models and theories developed in response to 
some of these questions and to expand them by incorporating different accounts of the temporal 
dimension of the translation process and of its outputs. 

I suggest that the landscape of cognitive approaches to translation is in fact structured 
around these variables (abstraction, variation, connectivity and temporality) in the sense that 
cognitive models and theories can be distinguished with respect to whether they target aspects 
of translation at a more abstract or concrete level, whether they accommodate a wider or a 
narrower domain of translation phenomena, whether they seek to integrate multiple models 
and theoretical ideas and even put them into practical models aimed at translator training 
programs, and whether they deal with the temporality of translation as a process and cultural 
product. In fact, these four variables can be used to articulate and further refine the questions 
pursued within different disciplines of cognitive science. Particular research problems will be
formulated at a certain level of abstraction and they will exclude or presuppose a certain range of cognitive phenomena involved in translation that are temporally or atemporally (i.e., constitutively or conceptually) related to other relevant cognitive phenomena.

The problems which define the agendas (or research programs) of different cognitive approaches in translation studies can be best understood as composite lists of multiple interrelated questions, which in turn can be individuated with the help of these four analytical variables. We do not need to presuppose that these problems are \textit{a priori} logically structured or well-defined in order to talk about their role in guiding long-term investigation in translation studies. On the contrary, thinking about cognitive scientific research in translation studies in terms of clusters of interrelated questions provides a descriptively adequate picture of the field because this erotetic structure is something that is primarily accessible to the working scientist.

To get an even broader picture of the field we can point to three further dimensions that structure the space of problems for the cognitive study of translation. These are the dimensions of \textit{history}, \textit{heterogeneity} and \textit{hierarchy} (Love 2014). The clusters of questions or problem agendas pursued in a discipline like psycholinguistics or AI will depend to a large extent on the \textit{historical development} of the field – that is, on the types of questions that have been historically investigated and the models that have been developed to answer to these questions. History also contributes to some degree to establishing whether a cognitive model or theory will be more or less abstract, to which other existent models it will be possible to link it and whether it could cover more or fewer kinds of translation phenomena. The \textit{heterogeneity} dimension corresponds to the fact that problem agendas contain multiple and distinct types of questions that can be related in specific ways depending on whether they are studied from a psycholinguistic or AI perspective, for instance. In addition, these heterogeneous questions can be \textit{hierarchically} organized, depending on either their level of abstractness or on their temporal properties (e.g., one aspect of translation can be part of or preceding another aspect, etc.). Emphasizing the \textit{hierarchical dimension} of problem agendas reinforces our previous point that even if a scientific field is not theory-driven but only theory-informed and erotetically organized, it can still constitute a fruitful and coherent area of scientific research.

This way of understanding the organizing structure of the cognitive studies of translation has three main advantages. First, the erotetic account refers to categories that fit the language of actual research practice, thereby being descriptively adequate. Second, by emphasizing the interconnectedness of the questions pursued by cognitive scientists investigating translation phenomena the proposed framework allows for a better understanding of the dynamics of the field – that is understanding why some problems are more stable than others and how one type of problem can evolve or be transformed into a different type of problem. And finally, the erotetic view of the organization of this field of research allows for a reassessment of the value of the exploratory studies developed in the field and their role in promoting new questions and research hypotheses.

The proposed analytical framework can also be used to help disentangle the relationships between the different research projects summarized in Section 2. In each of the chosen case studies, I have tried to identify the clusters of questions around which cognitive research on translation is organized. Some questions are only very abstractly specified, whereas others target very specific issues pertaining to particular translation tasks. Both expertise research and the newer area of affective science of translation try to cover a wide variety of phenomena related to the translation process. They also take into account quite explicitly the temporal dimension of the activity of translation. The section on machine translation showed how different cognitive models can be integrated to advance the general aims of translation studies.
Overall, I claim that thinking about the organization of cognitive approaches to translation in terms of the problem agendas researchers are actually pursuing is a more productive perspective on the field of translation studies as a whole.

I have also proposed that thinking about the history, heterogeneity and hierarchical structure of the field complements the erotetic perspective. Although I have not followed any strictly historical storyline in the selection of case studies, a more abstract perspective emerges. This perspective combines the three dimensions and imposes a further organization of the research programs and studies such as those sketched in Sections 2.3 to 2.5 into three groups: first-generation, second-generation and third-generation studies. First-generation cognitive studies of translation are characterized by their exploratory character and the general research questions pursued as well as by the predominance of a single empirical research method being used. I include in this category most of the studies investigating the link between emotion and translation. Second-generation studies focus on more fine-grained research questions investigated via a single research method. Such are some of the expertise studies and the first examples of machine translation research projects. Third-generation studies typically triangulate evidence and methods to validate robust results about specific aspects of the translation phenomena. Projected studies in the affective science of translation, expertise research and machine translation research fall into this category.

The erotetic view offers a descriptively adequate account of current and future cognitive approaches to translation. Thinking about the questions that organize cognitive scientific research in translation can also shed light on the various types of challenges that face the multidisciplinary collaborations pursued in translation studies. The success of these projects depends not only on the alignment of theoretical backgrounds of the participating researchers (linguists, cognitive psychologists, computer scientists, etc.) but also on the collective determination of the problem agendas and associated questions to be pursued in a joint research project. The job of negotiating the methods, assumptions and expectations of the different disciplines becomes easier when there is a common cluster of questions on which these disciplines are supposed to meet.

Related topics
Current trends in philosophy and translation; translation theory and philosophy; meaning; machine translation.

Notes
1 Some of the most forceful criticisms concern the loose treatment of methodological issues such as the research design, data analysis and research report involved in translation studies based on the Thinking Aloud Protocols (Bernardini 2001; Eftekhar and Aminizadeh 2012).
2 In fact, the ability to understand and transfer sensitive and context-bound information, to capture the meaning of source culture texts and to have the interpersonal skills to adapt to different working situations are acknowledged by the European Commission Directorate-General for Translation as key skills of competent translation professionals.

Further reading
statistical approaches to natural language processing. Highly relevant for understanding the prospects and challenges of statistical models of machine translation.)


References


