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MEASURING COGNITIVE EFFORT IN TECHNOLOGY-MEDIATED TRANSLATION

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This article is written as part of the project ‚The Digitization of the Initial Training Process for Teaching Staff to Ensure an Efficient Educational Approach, in Line with the Demands of the Labor Market’” explores the evolving landscape of translation in multilingual and digital contexts, focusing on machine translation (MT), and computer-assisted translation (CAT). It examines CAT and MT and how it has shifted translation workflows from linear to interactive, increasing efficiency but also cognitive load. The article reveals the theories like the Translation Process Model, Technology Acceptance Model, and Cognitive Load Theory that help explain translators’ mental processes and adaptation to digital tools. Practical applications of CAT tools and controlled language are highlighted, showing how they support consistency and quality in specialized domains. Overall, the translator’s role is changing from creator to editor raising questions about creativity, control, and the ethics of technologized translation.

Keywords: *Machine Translation (MT), Computer-Assisted Translation (CAT), Controlled Language, Translation Process Model.*

MĂSURAREA EFORTULUI COGNITIV ÎN TRADUCEREA MEDIATĂ DE TEHNOLOGIE

Acest articol, elaborat în cadrul proiectului „Digitalizarea procesului de formare inițială a cadrelor didactice pentru a asigura o abordare educațională eficientă, în concordanță cu cerințele pieței muncii” explorează tabloul în schimbare al traducerii în contexte multilingve și digitale, cu accent pe traducerea automată și traducerea asistată de calculator. Sunt analizate traducerea automată și traducerea asistată de calculator, și modul în care acestea au transformat fluxurile de lucru din procese liniare în procese interactive, sporind eficiența, dar și încărcătura cognitivă. Articolul valorifică teorii precum Translation Process Model, Technology Acceptance Model, and Cognitive Load Theory pentru a explica procesele mentale ale traducătorilor și adaptarea acestora la instrumentele digitale. Sunt evidențiate aplicații practice ale instrumentelor digitale și ale limbajului controlat, care sprijină consistența și calitatea în domenii specializate de traducere. În ansamblu, rolul traducătorului se schimbă de la creator la editor ridicând întrebări despre creativitate, control și etica traducerii tehnologizate.

Cuvinte-cheie: *traducere automată (TA), traducere asistată de calculator (TAC), limbaj controlat, modelul procesului de traducere.*

Introduction

In the context of globalized media and multilingual societies Computer-Assisted Translation (CAT) and Machine Translation (MT) of the multilingual content (subtitling international films, translating websites, global news feeds speed) is indispensable. In the context of globalized media and multilingual societies, where vast amounts of information circulate at unprecedented rates, Computer-Assisted Translation (CAT) and Machine Translation (MT) content are not only imperative but also vital for ensuring fast, reliable cross-cultural communication. These technologies have revolutionized translation practices by dramatically accelerating the speed of delivery while simultaneously reshaping the very role and profile of the translator [1].

Th role of the translator is no longer of language experts but also digital literacy experts to interact with translation memory systems, terminology databases, and corpora platforms. There are to be considered considerable changes in translation workflow, as traditional translation was largely a linear and manual process following the sequence: read → understand → translate → revise; with CAT and MT integration, the process now often involves pre-editing → automatic translation → post-editing → quality assurance stages changing the once-clear boundaries between comprehension and production. The shift toward post-editing, rather than translating from scratch, redefines professional practices and expectations in the translation field.

However, while these technologies offer speed and translation services, they also raise questions about accuracy, cultural nuance, and the human touch in translation.

Bernardini and Federico Gaspari (2016) confirm that CAT tools and MT systems affect the workflow, productivity, and cognitive processes of professional translators. There are identified both the technical and human aspects of integrating technology into translation [1].

With CAT tools and MT, the translation process now involves [1]:

1. Pre-translation using MT,
2. Post-editing the MT output
3. Quality check using CAT tools.

This pattern is called the “non-linear” or “interactive” translation process that is based on the Translation Process Model (Krings, 2001) that explains how translation includes problem-solving, decision-making, and revision [2].

While translating multilingual content multiple challenges arise like maintaining the foreign words, subtitling code-switching, translating into the target language [3].

Jorge Díaz Cintas and José Manuel Martínez Sierra (2021) identify various effective strategies to work while being involved in CAT and MT [4, 5]:

1. Preservation of multilingual elements (reflecting on the original sociolinguistic richness),
2. Normalization (translating everything into the same language),
3. Selective translation (translating only where comprehension is vital),
4. Visual/textual cues (using color, font, labels to distinguish languages).

Krings (2001) stipulates that several translation issues can appear during translation with CAT and MT that activate cognitive processes. These issues are lexical ambiguity and cultural references both of which pose significant challenges for CAT and MT [2].

Lexical ambiguity arises in the contexts when a source word or phrase has multiple possible meanings, making it difficult for the translation system to select the correct interpretation without sufficient context. Cultural references, on the other hand, involve idioms, realia, culturemes, metaphors, or culturally specific knowledge that do not have direct equivalents in the target language, leading to mistranslations or loss of meaning.

According to Krings the indispensable cognitive processes in CAT and MT are: reading and rereading, pausing, looking up dictionaries or databases, rewriting and reformulating. The last but the not least is the decision-making involved in solving these translation problems that is central to the process. Another must have strategies of CAT and MT emphasized by the researcher are the use of external resources or external aids (dictionaries, MT systems, glossaries).

Krings (2001) determined the following types of activities used during MT and CAT [2]:

Table 1. MT and CAT activities

Types of activity	Description
Comprehension	Reading and understanding the source text
Transfer	Moving meaning from source to target language
Reformulation	Creating an appropriate expression in the target language
Monitoring	Reviewing and evaluating the target text
Resource consultation	Using dictionaries, MT suggestions, glossaries, or online searches
Revision	Going back to correct or improve earlier translated segments

Models in CAT and MT

Translator's experience has moved towards speed and making a choice from a variety of suggestions. However, the translator can be caught or "trapped" by low-quality MT or rigid software. The process of adaptation is troublesome; it depends on translator's experience with technology, personal attitude, openness to change, language pair and text type. The Technology Acceptance Model (TAM) by Davis (1989) states that translators accept or reject new technologies based on usefulness and ease of use [6]. According to the Technology Acceptance Model (TAM) proposed by Davis (1989), translators accept or reject new technologies based on two key factors [6]:

1. Perceived Usefulness (PU)- the degree to which a translator believes that using a particular technology will increase the performance or make their tasks easier.
2. Perceived Ease of Use (PEOU)- the degree to which a translator believes that using the technology will be less effortful.

When translators identify a technology both useful and easy to use, they develop a positive attitude toward it, having in mind the formula: Perceived Usefulness + Perceived Ease of Use → Attitude Toward Use → Behavioral Intention to Use → Actual Use.

The theory of Ergonomics of Translation (Dragsted, 2012) focuses on translator's comfort, wellbeing, and mental load when translating with digital tools. The focus is

made on the human factors within the translation environment (the physical setup, interface design, and workflow structure) which have a direct impact on the translator's long-term efficiency, health, and mental state. Poorly designed interfaces can lead to physical strain (e.g., eye fatigue, back pain, or wrist injury) as well as mental fatigue, such as reduced attention, stress, or burnout [7].

Well-designed digital tools can support the translation process, minimizing redundant work, and providing visual clarity that can improve productivity and reduce cognitive overload. The translator in this case makes a shift from creator of text to editor or reviewer of machine output. In this scenario the translator loses his creative agency.

Post-Editing Process Model developed by O'Brien (2002) describes how translators revise machine output with pre-translated content, making fast decisions about what to keep, change, or rewrite. Through this model the role of translator has shifted toward editing rather than producing original content [8].

Another model, Keystroke Logging and Eye Tracking by Carl et al. (2011–2016) show technology-mediated environments and how translators do the post-editing, and how they behave when translating from scratch. The findings of this research show that translation is a dynamic, cognitively demanding, and interactive process mainly because [9]:

1. Translation is Non-Linear and Iterative because translators don't work word-for-word or linearly from start to finish but they travel back and forth between source and target texts.
2. The Cognitive Load demands Fixation Patterns like Eye tracking (it reveals which segments are cognitively demanding, often correlating with lexical ambiguity, cultural references, or MT errors).
3. Pauses and revisions are tied to problem solving realized through Keystroke logging (tracking and recording of all keyboard activity) as a process of negotiation, especially in post-editing machine translation (PEMT).
4. Post-Editing Involves Different Cognitive Effort.
5. Individual Styles and Experience of the translator matter as more experienced translators tend to show smoother workflows, shorter pauses, and better use of segmentation strategies.

Poor MT can increase workload and fatigue because the process of editing is harder than translation from scratch. Carl & Schulz (2012) compare translation and post-editing in real-time. The study compares the cognitive effort and editing behavior of professional translators when translating from scratch (HT: Human Translation) vs. Post-editing machine translation output (PEMT) [10].

Carl & Schulz wanted to see how the processes differ in terms of time, effort, and workflow using keystroke logging and eye tracking to measure where translators looked, for how long, and how often they switched between source and target texts. Carl & Schulz (2012) found [10]:

1. Post-editing is faster but not always easier, speed doesn't always equal less effort, especially when machine output was poor or unnatural, requiring intense revision.
2. Cognitive effort is more concentrated in PE (Post-editing) because eye fixations and pauses were more focused on problematic segments in the machine translated text.

3. There are different workflows in human translation: translators worked more linearly, creating content word by word, in PE they spent more time scanning and jumping around, selectively revising or skipping correct segments.
4. Revision patterns differ in post-editing, as translators often made minimal changes, correcting grammar or fluency; but retaining MT structure compared to human translation.

O'Brien (2010) analyzes how users evaluate and correct MT output and explores how much cognitive effort is involved when professional translators post-edit machine-translated texts. O'Brien defines Cognitive Effort as the mental processing required to complete a task that includes: detecting errors, deciding whether to keep or change segments, reformulating unnatural or awkward phrasing. O'Brien proposes using indirect process data to measure cognitive effort, such as [11]:

- Pause length (longer pauses means higher effort),
- Eye-tracking data (long fixations or regressions),
- Keystroke logging (number of edits, deletions, and insertions),
- Subjective rating (asking translators how difficult they found each segment).

O'Brien found that the quality of the MT output directly affects the mental effort: High-quality MT requires less cognitive effort. Low-quality MT increases effort i.e. translators spend more time reading, understanding, and rewriting large parts. Translators, even, report mental fatigue from dealing with badly structured MT, even if the text seems fluent.

Tools, Controlled Language, and Specialized Language Use

Schubert (2009) explains the concept of Controlled Language (CL) and how it can improve Machine Translation (MT) with the focus on rule-based and earlier statistical systems. The idea is to use a simple, standard version of natural language that according to Schubert is CL. Controlled language reduces ambiguity and complexity, with fewer errors in translation, more predictable and consistent output from MT systems that are important for rule-based MT systems, which follow fixed grammar and vocabulary rules. Schubert sees Controlled Language as a form of "pre-editing" in order to improve the source text before translation. Controlled Language is a bridge between natural and formal language that requires acquiring certain rules, creating and maintaining approved vocabularies. Schubert emphasizes the need for collaboration between: linguists, terminologists, translators, MT developers [12].

MT and CAT gives the feeling of loss of control over language, reduces creativity and autonomy with the risk of becoming „machine editors" rather than full language professionals. The Posthumanism in Translation Theory (Cronin, 2013) states that machine translation devalues and decenters the human translator, which is not the only actor in the translation process viewed as technological mediation. Within the Posthumanism Theory there should be considered the following concepts [13]:

- Posthuman translator is a figure entangled with machines, networks, and systems;
- Distributed agency is decision-making that is shared between human and non-human entities;

- Technological embeddedness is the framework where translation happens i.e. digitally-mediated contexts;
- Eco-translation is linking translation ethics with ecological sustainability.

The theory of Resistance to Technologization (Pym, 2011) encourages a balanced view of tools - useful, but not neutral. Bernardini & Gaspari determine the advantages and disadvantages of technology emphasizing the need for careful evaluation, proper training, and ethical reflection in how these tools are used [1].

Moorkens, J. (2020) investigates the human side of post-editing i.e. how professional translators (post-editors) feel about working with machine translation output, and what motivates or frustrates them in this hybrid translation environment. Translators often feel ambivalent about MT impacting their job satisfaction. Some value it as a time-saving tool, others find it frustrating and demotivating [14].

Bowker & Pearson (2002) gives step-by-step guides and examples showing how translators use software tools in real-life scenarios. When a translator is translating a technical manual that includes repeated terminology and instructions he might use Trados (or a similar CAT tool) to streamline the translation. There are the following steps that should be taken [15]:

1. Importing the Source File (File types supported: DOCX, HTML, XML, IDML, etc.). The CAT tool converts the document into translation units (TUs), typically sentence-level segments.
2. Pre-Translation using Translation Memory (TM). The CAT tool checks the existing TM for types of matches (exact match (100%), fuzzy match (e.g., 75–99%), or no match.
3. Interactive Translation is when checking segment by segment. If no match is found, it is entered a new translation manually. The tool may highlight terminology from the termbase or suggest phrasing from concordancers or MT plugins.
4. Terminology Management is when the tool identifies terms from a built-in termbase (or external source) and it suggests standard translations for technical or specialized vocabulary.
5. Consistency Checking is when CAT tools alert the translator about inconsistent terminology, formatting issues, or missing translations.
6. Saving Translations to the TM.
7. Generating the Target File when The CAT tool reconstructs the translated document in the original format (DOCX, HTML, etc.).
8. Post-Editing and Final Review when the translator or editor checks the file for accuracy, fluency and style.

Bowker & Pearson (2002) explain languages for Specific Purposes (LSPs) that refer to the specialized forms of language used in professional, academic, or technical fields like law, medicine, science, or engineering. Key Features of specialized forms of language are controlled vocabulary, domain-specific grammar (grammatical structures that appear more frequently in a certain field, phraseology unique to the field) [15].

Another aspect researched by Bowker & Pearson (2002) is corpus, a structured collection of real-world texts, either written or spoken, often organized by domain, language, or genre, used to provide authentic examples of language use. Unlike textbooks

or dictionaries, a corpus helps users observe how language behaves in context, showing frequency, typical patterns, and collocations that are not always obvious. Bowker & Pearson suggest to gather domain-relevant materials (scientific articles, reports, websites), remove irrelevant content (ads, menus, formatting errors), use software like: AntConc, Sketch Engine, WordSmith Tools that generate frequency lists (most common words/phrases), explore collocations (words that frequently appear together) and see concordances (words in their surrounding context).

Sennrich, Haddow, and Birch (2016) show how to handle rare or unseen words (out-of-vocabulary (OOV) words) in translation. The authors propose a method called Byte Pair Encoding (BPE) for splitting words into smaller subword units so that neural translation models can process any word, even unseen or rare ones, and still maintain morphological and semantic consistency. This helps reduce vocabulary size while improving translation quality, especially for languages with rich morphology (e.g., German, Finnish, Turkish). Sennrich, Haddow, and Birch (2016) fix, in this way, a big problem in early machine translation systems [16].

In older systems, if the model didn't recognize a word (like a rare or new word), it would just label it as [UNK] (unknown). That meant it couldn't translate it at all, which made translations incomplete or wrong. Sennrich, Haddow, and Birch came up with a smart idea to break words into smaller parts (called subword units) using a method called Byte Pair Encoding (BPE). By splitting words into smaller pieces, the system can understand and translate words it had never seen before. The machine didn't need to replace words with [UNK] anymore. That made the translation more complete and fluent. Instead of remembering 50,000 full words, the system only needed to learn a smaller list of parts (like ing, un, ness, tion, etc.). This made training faster, and translation more flexible. Instead of learning entire words, the computer learns parts of words translating almost everything, even if it's a rare or new word.

Method

To explore how translators work with multilingual content and digital tools, three hands-on classroom activities were designed for students as part of the master's degree course *Philosophy of Translation*, giving them the opportunity to experience real-life translation practices. The first activity focused on audiovisual translation (AVT). Students watched short scenes from multilingual films or series and examined how subtitles handled multiple languages. They looked for strategies like preserving original languages, translating everything into one language (normalization), or using visual cues like italics or color to show language changes. After that, the students discussed how the subtitles could be improved by applying different strategies.

In the second task, students practiced Controlled Language (CL). They were given a complex, ambiguous technical paragraph and asked to rewrite it using clear, simple sentences and standardized vocabulary. Then, both the original and rewritten versions were translated using machine translation (MT), and students compared the results. This helped them see how clarity in the source language can improve translation quality.

The third activity involved corpus analysis. Students were proposed real texts from a specialized field and explored how key terms were used. They examined word frequen-

cies, common word combinations (collocations), and the context of specific terms. This showed them how corpora can support accurate and consistent translation by providing examples from real language use.

Together, these activities gave students practical experience with tools and strategies that professional translators use in today's multilingual, tech-driven environment.

Discussion

Several theories were meaningfully integrated into the Controlled Language (CL) classroom activities. Through Controlled Language (CL) and Machine Translation (MT) **s**tudents rewrote complex texts into Controlled Language and compared MT output before and after. Through Posthumanism in Translation Theory students exercised to reflect on how translators become posthuman agents in decision making. Human Factors in Post-editing **b**rings in the emotional and cognitive aspects of working with MT output (**s**tudents may observe that texts rewritten in CL result in less frustrating post-editing experiences).

Table 2. Application within a lesson

Lesson Stage	Theory Applied	Pedagogical Purpose
Introduction	Schubert (2009)	Explain CL and pre-editing
Text rewriting	Bowker & Pearson (LSP)	Simplify and standardize terminology
MT Output Comparison	Sennrich et al. (2016)	Understand subword modeling benefits
Discussion	Cronin (2013), Pym (2011), Moorkens (2020)	Reflect on translator agency, satisfaction, and ethics

In the first task about audiovisual translation, students came to the conclusion how hard is to write subtitles, when there are spoken different languages in the same scene. The students chose to translate all texts into one language, it made the meaning clearer, sometimes something important was lost. Most students agreed that it depends on the situation.

In the second task, students practiced using controlled language. They took a difficult technical text and rewrote it using short, clear sentences and easy words. Then they used machine translation to compare the original and the rewritten texts. The controlled version gave better, cleaner results. Many students were surprised to see how big the difference was. But they also noticed that writing this way was not easy. It takes time to learn how to write clearly without losing important meaning.

The third task was about using a corpus to study how words are used in special fields. This helped them understand how to translate better without dictionaries.

To conclude, these activities showed students that translation today is more than just changing words from one language to another. Many students evoked that technology can save time and make their work easier though too much technology is less creative and original.

Conclusions

The translator suffers a great shift in efficiency, cognitive effort and quality because MT and CAT software definitely increase the speed, but affects quality. Today's translators need to do more than just know two or more languages. They need to think strategically, use digital tools wisely, and make decisions that balance clarity, accuracy, and creativity.

The empirical study gives a chance to experience the landscape of translation using technology, with the touch to lose creative control or to deal with poor machine output. The translator changes the role in this fast-changing field by combining the language skills, cultural insight and wise use of tools to stay creative, confident, and in control.

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