Translating is not (only) problem solving

Ricardo Muñoz Martín and Christian Olalla-Soler, Università di Bologna

ABSTRACT

The aims of this article are twofold: to challenge views on translation as problem solving in Cognitive Translation and Interpreting Studies (CTIS), and to outline an alternative approach that calls for tapping and investigating the whole translation process—and not (only) problem solving. We first offer a review of the concepts of problem and problem solving in psychology. Second, we discuss several approaches to problem and problem solving in translation and outline the conceptual troubles of these models. We then focus on the operationalisations of translation problem-solving constructs and discuss how the traditional use of pauses as an indicator of problem-solving stances in translation is troublesome. Finally, we outline an alternative approach to translation as problem-solving from a cognitive-translatological perspective. We approach translation as a type of constrained production of texts led by creative imitation. The overarching constraint is the existence of one or several source texts to which an intertextual relationship of identity is assumed. Such a shift in perspective, we contend, calls for an updated research agenda in CTIS based on considering the whole translation process instead of solely focusing on problem solving, along the lines laid down by cognitive translatology, a situated cognition framework within CTIS.

KEYWORDS

Cognitive Translation and Interpreting Studies, problem solving, translation process, translation as constrained text production, research agenda, cognitive translatology.

1. Introduction

One way to understand thinking is to equate it to mental activity. In this view, remembering an appointment, making sense of what we see and feel, imagining Alice's Queen of Hearts—and even intuiting that there is something funny in what we just read—are ways of thinking. There remain still open questions, such as whether we are thinking when we mechanically tie our shoelaces (e.g., Hansson *et al*. 2022), and when we dream (e.g., Siclari *et al*. 2017). In any case, this view of thinking is customarily deemed too wide to be of any use in science.

When we turn inwards to consider what thinking is, we often feel driven to focus on its more remarkable ways, those that we deem distinctively human—apparently unique to us. So *thinking* tends to be reduced to conscious, intentional mental activities, often synonymous with *rational thought.* Reasoning amounts to thinking logically, to drawing inferences, formulating explanations and judgments, predicting events. Logical thought is goal-directed and may be deductive, inductive, or abductive—intuition is not usually considered part of it, let alone emotions. Yet, there is more than one way of thinking rationally. *Critical* thinking is also careful thinking directed to a goal (Hitchcock 2020), and so is *problem solving*. However,

critical thinking is a way of considering things or states of affairs, whereas problem solving applies when aiming to change a specific situation.

At the beginning of the 1960s, *thinking (rationally)* would become further reduced to the "systematic transformation of mental representations of knowledge to characterize actual or possible states of the world, often in service of goals" (Holyoak and Morrison 2005: 2) and, ultimately, to problem solving (e.g., Johnson 1972). "Higher mental processes" (cf., e.g., Carlson 2019 vs Bargh and Ferguson 2000 and Williams *et al.* 2009) became primarily studied in terms of categorisation or problem solving. You did not need to be a human being to solve problems. Chimpanzees and "non sentient beings" (i.e., machines) could do it too (Premack and Woodruff 1978; Holyoak and Morrison 2005: 2); so, if only by definition, they could think the way we do. Artificial intelligence would hence be possible, for computers were expected to mimic the workings of the human mind—freeing researchers from both informants' biases and their own ethical concerns. This entailed developing scientific models that would apply to both people and computers (and chimpanzees).

Like time, problem solving has often been modelled metaphorically, and in terms of space. Newell and Simon (1972) used a spatial metaphor to account for problem solving in two steps: (1) defining the space of the problem—which includes identifying an undesired initial state and a desired goal state; and (2) searching for solutions within that space, which amounts to overcoming obstacles to reach the goal state. Hayes (1981: i) also described problem solving as "finding an appropriate way to cross a gap." This is done through trial-and-error ('hillclimbing'; Robertson 2001) or through means-ends analysis—like in the test of the Tower of Hanoi, where only one solution is possible; solvers are aware of the desired end state and easily infer the rules and constraints to adhere to before they start solving it. According to Shih,

> Newell & Simon's problem-solving theory is a solid foundation for translation process research, not only because it introduces the valuable concept of problem space construction but also because it includes subgoaling and the recursive nature of problem-solving (2015: 71).

Translating has, indeed, often been described as a chain of problem-solving instances (e.g., Krings 1986; Bell 1998; Englund Dimitrova 2005; Nitzke 2019) interspersed with processing unproblematic or non-strategic text stretches (cf. Lörscher 2005: 600)[1]. Table 1 shows that early proposals on problem-solving steps in cognitive translation and interpreting studies (CTIS), such as Krings (1986) and Wilss (1996), are conceptually similar to cycles of problem-solving steps in *traditional* or *phase* models (Jonassen 2012: 2684) in cognitive psychology, from where they were borrowed.

Cognitive Psychology		Cognitive Translation and Interpreting Studies	
Hayes (1981: 1)	Pretz *et al*. (2003: 3–4)	Krings (1986: 269)	Wilss (1996: 188)
find/identify problem	find/identify problem	find/identify problem	find/identify problem
represent problem	represent problem	represent problem	describe problem
		organise knowledge	research/collect background information
plan/develop solution	plan/develop solution	plan/develop solution	plan/develop solution
	allocate mental and physical resources		
carry out plan		apply strategies	
	monitor progress	evaluate strategies	
		solve problem	moment of choice
evaluate solution	evaluate solution	evaluate solution	evaluate solution
consolidate gains			

Table 1. Problem-solving steps in some models from psychology and CTIS

Note: Labels referring to similar contents have been homogenised, whereas those steps considered not to be the same or only partially overlapping maintain their terminological differences.

Table 1 hints at differences between these psychological and early CTIS approaches. Only Pretz *et al*. (2003) suggest a step to allocate mental and physical resources, although the omission of this step in the other proposals might be more a matter of granularity than something the others would not agree with. Early CTIS researchers highlight *knowledge organisation* and *seeking and collecting background information,* important subgoals entailing modifications in the space of the problem, whose potential obstacles may change with newly acquired or differently organised information. In so doing, they allow for more dynamic, interactive views on problem solving.

Until this point, we traced the origins of problem-solving notions in CTIS. Our next steps will focus on the very notion of problem in translation, the mismatch between phase models of problem solving in psychology and in CTIS, and the relationship between problem solving and decision making. Section 3 will examine methodological choices, understandings and

operationalisations that did not do justice to the study of translation processes—e.g., the assumed link between translation problems and pauses, the use of long(er) pauses to segment the translation process flow, and a few measurement errors due to oversimplifications in the constructs or limitations in data-collection tools. To do so, we will focus on keylogging research. Section 4 sketches an alternative approach to translation, which moves away from the notion of translating as problem-solving (Gaddis Rose 1979; Sirén and Hakkarainen 2002; Pym 2003) and paves the way for broader, more integrative, and deeper investigations of the translation process built upon cognitive translatology.

2. The troubles of a model…

This section will review the very notion of problem in translation, the mismatch between phase models of problem solving in psychology and in CTIS, and the relationship between problem solving and decision making.

2.1. The notions of problem in translation

To start out, some translation problem-solving characteristics do not seem to match those of the typical problems addressed in psychology. *Problem,* for many psychologists, describes situations where anyone would identify an unwanted state of affairs after being presented with a situation or task to perform (see Bassok and Novick 2012). The example of the Tower of Hanoi perfectly fits this view. When presented with the task of solving this puzzle, people usually identify the unwanted (and wanted) state. The point of departure, the goal, and the rules are clear. People may take little time to solve it or spend hours (see Dörner 1987: 10-11 for a distinction between *problem* and *task*), but all of them would identify the initial situation as an unwanted state.

In translation, however, it is difficult to find a single phenomenon that any translator would identify as an unwanted state that needs to be transformed into an end state—i.e., a problem, as conceptualised in early psychological models. Nord (1987) distinguishes *learner-dependent* (individual) from *learner-independent* translation phenomena. Learner-dependent problems are due to lack of knowledge or language command. In Nord's view, which draws from early understandings of *problem* in psychology, only *learner-independent* problems qualify as true *translation problems,* in that they are assumed to be identified as an unwanted state by all translators alike. Yet, can we really draw a line between them? Often we spot a phenomenon that we recognise as a translation problem for other people but not for us; in such cases, is it still a problem? Is a certain source-text (ST) phenomenon a translation problem for somebody reading past it unawares? Is there any translation problem certain to be universally identified and faced, let alone solved? Is there a single way to solve a translation problem? The answer to

all these questions, we contend, is no, because translation problems only exist for their solvers.

Our first argument is based on the very nature of translation problems. In psychology, problems are divided into well- vs ill-defined or -structured (Pretz *et al*. 2003, Jonassen 2012). The first kind typically presents all elements of a problem or class of problems. Solving it asks for a number of rules, organised in a predictive (or prescriptive) sequence. That is, again, the case of the Tower of Hanoi. An example of conceiving translation problems as well-defined in CTIS is Leppihalme (1997, chapter 4), who devised flowcharts to translate cultural allusions. That is, rather than to a single, specific problem, she meant to apply them to a whole problem class. In contrast, ill-defined or ill-structured problems have (a) unclear goals and constraints, which have to be defined by the solver; (b) multiple alternative paths leading to many solutions, dependent on the solver's representation of the problem; and (c) multiple scopes and criteria from which they can be evaluated (Jonassen 2012: 2684–2685). Nitzke explains that

> Most translation problems are ill-defined because the steps required to solve the problem were not necessarily learned in advance, experience in different domains is required, personal opinions/judgements might be necessary. Further, different solutions and different solution paths are possible (and natural) [...] (2019: 259).

A consequence of understanding translation problems as ill-defined is that traditionally they have been deemed dependent on the kind of knowledge presumed necessary to solve them (e.g., Nord 1988; PACTE 2011): if you just need linguistic knowledge, then it is not considered a real translation problem any longer, but rather a linguistic problem. However, problems can be classified in many ways. For instance, Jonassen and Hung (2008: 9) classify problems based on (1) their complexity and (2) their structuredness (well- or ill-defined). The complexity of the problem includes "the breadth of knowledge required [i.e., the main criterion in many translation problem classifications], the difficulty level of comprehending and applying the concepts involved, the skill and knowledge levels required to solve the problem, and the degree of nonlinearity of the relations among the variables within the problem space."

Narrow problem classifications in CTIS often focus on text elements rather than on the observed behaviours of the informants, as in the case of Nord's (1994), or on the purported mental processes, as in PACTE's (2009: 212-213) *rich points*, or "specific source text segments that contained translation problems". Rather than problems themselves, we suggest, ST elements might be considered to be *potential problem triggers*, i.e., ST segments that *may* be identified as initial, unwanted states. In brief, translation problems and problem solving vary in several ways, including the contexts where they occur, the skills and abilities of the translators, how they represent these problems, and the very nature of the problems (Jonassen 2007).

Nearly every translation problem is *sui generis*—an ill-defined problem with several acceptable solutions that also depends on who is solving it, in which environments, and with which goals. Abstracting problem classes is possible but the exception and should always be taken with a grain of salt. For instance, the rules for translating the names of UN specialised agencies from English into peninsular Spanish—a very low abstraction, yielding a scarcely productive and reduced class of problems with just 15 instances)—might correctly render WHO, ILO and IMF as *OMS*, *OIT* and *FMI* but would need to explain why but FAO and UNESCO remain untranslated.

Translation-problem findings thus often risk turning out trivial, because many such findings do not generalise. For example, contrary to received wisdom, "[...] professional status does not necessarily guarantee high-quality performance, and conversely, that novices' performance may manifest features of expertise" (Tirkkonen-Condit 2005: 406). Interesting findings might, in fact, be found in places where laypeople or experts see problems and the other group does not, because that is where some gains or losses—e.g., learning or arrested expertise—may have played a role. Those gains were part of Hayes' model (Table 1) but they disappeared in CTIS problem-solving models, which are nevertheless often used to describe differences between junior and expert translators.

The notion of expertise as steady superior performance at problem solving, based on "skilled" memory (Ericsson and Staszewski 1989), may have encouraged views of translating as a chain of problem-solving instances. However, as professionals accumulate relevant, feedbacked experience, they tend to find fewer problems when facing an ST than junior professionals and translation trainees do (e.g., Shih 2015). The PACTE group (2020: 149) adopted a notion of well-defined problems mainly based on Nord (1987). PACTE characterised pre-selected ST segments as translation problems of different types, according to the knowledge required for their translation. Paradoxically, however, professionals were found to identify fewer problems than trainees, and advanced trainees identified fewer problems than those in initial years.

If a problem is objective (i.e., if it is a textual segment that acts as an unwanted initial state for every translator, as suggested by Nord 1987), the logical assumption would be that all participants would identify the same pre-selected, problematic ST segments (even if they knew how to solve them), but they did not. Thus, the assumption seems empirically falsified. If professionals find fewer problems, does that make what they do less of a translation, or just less of a problem? Obviously, displaying more efficient behavioural indicators and finding fewer (and perhaps different) problems while producing better translations cannot be considered *not translating.* So translating needs to be something other than, and in addition to, translation problem solving. The trouble with translating as problem solving may lie

deeper in our thought—in the somewhat acritical borrowing of psychological models for describing translation processes (cf. O'Brien 2013).

Nitzke (2019: 77) argues that in translation we apply "rules and assumptions that were defined for broader contexts and situations to smaller units in the translation context." Sirén and Hakkarainen (2002: 72) and Pym (2003: 489) have suggested that the whole translation task be considered a single instance of problem solving: "Put as plainly as possible, translation is problem-solving. The overriding problem is how to get a text from one language to another" (Gaddis Rose 1979: 20). However, if we accept that most translation (micro-)problems are *sui generis,* then the particular combination of micro problems somebody finds in a whole text (the macro-problem) is necessarily unique to each person and reading. In any case, applying phase problem-solving models at this macro level of granularity is not feasible, because the desired end state for a whole text has countless possibilities and the factors, micro-problems and ways to solve them along the way are unique.

2.2. Problem solving models in psychology and CTIS

Let us focus on the mismatch between phase models of problem solving in psychology and in CTIS by going back to the notion of translating as a chain of problem-solving instances. Let us remember that Hayes' model of problem comprises an undesired initial state, a desired goal state, and logically steering your way to sidestep obstacles from the former to the latter. Shih (2015: 71) notes that "the ultimate goal of translation and revision is often difficult to define and in practice the concept of an ideal translation is still debatable." Nitzke (2019: 78) agrees that "the desired final state of the problem is never known" and adds that the means to reach solutions are sometimes also unknown to translators.

Given that their target—the desired goal state—is not ill-defined, but unknown, the application of Hayes' (1981) model and other phase models to translating is in trouble. We could next ask: What might the initial and unwanted state of affairs be for a translation problem, anyway? It cannot be the *existence* of an ST stretch. Without a source text, there could not be translation, so that can hardly be deemed an unwanted situation. The current, unsatisfactory state cannot be that the ST stretch is in another language either: This view would render the whole enterprise pointless, for everything in the ST would thus become a problem. Furthermore, it would leave problems always unsolved—whatever you write in your target text (TT) leaves the ST unchanged: the problem is not in the ST segment, but in the minds of translators as they strive to formulate new TT segments to render it.

Taking the inability to translate an ST stretch into another language in a straightforward manner as the initial, undesired state of affairs (as in the *monitor model*; Tirkkonen-Condit 2005) is also questionable. Failing to

produce a straightforward translation may be a failed trial-and-error attempt to solve a problem. Thus, we might consider it the unwanted initial state that jump-starts the problem-solving cycle. Yet this step would have been taken before the problem was identified, and this is theoretically not possible. In problem-solving models, motivation, problem-spotting and description (or representation) are *necessarily* prior to action. Problem identification (awareness) necessarily comes before action. We might thus hypothesise that a given ST stretch *became* a problem only after we failed to render it *mechanically* and *decided* that the first translation attempt had been unsuccessful. But this initial, mechanical attempt would not be an instance of problem solving, but rather the result of an *automatic* behaviour the quality of whose result we need to decide upon. This is what proponents of the monitor model suggest (see below).

2.3. The links between problem solving and decision making

Tirkkonen-Condit (1993: 8) states that "choice and decision-making are perhaps so fundamental in translation that almost any theoretical or research-oriented treatment is bound to relate to them in one way or another." Wilss' (1996) model (Table 1) draws on Corbin's (1980) approach to decision making, and highlights the *moment of choice* as a distinctive part of the process. Perhaps Wills aimed to establish a connection with the process of translating non-problematic text segments, which still need to be assessed and sanctioned through decision-making. Translating would thus be a chain of decision-making processes, some of which would lead to nested problem-solving instances.

Still, problem solving and decision making are quite different. In problem solving, end goal states—here, detailed expectations for optimal candidate renditions of ST stretches—may be unclear and the process may not immediately offer any option (hence, the problem), whereas in decision making end goal states are there and clear but offer several options to choose between. Problem solutions are thought to be the best (or least bad) *available* options (see, e.g., Wang and Chiew 2010; Mayer 2013). Decision-making choices, in contrast, may be different from each other, rather than better or worse, in the ways they frame the information, what they drop and what they need to add, and may also entail revisions of decisions (see, e.g., Kahneman 2003; Krantz and Kunreuther 2007; Gonzalez 2014). Wilss (1996: 188) himself admits that, in practice, translators' decision making and problem solving may not be so streamlined.

We might still choose to add decision making to problem solving within a model, as mutually alternative translation processes, turning it into a dual model. Dual process models basically divide cognitive processes into automatic, unconscious, and light, vs controlled, conscious, and demanding (reviews in Evans and Stanovich 2013 and in Gawronski and Creighton 2013). Decision making may become non-conscious or automatic (Jääskeläinen and Tirkkonen-Condit 1991: 106), so it would cohere with the

dual process models of translating, such as the monitor model (Tirkkonen-Condit 2005; Carl and Dragsted 2012; Schaeffer and Carl 2013; but see also Muñoz 2016a, 2016b)[2].

However, in this monitor model the translator's mind is reduced to a neutral, passive, clockwork-like bilingual text processor chunking the ST, deciding somehow on the quality of automatic retrievals, and solving problems when such retrievals are not good. In the words of Kohlmayer,

> With Wolfram Wilss' (1977) book *Übersetzungswissenschaft* ['The Science of Translation'] I—like many others—was confronted for the first time with the aggressive reduction of translation to purely cerebral linguistic processes. As a consequence of the first Wilss' (1977) model, the translator shrank to a linguistically contrastive functioning super brain (2004: 12, our translation).

Making room for decision making opens up the monolithic, oversimplified model of translation as problem solving, and it certainly covers a larger share of cognitive processes at work. Yet, in no way does the combination of problem solving and decision making exhaust the set of ongoing cognitive processes when translating. When the whole process of translation (the *cognitive* "event", Muñoz 2016b) is considered, other cognitive processes become involved in higher proportions—and not only monitoring. For instance, planning, evaluating, steering and managing attention and mental resources deserve to become central to the model, too. This is the realm of metacognition, of one's awareness of and ability to regulate one's own thinking. Shreve writes:

> There is likely to be a significant metacognitive component to the translation task. Metacognition (also: self-regulation, executive control, executive processes) in translation [...] involves active control over the component cognitive processes involved in translation. The extent and location of metacognition (where active control occurs) may vary both by level of translation expertise and the novelty and complexity of the task. Translation metacognition assumes that the translator has an explicit knowledge and awareness of the mental processes involved in the translation, where active control is required, and, most importantly, what conscious strategies might be applied at these conscious control points (2006b: 39).

It looks like we might need a new model, then, one that stresses agency, metacognition, and awareness. We will offer an outline of an alternative model in §4 that opens the door to accounting for the whole translation process—and not (only) problem-solving stretches. Here we provide the conceptual basis of this alternative model, rooted in cognitive translatology. Muñoz and Apfelthaler (2022) sketch one possible method to operationalise it.

Before addressing it, however, let us focus on research methods and some operationalisations linked to translation problem-solving models. We may have erred in defining a construct and still apply procedures based on it and obtain good results. In medicine, for instance, researchers do not know how acupuncture works, but it seems to work. Readability formulas have no

theoretical base, but are widely used with modest but positive results. We might have a mistaken notion of problem, and still apply problem-solving models with good results. The next section suggests that dropping the notion of translating as problem solving is not like changing horses in the middle of the race.

3. … and its operationalisations

Focusing on problem-solving instances within translation processes was facilitated by the use of think-aloud techniques (Ericsson and Simon 1984), which seem to prompt both informants and researchers to focus on problems. Think-aloud has some important drawbacks: First, cognitive processes tend to become automatic through repeated practice, and automatised processes might bypass short-term memory and be unavailable for verbalisation. That is, the higher the level of expertise, the less the informant would have to say. Second, when experiencing higher cognitive demands—often associated with problem solving—informants "tend to stop verbalising or they provide less complete verbalisations" (Ericsson and Simon 1984: 242). Problem-induced silence would affect all informants, not only experts. The conclusion was that "think-aloud can offer informative glimpses of cognitive processing in progress, but never a complete account" (Jääskeläinen 2010: 371).

Due to the above and other reasons, think-aloud techniques would receive sharp methodological criticisms (e.g., Hönig 1988; Jakobsen 2003; Muñoz 2013: 258). Soon keylogging, and then eyetracking, would sweep the field, and introspective methods survived mainly through cued retrospection. Nevertheless, two important methodological features were handed down intact to the new observational methods: First, pauses—any activity gaps in the recordings—remain associated with translation problems. Second, researchers keep their focus on text excerpts where they identify that informants were dealing with problems, and tend to disregard the rest. Choosing the appropriate passages to focus upon has been done through several strategies (e.g., selecting "rich points"; PACTE 2008, 2009) but mainly by establishing pause thresholds as indicators of translation problems in process recordings. Pauses would then be used not only as problem-solving indicators, but also as chunking touchstones demarcating the *opening* boundaries of interesting text stretches. To the best of our knowledge, no one has ever explained how to unequivocally find *the end* of a problematic text stretch.

3.1. The assumed link between pauses and translation problems

Pauses have customarily been interpreted as related to the actions flanking them (Schilperoord 2001: 77–82). In translation, different pause lengths are usually taken to indicate different cognitive phenomena and (long) pauses are assumed to signal cognitive effort in mentally taxing processes (reviews in Kumpulainen 2015 and Muñoz and Cardona 2019: 526-534).

Thresholds are customarily set between one to five seconds across informants. Pauses at or above the cut-off point are often assumed to be associated with problems, intrinsic ST difficulty, and higher cognitive efforts: "Major disruptions generally stem from hiccups either in ST comprehension or in target text reformulation" (Jakobsen 2019: 72, but see O'Brien 2006). However, problems are not only faced when pausing, and longer pauses do not always flag more difficult problems.

In writing research, Olive *et al*. (2009) found that all major cognitive processes—such as planning and revising, and not only problem solving—occur to different extents during pauses. In CTIS, Dragsted (2012) and Kruger (2016: 48) find that informants devote longer pauses to reading the original, or both the original and their own draft. Dragsted and Hansen (2008: 25) found that long pauses are sometimes due to switching from the ST to the translation. Angelone (2010) recorded pauses when informants just scrolled or moved the cursor elsewhere. Lacruz and Shreve (2014) point out that clusters of pauses as short as 500 ms may hint at higher cognitive efforts. Since longer pauses may flag all kinds of processes and shorter pauses may hint at problems, one can safely conclude—with Kumpulainen (2015: 48)—that in translation, "a pause may signify both problem-free and problematic processing." Even more, we can assume that many long pauses are devoted to activities—such as reading the ST—that require the cognitive resources assigned to typing. This suggests that long pauses tend to be intentional.

3.2. Using long pauses to segment the translation process flow

Leaving aside long pauses as indicators of problem-solving spots, there emerges a view of the keylogged aspects of translating as an alternating progression of pausing and typing[3]. Until we nail down how to discern what goes on in long (and other) pauses, they may be used as chunking indicators. VandenBos defines *chunking* as:

> [...] the process by which the mind divides large pieces of information into smaller units (*chunks*) that are easier to retain in short-term memory. [...] effective communication between humans depends on sorting information into units that do not exceed the mind's capacity to chunk them (*the chunking limit*) (2015: 186).

With texts, chunking entails grouping related, contiguous words into non-overlapping, consecutive larger units. Dragsted (2005) chunked her informants' keylogged TTs with different pause values for each informant. To do so, she randomly chose one of her informants and manually calculated a pause value that would best fit well-defined syntactic units (probably at the phrase level). She then generalised that particular ratio pause value/overall typing speed to the rest of her informants. Resulting chunks were *translation units,* defined as 'units processed cognitively in translation' (p. 49) and operationalised as "the text string

comprehended/produced between two pauses of a certain duration" (p. 52). Vale points out that

> [...] even though Dragsted's approach is much better at capturing the writing rhythm of fast and slow writers, it tells little about how much cognitive' effort was put in each pause. It is also a poor indicator of cognitive effort since it tends to find boundaries of translation process units before all capital letters.
> This might lead researchers to believe that sentence beginnings and German nouns are especially charged with cognitive effort, when that is not really what is happening. It just takes longer for a person to type a capital letter than a small letter. Dragsted's approach also has the tendency to underestimate the cognitive effort of writing pauses between two small letters, which are typically shorter because less typing occurs during them (2017: 234–235).

Personalising pause thresholds can at least be a step forward for chunking. However, pauses are only the first problem with problem solving operationalisations.

3.3. Model distortions leading to measurement errors

Jakobsen (2002) found that for every 100 characters in their final versions, his informants had pressed a mean of 14–15 additional navigation keys. On top of those keys, translation professionals had pressed on average 15 additional production keys and translation trainees, 26 more production keys. In sum, 29 *dead keypresses* for every 100 for professionals, and 40 for the trainees. Thus, calculating typing speeds with the number of characters and spaces in the final drafts, instead of all pressed keys (and mouse movements, clicks, and scrolls), might carry an error above 20%. Vale (2017: 210–212) explains that typing a character such as *Á* may take several keystrokes (*accent*+*shift*+*a,* where the first two are dead keypresses). Worse, it may affect laypeople, junior and expert translator data differently, and be higher or lower depending on the text, and on language (e.g., suprasegmentals) and writing conventions (e.g., capitalising nouns). These distortions cannot be completely evened out or ignored.

The above calculation implicitly assumes that everything informants type while translating is additions to the TT. Any text typed in a web browser may not be computed. Translation units so conceived leave out information searches, even though translators devote 20%–60% of task time to interacting with online resources, with an average of 33% (Gough 2016: 133). Paradowska (2015) set the minimum temporal amount of information search at 30%. Some keyloggers only record keys pressed within a program-internal text processor. That is, everything typed in web browsers is not registered, and search time is reflected as pause time between translation units. Technological developments should now let us do a more fine-grained analysis, leading to lower error rates. Nevertheless, the problem may not be in the tools, but in the constructs.

3.4. Oversimplification of constructs

For Carl and Kay (2011: 952), a *translation unit* is "the translator's focus of attention at a time". It is a unit of cognitive activity that cannot be observed. It is rather inferred by combining sequences of TT keystrokes, or *production units,* and of ST fixations, or *fixation units.* In other words, a translation unit, for Carl and Kay (2011: 954), is a set of reading and writing activities consisting of:

1. The ST segment(s) of which the produced TT chunk is a translation;
2. ST reading activities, sufficient to gather what translation(s) should be produced;
3. Writing activities to produce a TT chunk within a certain time span.

Translation units, in their proposal, need to (a) host coherent sets of signs corresponding to grammatical units, and (b) have internal pauses between keystrokes and fixations below certain thresholds in order to qualify as sequences. Carl and Kay (2011) find that in Danish the average length in characters of production units—with an 800 ms–1 s chunking threshold—is 17.6 for experienced translators and 12.5 for translation trainees. We were unable to find a reliable source for average word length in Danish, but it should be slightly longer than in English, perhaps nearly 5 characters (Norvig n.d.). Pedersen (2011: 19, note 16) adds that in some subtitles the average word length for both English and Swedish is ca. 5 characters. Let us then speculate with 5 characters as a safe value for Danish average word length, to express the average length of production units to words. Carl and Kay's average production units would then be 3.52 words long for professionals, and 2.5 for trainees.

Carl *et al*. (2010) found that, on average, professionals working into Danish performed one self-revision for every 7.8 words, and translation trainees did so every 6.5 words: "deletions and corrections are possible in one PU [production unit] if they are within the vicinity of the current cursor position. A correction or insertion of text more than two AUs [words] away would result in a PU boundary." If Carl and Kay (2011) applied the same strategy, then corrections define the borders of production units every 2.2 to 2.6 production units. Small wonder that they report that only approximately 50% of their production units meet their own criteria of intelligibility to be considered a translation unit, while more than 40% either end or begin in the middle of a word. In brief, "the complex and recursive nature of the writing process means that undifferentiated measures of global properties of keystroke logs are likely to be extremely insensitive measures of underlying writing processes" (Baaijen *et al*. 2012: 247).

Again, how translation-process units are chunked might not be a clear-cut affair, resulting in considerable error. Martínez *et al*. (2014) and Lu *et al*. (2020) fragmented the translation-process data flow into *activity units*—segments of translation activity recordings—lasting at least one second (a

heuristic minimal threshold). Table 2 displays the types of activity units they considered. Basic activities (or lack thereof) are on the left-hand side. Mixed activity types are on the right. In order to devise activity units, these authors used (a) fixation locations in ST and TT reading; (b) whether the keystrokes in TT typing were insertions or deletions; (c) their combinations, plus (d) an empty category for the stretches where no activity was recorded.

1. Source text reading	
2. Target text reading	3. Source text and target text reading (1+2)
4. Typing (no source or target text reading)	5. Typing and source text reading (1+4)
	6. Typing and target text reading (2+4)
	7. Typing, source text, and target text reading (1+2+4)
8. No activity recorded	

Table 2. Activity unit types in Martínez *et al*. (2014) and Lu *et al*. (2020)

Martínez *et al*. (2014) found that sequences of activity units such as [*typing & ST reading*]+[*typing & TT reading*]+[*pause*] are helpful to discriminate translation experts from non-experts. However, Lu *et al*. argue that

> [...] activity units only represent certain parts of the translation process. The translation process may include more activities [...], such as dictionary referring and online searching. Additionally, a growing volume of translation involves computer aided tools (CATs), which are not considered in the current framework of activity units. In this sense, activity units represent a translation process during which a translator first reads a source text and then translates, without using or referring to any external tools or materials (2020: 81).

In brief, theirs is not a full depiction of translators' behaviour at the keyboard in the translation process. Again, the status and calculation of deletions and other changes in the texts is not clear. Martínez *et al*. (2014) considered whether informants (a) modified word cluster identity in the STs or TTs; (b) introduced many or fewer deletions and insertions in the text span between the last ten and next ten keylogged events from the point being considered, and in the prior five seconds; and (c) whether they introduced modifications on a completed text segment. Deletions were operationalised as number of keystrokes, although one typo often results in informants deleting as many as three words using the backspace—character by character, each one counting perhaps as a separate deletion. Some other times they will highlight several words and simply start overtyping their new version, so that no deletion gets registered (or just one, depending on the keylogger). In fact, Lu *et al*. (2020: 88) express concern for the errors in their data and declare that their approach "allows for broader qualitative and exploratory research."

We have seen that simplifications in constructs and their operationalisations may lead to typing speed distortions above 20%; to missing 30% of the behaviour in terms of time; and also to render more than 40% of the postulated process units unfit due to the way deletions and interruptions are handled. A different source of distortions is the fine line that divides recorded data from its interpretation. For instance, in CTIS, correcting typos is often ignored or associated with problem solving, while in writing process research they are conventionally excluded as indicators of revision but classified as *corrections* of errors *within* a word (Baaijen *et al*. 2012: 257).

4. Translating is a type of constrained text production

Translators' mental processes cannot be reduced to translating text stretch after text stretch. Translators read, write, revise, seek information, interact with the computer in many ways, etc. Solving problems is one of them, but clearly not the only one. Focusing only on problem-solving is an extremely reductionist approach to the translation process. We need to devise new frameworks to empirically study translating and other multilectal mediated communication tasks. We cannot offer here a full account of an alternative model, but we will instead present the conceptual underpinnings of the Task Segment Framework (TSF), an analytical procedure to study translation typing flows by chunking them into task segments that may also be used to investigate problem-solving. The TSF is not focused on the words, the problems, or the texts, but on the (sub-)tasks. A full description of the way the TSF is applied for analysis can be found in Muñoz and Apfelthaler (2022).

In cognitive translatology, from which the TSF draws, translation is conceived of as a type of constrained production of texts led by creative imitation (see below). Translation performance is driven by interacting top-down and bottom-up processes. Computationalist models of translation, such as the monitor model (Tirkkonen-Condit 2005), envisage translation processes as only or mainly bottom-up, i.e., data-driven processes based on processing real-time sensory information (Gibson 1966) that exclude the use of predictive processes that build on previous knowledge and experiences (Gregory 1974).

Translation routines (i.e., *default* translations; Halverson 2019), their entrenchment and their application are all hints at top-down processes. Traditional conceptions of translation problems as objective, located in the ST, and present for all translators exclude such processes, as they do not take into consideration the translators' experience and prior knowledge. Priming, in this sense, is not to be considered top-down processing, but just shortcuts in mental lexicon searches. As with think-aloud protocols and problem solving, the notion of priming might have been stretched in CTIS, in that the range of phenomena considered priming in CTIS may not always fit the narrower, original psycholinguistic understanding of this construct. Top-down processes, however, allow building a dynamic context (De Mey 1982), i.e., a web of relevant information and processes which is activated

to interpret signals and predict what is next. Dynamic contexts allow for sparing and distributing mental resources by adapting to specific situations and adjusting expectations (Hohwy 2013).

Juggling between the different tasks that build the translation process is not automatic. Translators need to understand, be aware of and constantly monitor their own thought processes and steer them towards a vague goal until task completion by constantly adapting the activated information in their minds and managing and juggling their mental resources to yield the best performance possible. Hence, metacognition (Shreve 2009) is a central element that makes translators active agents of their processes.

If equating translation to problem solving does not work, then what is it that we do when we translate? It is, we argue, a type of constrained production of texts. Such approach is not novel. *Constrained translation* was first introduced in TIS by Titford (1982), who defined subtitling as constrained by (1) the interplay between the action on the screen and (the amount of) written information, (2) the coherence and cohesion of subtitled texts, and (3) the relationship between the visual and the linguistic material in terms of equivalence. Mayoral Asensio *et al*. (1988) expanded the concept and identified two circumstances constraining translations: (a) the co-existence of various (non-linguistic) systems in addition to the linguistic one, and (b) the change from visual to aural channels in multimodal translation. They identified communication acts other than subtitling where such constraints played a role in translation (advertisement, comics, songs, and dubbing) and compared them to prose, where constraints were assumed not to exist.

The notion of constrained processes quickly took root in audiovisual translation (see, e.g., Díaz Cintas 2004; Chaume Varela 2019). Most interestingly, the idea that written-to-written translation was free of constraints was soon challenged. Indeed, many textual and non-textual factors constrain (all kinds of) translation: images, in technical translation (Ketola 2018); register and text genre characteristics, in scientific translation (Krein-Kühle 2011); differences in legal systems, in legal translation (Cao 2007); ideology, in literary translation (Megrab 1999); translation memory segmentation, in localisation (de la Cova 2016). In a nutshell, every translation act is constrained by sociocultural, technological and cognitive factors (de Sutter and Lefer 2020). Now, the difference between translation and text production (i.e., writing) may be argued to lie in the translation being constrained while the latter is unconstrained. However, these two communication acts do not differ that much when it comes to constraints.

Many factors influence our writing (Wen and Coker 2020): skills, motivation, self-efficacy; technological, sociocognitive, contextual and demographic factors; and knowledge about topic, intended audience and genre characteristics. These factors act as constraints in text production. Let us

examine knowledge about genre characteristics. In a corpus-based analysis, Biber (1988) identified characteristic lexical and grammatical features of twenty-three genres. Lee (2001) observed that genre categories are derived by social consensus rather than by textual features, which makes such categories unstable trough time and permeable to change. We build knowledge about and models of the genres we live by (Tardy 2009) and tend to produce texts imitating them (Devitt and Reiff 2014).

New multimodal communication tools are shaping (mainly digital) writing practices. Combining image, sound, video, and drawn and written text is now a common practice in social media and instant messaging platforms (Mills and Unsworth 2017). Such tools are also fostering new purposes of writing (see Hicks and Perrin 2014 for a comparison between focused writing vs writing-by-the-way) and new ways of collaborating both in professional and non-professional communication (as in Wikipedia). In the former, Leijten *et al*. argue that writing processes are characterised by:

> [...] dynamic interactions among evolving texts and graphics, previously produced documents, and a plethora of additional digital sources (both internal and external to the organization). These interactions involve constructing and reconstructing one's own and other's texts-refashioning and reusing content from multiple sources (2014: 286).

This document reuse and adaptation is found both in professional and in everyday writing (Leijten *et al*. (2014: 287). We may reuse and adapt an email we sent, or rephrase a text for a new audience or format. This is an extended form of intertextuality, which cues, scaffolds and constraints our behaviour when we receive and produce texts. Text production and translation do not differ much, after all, when it comes to constraints (further similarities in Dam-Jensen and Heine 2013 and Dam-Jensen *et al*. 2019).

One constraint is crucial to differentiate translation from free text production: the existence of an ST to which a relationship of identity is assumed. To the best of our knowledge, translation in general was first conceived as constrained text production by Shreve, who employed *restrained* instead of *constrained:*

> Instead it [translation] is restrained, 'pulled back' if you will, under the continuing influence of the source text, most often by the compulsion of the translator to produce sequence by sequence matches of the corresponding translation units of the source and target text. This occurs because the conventions of normal (verbatim) translation call for the propositions expressed in the source to have clearly discernible analogs at every semantic level in the target text. Even the freer, more communicative forms of translation adhere to some notion of semantic sequence correspondence between the propositions of the source and the target (2006a: 99).

In relation to creativity, Dam-Jensen and Heine (2013) observed that the indirect relation to existing texts in writing implies more freedom for the text producer to be more creative, whereas creativity in translation is

portrayed as restricted by the ST. Risku *et al*. also observed that the degree of creativity is larger in copywriting than in translation, even if both tasks are considered "*restricted* text production" (2016: 64).

Following the observations by other scholars in cognitive translatology (i.e., Shreve and Risku), translating seems to amount to the constrained production of texts led by creative imitation (Muñoz 2010: 176–177), in which the overarching constraint is the existence of one or several STs to which an intertextual relationship of identity is assumed. Now, the nature of the identity is controversial, for translation has frequently been considered "a more constrained mode of transfer associated with equivalence or invariance requirements" (Göpferich 2010: 374), whereas adaptations tend to be seen as a looser relationship between the source and the target text (Muñoz and González 2021). We cannot offer an in-depth discussion of this issue because of limitations of space (but see, e.g., Nord 1988 for an opposition between documentary and instrumental translation and the various translation forms in each type). In line with Halverson's (2019) definition of *default translation,* however, we do not establish aprioristic assumptions regarding the relationship between the source and the target text, except for the fact that the TT is offered in good faith as a translation of the ST.

We have argued that both writing and translating are kinds of constrained text production. We have also identified the main difference in terms of constraints between the two tasks. Constraints affect the whole task, not only the problem solving bits. In writing studies, Sala-Bubaré *et al*. (2021) argue that investigating the whole process is the only way to investigate *writing regulation*, i.e., "a highly recursive and dynamic socially situated activity that takes places [sic] at all textual levels and throughout the writing process […] [and] is composed of explicit decision-making processes, but also implicit adjustments" (2012: 2). The same principles apply in CTIS: if translation problems are not in STs but in the mind of their translators, only tapping the whole process may give us both a hint of the problems that the translators may face and a glimpse into the rest of mental operations and processes that belong to the task.

5. Concluding remarks

In this paper, we have argued that the traditional way of conceiving translation as a problem-solving endeavour is highly problematic from a conceptual viewpoint. Translation problems are ill-defined, while in translation research they have been treated as well-defined. They have been regarded as objective, rather than individual and arising from an interplay between the characteristics of the person and the task she carries out. Translation problems have been equated to ST segments (mixing problems with potential problem triggers) when they arise in and do not leave the minds of their solvers. Most importantly, traditional approaches have disregarded data from presumed non-problematic text stretches.

The methodological operationalisations to investigate problem solving are also questionable, both when ST segments are selected as translation problems (i.e., *rich points*) and when using pauses as indicators of problem-solving activity. In the latter case, pauses (and arbitrary thresholds to identify them) do not necessarily indicate problem-solving stances, nor do longer pauses indicate bigger problems. The alternating progression of pauses and actions may be a strategical way to chunk the task into mentally manageable bits. Exclusively selecting chunks that hint at problem-solving for investigation is difficult to justify, since translation goes on in every single chunk. The limitations of the tools used to capture pauses and the way some process phenomena have been treated also detract from the reliability of some past results.

CTIS needs to update its research agenda and start studying whole translation processes instead of solely focusing on problem solving. We have offered a sketch of an alternative approach that may provide a new way to do so, and there are others (e.g., O'Brien 2012 and Risku *et al*. 2013). The overarching and defining constraint is the (sometimes just assumed) existence of one or several STs to which an intertextual relationship of identity is presumed. Such constraint underscores the importance of tracking the whole translation process, as it covers the whole process, whereas a notion of translating as problem solving does not comprise the whole process. One of the possible ways to capture, analyse and interpret the whole process based on pauses is the Task Segment Framework (TSF; Muñoz and Apfelthaler 2022).

The TSF is an analytical procedure to study translation processes by chunking typing flows with subject-dependent thresholds of inter-keystroke intervals. This segmentation allows for identifying many aspects of the process, such as subtasks and subtask switching, fluency, default translations, and translation problems. This procedure, includes several advantages over the discussed operationalisations of translation as problem solving. First, in the TSF, no ST segments are pre-selected as translation problems. Instead, translation problems are identified using behaviouristic indicators that may hint at the existence of a translation problem for a given translator. For instance, if for the translation of an ST segment we observe long pauses, frequent deletions, and multiple tasks (for instance, reading > seeking for information > adding text > revising text > modifying text, etc.) we can infer that participants are dealing with a segment that they may identify as problematic.

Second, in the TSF the whole text is captured and analyzed. This means that, instead of focusing on one of the many tasks of the translation process (i.e., problem-solving), all tasks and their combinations are considered. The third advantage is related to the procedure used for chunking the typing flow as keylogged. As discussed, many authors have used a subject-independent threshold to identify pauses in the typing process. However,

typing speed and flow vary from one translator to the next and may be affected by multiple factors, such as linguistic, ergonomic, or psychological. Subject-dependent thresholds allow the TSF to adapt to the characteristics of each participant. This analytical procedure is adequate to measure, e.g., expertise traits in the multiple tasks that build up translating—again, including problem-solving.

This article should not be understood as a call to stop investigating problem solving. It is a call to rethink our approach to make room for whole translation processes in our work. Research on source-based writing, which comprises different kinds of constrained production of texts, may show further useful and methodologically sound ways to investigate them.

Acknowledgements

We would like to thank Álvaro Marín, Iris Schrijver, Sun Sanjun, Bogusława Whyatt, the MC2 Labbers, the editors and the two anonymous reviewers, for their patience when reading earlier drafts of this paper.

References

- **Angelone, Erik** (2010). "Uncertainty, uncertainty management and metacognitive problem solving in the translation task." Gregory M. Shreve and Erik Angelone (eds) (2010). *Translation and Cognition*. Amsterdam/Philadelphia: John Benjamins, 17–40.

- **Baaijen, Veerle *et al.*** (2012). "Keystroke analysis: Reflections on procedures and measures." *Written Communication* 29(3), 246–277.

- **Bargh, John A. and Melissa J. Ferguson** (2000). "Beyond behaviorism: On the automaticity of higher mental processes." *Psychological bulletin* 126(6), 925-945.

- **Bassok, Miriam and Laura R. Novick** (2012). "Problem solving." Keith K. Holyoak and Robert G. Morrison (eds) (2012). *The Oxford Handbook of Thinking and Reasoning*. Oxford: Oxford University Press, 413-432.

- **Bell, Roger T.** (1998). "Psycholinguistic/cognitive approaches." Mona Baker (ed.) (1998). *Routledge Encyclopedia of Translation Studies*. London: Routledge, 185-190.

- **Biber, Douglas** (1988). *Variation across Speech and Writing*. Cambridge: Cambridge University Press.

- **Cao, Deborah** (2007). "Inter-lingual uncertainty in bilingual and multilingual law." *Journal of Pragmatics* 39(1), 69–83.

- **Carl, Michael and Barbara Dragsted** (2012). "Inside the monitor model: Processes of default and challenged translation production." *TC3, Translation: Computation, Corpora, Cognition* 2(1), 127-145.

- **Carl, Michael and Martin Kay** (2011). "Gazing and typing activities during translation: A comparative study of translation units of professional and student translators." *Meta* 56(4), 952-975.

- **Carlson, Richard A.** (2012). "The higher mental processes in *The American Journal of Psychology*." *The American Journal of Psychology* 125(1), 25-38.

- **Chaume Varela, Frederic** (2019) "Audiovisual translation." Roberto A. Valdeón and M. Carmen África Vidal Claramonte (eds) (2019). *The Routledge Handbook of Spanish Translation Studies*. London: Routledge, 311-347.

- **Corbin, Ruth M.** (1980). "Decisions that might not get made." Thomas E. Wallsten (ed.) (1980). *Cognitive Processes in Choice and Decision Behavior.* Hillsdale: Lawrence Erlbaum, 47-67.

- **Dam-Jensen, Helle and Carmen Heine** (2013). "Writing and translation process research: Bridging the gap." *Journal of Writing Research* 5(1), 89-101.

- **Dam-Jensen *et al.*** (2019). "The nature of text production – Similarities and differences between writing and translation." *Across Languages and Cultures* 20(2),155-172.

- **de la Cova, Elena** (2016). "Translation challenges in the localization of web applications." *Sendebar* 27, 235-266.

- **De Mey, Walter** (1982). *The Cognitive Paradigm*. Chicago: University of Chicago Press.

- **de Sutter, Gert and Marie-Aude Lefer** (2020). "On the need for a new research agenda for corpus-based translation studies: A multi-methodological, multifactorial and interdisciplinary approach." *Perspectives* 28(1), 1-23.

- **Devitt, Amy and Mary Jo Reiff** (2014). "Reproducing genres: Pattern-related writing." Eva-Maria Jakobs and Daniel Perrin (eds) (2014). *Handbook of Writing and Text Production*. Berlin: De Gruyer Mouton, 263-284.

- **Díaz Cintas, Jorge** (2004). "Subtitling: The long journey to academic acknowledgement." *The Journal of Specialised Translation* 1, 50-70.

- **Dörner, Dietrich** (1987). *Problemlösen als Informationsverarbeitung*. 3rd ed. Stuttgart: Kohlhammer.

- **Dragsted, Barbara** (2005). "Segmentation in translation: Differences across levels of expertise and difficulty." *Target* 17(1), 49-70.

- **Dragsted, Barbara** (2012). "Indicators of difficulty in translation. Correlating product and process data." *Across Languages and Cultures* 13(1), 81-98.

- **Dragsted, Barbara and Inge Gorm Hansen** (2008). "Comprehension and production in translation: A pilot study on segmentation and the coordination of reading and writing processes." Susanne Göpferich *et al.* (eds) (2008). *Looking at Eyes: Eye-tracking Studies of Reading and Translation Processing*. Copenhagen: Samfundslitteratur, 9-29.

- **Englund Dimitrova, Birgitta** (2005). *Expertise and Explicitation in the Translation Process*. Amsterdam: John Benjamins.

- **Ericsson, K. Anders and Herbert A. Simon** (1984). *Protocol Analysis: Verbal Reports as Data*. Cambridge: MIT Press.

- **Ericsson, K. Anders and James J. Staszewski** (1989). "Skilled memory and expertise: Mechanisms of exceptional performance." David Klahr and Kenneth Kotovsky (eds) (1989). *Complex Information Processing: The Impact of Herbert A. Simon*. Hillsdale: Lawrence Erlbaum, 235-267.

- **Evans, Jonathan St. B. T. and Keith E. Stanovich** (2013). "Dual-process theories of higher cognition: Advancing the debate." *Perspectives on Psychological Science* 8(3), 223-241.

- **Gaddis Rose, Marilyn** (1979). "Translation as problem-solving." *Translation Review* 3(1), 20-21.

- **Gawronski, Bertram and Laura A. Creighton** (2013). "Dual process theories." Donal E. Carlston (ed.) (2013). *The Oxford Handbook of Social Cognition*. Oxford: Oxford University Press, 282-312.

- **Gibson, James J.** (1966). *The Senses Considered as Perceptual Systems*. Boston: Houghton Mifflin.

- **Gonzalez, Cleotilde** (2014). "Decision-Making: A Cognitive Science Perspective." Susan E. F. Chipman (ed.) (2014). *The Oxford Handbook of Cognitive Science*. Oxford: Oxford University Press. DOI: 10.1093/oxfordhb/9780199842193.013.6.

- **Göpferich, Susanne** (2010). "Transfer and transfer studies." Yves Gambier and Luc van Doorslaer (eds) (2010). *Handbook of Translation Studies.* Vol. 1. Amsterdam: John Benjamins, 374-377.

- **Gough, Joanna** (2016). *The Patterns of Interaction between Professional Translators and Online Resources*. PhD thesis. University of Surrey.

- **Gregory, Richard L.** (1974). *Concepts and Mechanisms of Perception*. London: Duckworth.

- **Halverson, Sandra L.** (2019). "'Default' translation. A construct for cognitive translation and interpreting studies." *Translation, Cognition & Behavior* 2(2), 187-210.

- **Halverson, Sandra L. and Ricardo Muñoz Martín** (2020). "The times, they are a'changin'. Multilingual mediated communication and cognition." Ricardo Muñoz Martín and Sandra L. Halverson (eds) (2020). *Multilingual Mediated Communication and Cognition*. London: Routledge, 1-17.

- **Hansson, Mathias *et al.*** (2022). "The effect of repertoire, routinization and enacted complexity: Explaining task performance through patterns of action." *Organization Studies*, February 2022. DOI: doi:10.1177/01708406211069438.

- **Hayes, John R.** (1981). *The Complete Problem Solver*. Philadelphia: The Franklin Institute.

- **Hicks, Troy and Daniel Perrin** (2014). "Beyond single modes and media: Writing as an ongoing multimodal text production." Eva-Maria Jakobs and Daniel Perrin (eds) (2014). *Handbook of Writing and Text Production*. Berlin: De Gruyer Mouton, 231-253.

- **Hohwy, Jakob.** 2013. *The Predictive Mind*. Oxford: Oxford University Press.

- **Holyoak, Keith J. and Robert G. Morrison** (2005). "Thinking and reasoning: A reader's guide." Keith J. Holyoak and Robert G. Morrison (eds) (2005). *The Cambridge Handbook of Thinking and Reasoning*. New York: Oxford University Press, 1-9.

- **Hönig, Hans G.** (1988). "Wissen Übersetzer eigentlich, was sie tun?" *Lebende Sprachen* 33(1), 10-14.

- **Jääskeläinen, Riitta** (2010). "Think-aloud protocol." Yves Gambier and Luc van Doorslaer (eds) (2010). *Handbook of Translation Studies.* Vol. 1. Amsterdam: John Benjamins, 371-373.

- **Jääskeläinen, Riitta and Sonja Tirkkonen-Condit** (1991). "Automatised processes in professional vs. non-professional translation: A think-aloud protocol study." Sonja Tirkkonen-Condit (ed.) (1991). *Empirical research in Translation and Intercultural Studies*. Tübingen: Gunter Narr, 89-109.

- **Jakobsen, Arnt L.** (2002). "Translation drafting by professional translators and by translation students." Gyde Hansen (ed.) (2002). *Empirical Translation Studies*. Copenhagen: Samfundslitteratur, 191-204.

- **Jakobsen, Arnt L.** (2003). "Effects of think aloud on translation speed, revision and segmentation." Fabio Alves (ed.) (2003). *Triangulating Translation: Perspectives in Process Oriented Research*. Amsterdam: John Benjamins, 69-95.

- **Jakobsen, Arnt L.** (2019). "Segmentation in translation: A look at expert behaviour." Defeng Li, Victoria L. C. Lei and Yuanjian He (eds) (2019). *Researching Cognitive Processes of Translation*. Singapore: Springer, 71-108.

- **Johnson, Donald M.** (1972). *A Systematic Introduction to the Psychology of Thinking.* New York: Harper & Row.

- **Jonassen, David H.** (2007). "What makes scientific problems difficult?" David H. Jonassen (ed.) (2007). *Learning to Solve Complex, Scientific Problems*. Mahwah: Lawrence Erlbaum, 3-23.

- **Jonassen, David H.** (2012). "Problem typology." Norbert M. Seel (ed.) (2012). *Encyclopedia of the Sciences of Learning*. Boston, MA: Springer, 2683-2686.

- **Jonassen, David H. and Woei Hung** (2008). "All problems are not equal. Implications for problem-based learning." *Interdisciplinary Journal of Problem-Based Learning* 2(2), 6-28.

- **Kahneman, Daniel** (2003). "A perspective on judgment and choice: Mapping bounded rationality." *American Psychologist* 58(9), 697-720. DOI: 10.1037/0003-066X.58.9.697.

- **Karmiloff-Smith, Anette** (1986). "From metaprocesses to conscious access: Evidence from children's metalinguistic and repair data." *Cognition* 23(2), 95-147.

- **Ketola, Anne** (2018). "Word–Image Interaction in Technical Translation: Students Translating an Illustrated Text." *Acata universitatis Tamperensis* 2364. Tampere: Tampere University Press.

- **Kohlmayer, Reiner** (2004). "Einfühlungsvermögen: Von den menschlichen Grundlagen des Literaturübersetzens." Reiner Kohlmayer and Wolfgang Pöckl (eds) (2004). *Literarisches und mediales Übersetzen: Aufsätze zu Theorie und Praxis einer gelehrten Kunst*. Frankfurt: Peter Lang, 11-30.

- **Krantz, David H., and Howard C. Kunreuther** (2007). "Goals and plans in decision making." *Judgment and Decision Making* 2(3), 137-168.

- **Krein-Kühle, Monika** (2011). "Register shifts in scientific and technical translation." *The Translator* 17(2), 391-413.

- **Krings, Hans P.** (1986). "Translation problems and translation strategies of advanced German learners of French (L2)." Juliane House and Shoshana Blum-Kulka (eds) (1986). *Interlingual and Intercultural Communication*. Tübingen: Gunter Narr, 263-276.

- **Kruger, Haidee** (2016). "What's happening when nothing's happening? Combining eyetracking and keylogging to explore cognitive processing during pauses in translation production." *Across Languages and Cultures* 17(1), 25-52.

- **Kumpulainen, Minna** (2015). "On the operationalisation of 'pauses' in translation process research." *Translation & Interpreting* 7(1), 47-58.

- **Lacruz, Isabel and Gregory M. Shreve** (2014). "Pauses and cognitive effort in post-editing." Sharon O'Brien *et al*. (eds) (2014). *Post-Editing of Machine Translation: Processes and Applications*. Newcastle upon Tyne: Cambridge Scholars Publishing, 246-272.

- **Lee, David Y. W** (2001). "Genres, registers, text types, domains and styles: Clarifying the concepts and navigating a path through the BNC jungle." *Language Learning & Technology* 5(3), 37-72.

- **Leijten, Mariëlle and Luuk Van Waes** (2013). "Keystroke logging in writing research: Using Inputlog to analyze and visualize writing processes." *Written Communication* 30(3), 358-392. DOI: 10.1177/0741088313491692.

- **Leijten, Mariëlle *et al.*** (2014). "Writing in the workplace: Constructing documents using multiple digital sources." *Journal of Writing Research* 5(3), 285-337.

- **Leppihalme, Ritva** (1997). *Culture Bumps: An Empirical Approach to the Translation of Allusions*. Clevedon: Multilingual Matters.

- **Logan, Gordon D.** (1982). "On the ability to inhibit complex movements: A stop-signal study of typewriting." *Journal of Experimental Psychology: Human Perception and Performance* 8(6), 778-792.

- **Lörscher, Wolfgang** (2005). "The translation process: Methods and problems of its investigation." *Meta* 50(2), 597-608.

- **Lu, Sheng *et al.*** (2020). "Predicting translation behaviors by using Hidden Markov Model." *Translation, Cognition & Behavior* 3(1), 76-99.

- **Martínez Gómez *et al.*** (2014). "Recognition of translator expertise using sequences of fixations and keystrokes." Pernilla Qvafordt and Dan W. Hansen (eds) (2014). *ETRA '14: Proceedings of the Symposium on Eye Tracking Research and Applications*. New York: Association for Computing Machinery, 299-302.

- **Mayer, Richard E.** (2013). "Problem solving." Daniel Reisberg (ed.) (2013). *The Oxford Handbook of Cognitive Psychology*. Oxford: Oxford University Press. DOI: 10.1093/oxfordhb/9780195376746.013.0048.

- **Mayoral Asensio, Roberto *et al.*** (1988). "Concept of constrained translation. Non-linguistic perspectives of translation." *Meta* 33(3), 356-367.

- **Megrab, R. A.** (1999). "Ideological shifts in cross-cultural translation." Jean Boase-Beier and Michael Holman (eds) (1999). *The Practices of Literary Translation. Constraints and Creativity*. Manchester: St. Jerome, 59-70.

- **Muñoz Martín, Ricardo** (2010). "On paradigms and Cognitive Translatology." Gregory M. Shreve and Erik Angelone (eds) (2010). *Translation and Cognition.* Philadelphia: John Benjamins, 169-187.

- **Muñoz Martín, Ricardo** (2013). "Cognitive and psycholinguistic approaches." Carmen Millán and Francesca Bartrina (eds) (2013). *The Routledge Handbook of Translation Studies*. New York: Routledge, 241-256.

- **Muñoz Martín, Ricardo** (2016a). "Of minds and men—computers and translators." *Poznań Studies in Contemporary Linguistics* 52(2), 351-381.

- **Muñoz Martín, Ricardo** (2016b). "Processes of what models? On the cognitive indivisibility of translation acts and events." *Translation Spaces* 5(1), 145-161.

- **Muñoz Martín *et al.*** (2021). "Cognitive Translatology: A primer, revisited." *语言、翻译与认知 (Studies in Language, Translation & Cognition)* 1(1), 131-165.

- **Muñoz Martín, Ricardo and José María Cardona Guerra** (2019). "Translating in fits and starts: Pause thresholds and roles in the research of translation processes." *Perspectives* 27(4), 525-551.

- **Muñoz Martín, Ricardo and Matthias Apfelthaler** (2022). "A Task Segment Framework to study keylogged translation processes." *Translation & Interpreting* 14(2).

- **Newell, Allen and Herbert A. Simon** (1972). *Human Problem Solving*. New Jersey: Prentice-Hall.

- **Nitzke, Jean** (2019). *Problem Solving Activities in Post-Editing and Translation from Scratch: A Multi-Method Study*. Berlin: Language Science Press.

- **Nord, Christiane** (1987). "Übersetzungsprobleme—Übersetzungsschwierigkeiten. Was in den Köpfen von Übersetzern vorgehen sollte." *Mitteilungsblatt für Dolmetscher und Übersetzer* 2, 5-8.

- **Nord, Christiane** (1988). *Textanalyse und Übersetzen*. Heidelberg: J. Gross Verlag.

- **Nord, Christiane** (1994). "It's tea-time in Wonderland. Culture-markers in fictional texts." Heiner Pürschel (ed.) (1994). *Intercultural Communication*. Duisburg: Peter Lang, 523–538.

- **O'Brien, Sharon** (2006). "Pauses as indicators of cognitive effort in post-editing machine translation output." *Across Languages and Cultures* 7(1), 1-21.

- **O'Brien, Sharon** (2012). "Translation as human–computer interaction." *Translation Spaces* 1, 101-122.

- **O'Brien, Sharon** (2013). "The borrowers: Researching the cognitive aspects of translation." *Target* 25(1), 5-17.

- **Olive, Thierry *et al.*** (2009). "Cognitive processes in writing during pause and execution periods." *European Journal of Cognitive Psychology* 21(5), 758-785.

- **PACTE** (2008). "First results of a translation competence experiment: 'Knowledge of translation' and 'efficacy of the translation process'." John Kearns (ed.) (2008). *Translator and Interpreter Training: Issues, Methods and Debates*. London: Continuum, 104–126.

- **PACTE** (2009). "Results of the validation of the PACTE translation competence model: Acceptability and decision making." *Across Languages and Cultures* 10(2), 207-230.

- **PACTE** (2011). "Results of the validation of the PACTE translation competence model: Translation problems and translation competence." Cecilia Alvstad *et al.* (eds) (2011). *Methods and Strategies of Process Research: Integrative Approaches in Translation Studies*. Amsterdam: John Benjamins, 317-343.

- **PACTE** (2020) "Translation competence acquisition. Design and results of the PACTE group's experimental research." *The Interpreter and Translator Trainer* 14(2), 95-233.

- **Paradowska, Urszula** (2015). "Expert web searching skills for translators – a multiple-case study." Paulina Pietrzak and Mikołaj Deckert (eds) (2015). *Constructing Translation Competence*. Frankfurt: Peter Lang, 227-244.

- **Pedersen, Jan** (2011). *Subtitling Norms for Television: An Exploration Focussing on Extralinguistic Cultural References*. Amsterdam: John Benjamins.

- **Premack, David and Guy Woodruff** (1978). "Does the chimpanzee have a theory of mind?" *Behavioral and Brain Sciences* 1(4), 515-526.

- **Pretz, Jean E. *et al.*** (2003). "Recognizing, defining, and representing problems." Janet E. Davidson and Robert J. Sternberg (eds) (2003). *The Psychology of Problem Solving*. New York: Cambridge University Press, 3-30.

- **Pym, Anthony** (2003). "Redefining translation competence in an electronic age: In defence of a minimalist approach." *Meta* 48(4), 481-497.

- **Risku, Hanna *et al.*** (2013). "A dynamic network model of translatorial cognition and action." *Translation Spaces* 2, 151-182.

- **Risku, Hanna *et al.*** (2016). "Writing vs. translating. Dimensions of text production in comparison." Ricardo Muñoz Martín (ed.) (2016). *Reembedding Translation Process Research*. Amsterdam: John Benjamins, 47-68.

- **Robertson, S. Ian** (2001). *Problem Solving*. Philadelphia: Psychology Press.

- **Sala-Bubaré, Anna *et al.*** (2021). "Writing processes as situated regulation processes: A context-based approach to doctoral writing." *Journal of Writing Research* 13(1), 1-30.

- **Schaeffer, Moritz and Michael Carl** (2013). "Shared representations and the translation process: A recursive model." *Translation and Interpreting Studies* 8(2), 169-190.

- **Schilperoord, Joost** (2001). "On the cognitive status of pauses in discourse production." Thierry Olive and C. Michael Levy (eds) (2001). *Contemporary Tools and Techniques for Studying Writing*. Amsterdam: Kluwer, 61-90.

- **Shih, Claire Y. Y.** (2015). "Problem-solving and decision-making in translation revision: Two case studies." *Across Languages and Cultures* 16(1), 69-92.

- **Shreve, Gregory M.** (2006a) "Integration of translation and summarization processes in summary translation." *Translation and Interpreting Studies* 1(1), 87-109.

- **Shreve, Gregory M.** (2006b). "The deliberate practice: Translation and expertise." *Journal of Translation Studies* 9(1), 27-42.

- **Shreve, Gregory M.** (2009). "Recipient-orientation and metacognition in the translation process." Rodica Dimitriu and Miriam Shlesinger (eds) (2009). *Translators and Their Readers. In Homage to Eugene A. Nida.* Brussels: Editions du Hazard. 255-270.

- **Siclari, Francesca *et al.*** (2017). "The neural correlates of dreaming." *Nature Neuroscience* 20(6), 872-878.

- **Sirén, Seija and Kai Hakkarainen** (2002). "Expertise in translation." *Across Languages and Cultures* 3(1), 71-82.

- **Tardy, Christine** (2009) *Building Genre Knowledge*. West Lafayette: Parlor Press.

- **Tirkkonen-Condit, Sonja** (1993). "Choice in translation: A challenge to theory and practice." Sonja Tirkkonen-Condit and John Laffling (eds) (1993). *Recent Trends in Empirical Translation Research*. Joensuu: Joensuun Yliopisto Monistuskeskus, 5-9.

- **Tirkkonen-Condit, Sonja** (2005). "The monitor model revisited: Evidence from process research." *Meta* 50(2), 405-414.

- **Titford, Christopher** (1982). "Sub-Titling. Constrained translation." *Lebende Sprachen* 3, 113-116.

- **Vale, Daniel Couto** (2017). "What does a translator do when not writing?" Silvia Hansen-Schirra *et al.* (eds) (2017). *Empirical Modelling of Translation and Interpreting*. Berlin: Language Science Press, 209-237.

- **VandenBos, Gary** (ed.) (2015). *APA Dictionary of Psychology*. 2nd ed. Washington, DC: APA.

- **Wang, Yingxu and Vincent Chiew** (2010). "On the cognitive process of human problem solving." *Cognitive Systems Research* 11(1), 81-92.

- **Wen, Huijing and David L. Coker** (2020). "The role of discourse knowledge in writing among first-graders." *Journal of Writing Research* 12(2), 453-484.

- **Williams, Lawrence E. *et al.*** (2009). "The Scaffolded Mind: Higher mental processes are grounded in early experience of the physical world." *European Journal of Social Psychology* 39(7), 1257-1267.

- **Wilss, Wolfram** (1996). *Knowledge and Skills in Translator Behavior*. Amsterdam: John Benjamins.

Websites

- **Carl, Michael *et al.*** (2010). "Long distance revisions in drafting and post-editing." *CICLing*, Iasi, Romania, 21-27 March 2010. https://research-api.cbs.dk/ws/portalfiles/portal/58951800/LonDistRevision.pdf (consulted 04.05.2022).

- **Hitchcock, David** (2020). "Critical Thinking." Edward N. Zalta (ed.) (2020). *The Stanford Encyclopedia of Philosophy* (Fall 2020 Edition). https://plato.stanford.edu/archives/fall2020/entries/critical-thinking/ (consulted 04.05.2022).

- **Mills, Kathy A. and Len Unsworth** (2017). "Multimodal literacy." Bob Lingard, Sam Sellar and Steven Lewis (eds) (2017). *Oxford Research Encyclopedia of Education*. Oxford: Oxford University Press. https://doi.org/10.1093/acrefore/9780190264093.013.232 (consulted 09.05.2022).

- **Norvig, Peter** (n.d.). "English letter frequency counts: Mayzner revisited or ETAOIN SRHLDCU." http://norvig.com/mayzner.html (consulted 04.05.2022).

Biographies

Ricardo Muñoz Martín works at the Department of Interpreting & Translation of the University of Bologna, Italy, where he directs the *Laboratory for Multilectal Mediated Communication & Cognition* (MC2 Lab). He is also a member of EST, AIETI, and the TREC and HAL networks and co-editor of the *Encyclopedia of Translation & Interpreting* and the journal *Translation, Cognition & Behavior*.

E-mail: ricardo.munoz@unibo.it
ORCID: 0000-0001-6049-9673

Christian Olalla-Soler works as a post-doc researcher at the Department of Interpreting and Translation of the University of Bologna, where he is a member of the Laboratory for Multilectal Mediated Communication & Cognition (MC2 Lab). His main research interests are translation and cognition, and bibliometrics. He is a member of the TREC network. He is also a member of EST and AIETI.

E-mail: christian.olalla@unibo.it
ORCID: 0000-0001-9251-476X

Notes

[1] We use *translation* here to refer to all *multilectal mediated communication* tasks (Halverson and Muñoz 2020: 2).
[2] Logan (1982: 791) asks: "Why do skilled typists have such close control over typing if skilled typing is automatic? [...]automatization need not involve abdication of control." See also Karmiloff-Smith (1986).
[3] Here *pause* means 'any blank time gap in the typing flow', as keylogged. For a different, technical definition of pause within the Task Segment Framework, see Muñoz and Apfelthaler (2022).