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Temporal Dynamics of Emotion and Cognition in Human Translation: Integrating the Task Segment Framework and the HOF Taxonomy

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Abstract: This article presents a framework for modeling the human mind during translation, based on empirical data. It argues that three interrelated layers of mental processing operate simultaneously which can be detected in behavioral data: routinized/automated sequences reflected in fluent translation behavior; cognitive/reflective processes indicated by extended keystroke pauses; and affective/emotional states, which manifest in distinctive typing and eye-tracking patterns. Drawing on data from the CRITT Translation Process Research Database (TPR-DB), the article demonstrates how the temporal dynamics of keystrokes and gaze behavior can be linked to these underlying mental strata. The proposed embedded generative model is situated within broader theoretical contexts, including dual-process theories and Robinson's (2023) ideosomatic theory of translation. In doing so, the article offers a novel empirical foundation for advancing theoretical developments in Cognitive Translation Studies.

Keywords: cognitive translation and interpretation studies; translation process research; pause analysis; cognitive modeling; ideosomatic theory of translation; hierarchical mental architecture

1 Introduction

This article introduces a novel generative framework for modelling the temporal dynamics of translation behavior. It posits that translation emerges from the interaction of three embedded layers of mental processing: (A) affective/emotional states, (B) behavioral, automated translation routines, and (C) cognitive, reflective

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thought. This ABC model of the translating mind suggests that these embedded processes can be inferred from observable behavioral data – primarily keystrokes and gaze patterns – captured through keylogging and eye-tracking technologies. Such data have long been foundational in Translation Process Research (TPR) and Cognitive Translation and Interpretation Studies (CTIS) for analyzing cognitive effort, translator expertise, as well as the behavioral impacts of text difficulty, translation quality, and others.

Among the methods used in TPR, pause analysis – the measurement of inter-keystroke intervals (IKIs) – has served as a proxy for translation effort (e.g., Carl, Schaeffer, and Bangalore 2016; Lacruz and Shreve 2014; Vieira 2017). However, defining and interpreting pause lengths remains contested (Couto-Vale 2017; Kumpulainen 2015). In this article, I propose a reinterpretation of pause analysis through the lens of the ABC model by integrating two conceptual tools: the Task Segment Framework (Muñoz and Apfelthaler 2022) and the HOF taxonomy (Carl et al. 2024).

The TSF, introduced by Muñoz and Apfelthaler (2022), distinguishes between *Tasks* – automated/routinized actions such as brief keystroke bursts – and *Task Segments* (TSs), which are longer, intentional production units composed of a sequence of one or more Tasks. These Task Segments are separated by Task Segment Pauses (TSPs), whose duration varies by translator and is thought to reflect moments of increased cognitive demand.¹

Complementing this, Carl et al. 2024 proposed the HOF taxonomy, which categorizes translation processes into three experiential states: *Hesitation* (linked to uncertainty and elevated cognitive effort), *Orientation* (characterized by attentional shifts and evaluative engagement), and *Flow* (a state of focused, effortless production often accompanied by positive affect). These affective states modulate different phases of attention and readiness for action, and are seen as responses to dynamic cognitive demands.

Both the TSF and the HOF taxonomy share a generative perspective: that internal translation processes – whether automated, reflective, or affective – leave discernible traces in behavioral data, such as IKIs structures and gaze trajectories. On this view, hidden mental states generate observable actions, and the structure of

¹ A TSP, together with the successive production (i.e., the Task Segment) amounts to what has sometimes been referred to as a Translation Unit (e.g., Malmkjaer 1998; Alves and Vale 2009; Carl and Kay 2011). Previous work, e.g., Carl and Kay (2011), Carl et al. (2016) introduced the term Production Unit (PU) which roughly corresponds to a TS. While I stick to “Task” and “TS” in this article, Carl et al. (in print) propose “Keystroke Bursts” (KBs) and “Production Units” (PUs) respectively. In the terminology of Muñoz and Apfelthaler (2022), “Tasks” subsume also Internet Search and other forms of Translator-Computer Interaction, but as we deal with logs of text production keystrokes only, we will uses “Keystroke Bursts” in future publications.

those actions reflects the underlying processes that gave rise to them. This reciprocal relationship resonates with Bayesian theories of cognition, including Predictive Processing (Seth 2021; Clark 2023) and Active Inference (Friston et al. 2023; Parr et al. 2022; Pezzulo et al. 2024), which conceptualize the human mind as operating on generative models that iteratively approximate and adapt to environmental conditions.

In light of these theoretical developments, Carl (2024) and Carl et al. (in print) propose simulating translation behavior via an artificial Active Inference agent organized into three interconnected ABC processing layers. The A-layer captures affective states and emotional responses; the B-layer reflects automated, routinized behavior; and the C-layer governs reflective and deliberate cognitive processes. Within this model, the TSF can be used to differentiate automated behavioral routines (B) from cognitive reflective behavior (C) based on pause structure, while the HOF taxonomy provides insight into the emotional states accompanying translation activity (A). Together, they support a multi-layered, embedded architecture in which translation processes unfold simultaneously across multiple cognitive-affective dimensions and timelines.

This article elaborates on that architecture by examining the relationships between Tasks, Task Segments, and HOF states using a large corpus of translation process data. Section 2 situates the proposed framework in relation to prior translation theories, highlighting its novel contribution. Section 3 outlines the TSF and HOF taxonomy and illustrates their segmentation logic using annotated progression graphs. Section 4 presents an empirical analysis of IKI distributions across 100 from-scratch translation sessions and explores the pausing patterns that define TSF segments. Section 5 offers conclusions in the light of Robinson's (2023) ideosomatic theory, underscoring the integrative value of this model for future research in translation cognition.

2 Models of the Translation Process

Over the past 60 years, numerous approaches have emerged to explain and model translation processes in both humans and machines (MT). Despite fundamental differences, there are notable overlaps between these two approaches. This section provides a very brief review and situates the current proposal within this historical context.

Rule-based MT (RBMT), dominant until the early 1990s, modeled translation as a sequence of linguistic analyses: analysis, transfer, and generation. In Cognitive Translation and Interpreting Studies (CTIS), this mirrors the comprehension-transfer-production model (Angelone 2010), involving problem recognition, solution proposal, and evaluation. RBMT emphasized source text (ST) disambiguation, assuming transfer and target language generation to be relatively straightforward (Hutchins and Somers 1992).

The emergence of statistical MT (SMT) in the 1990s marked a shift. SMT built probabilistic models capable of generating many potential translations and selecting the most likely one using advanced decoding techniques. A similar shift occurred in Translation Studies, moving from equivalence-based linguistic theories (e.g. Nida 1964; Catford 1965) to Functionalism and Skopos Theory, which emphasized target audience needs and communicative purpose (Nord 2006; Pym 2003).

From the mid-1980s, cognitive theories were increasingly used in translation studies, focusing on the *process* of translation. Gile's Effort Model (Gile 1985, 2009) highlight cognitive load and resource allocation in interpreting. Think-Aloud Protocols (TAPs) and later keystroke logging (Jakobsen 1999) offered empirical insights into mental operations, revisions, and hesitation patterns. Eye-tracking, introduced around 2005 in TPR, further revealed attention distribution and cognitive effort (Alves and Albir 2025).

Cognitive translation research has drawn from bilingualism and cognitive psychology. Theories like the Revised Hierarchical Model (Kroll and Stewart 1994) and the Bilingual Interactive Activation Model (Dijkstra and Van Heuven 2002) argue for non-selective language activation – bilinguals access all known languages simultaneously, a trait shared by multilingual large language models (LLMs), which also handle code-switching with ease.

Translation Process Research (TPR) has adopted dual-process theories, distinguishing between fast, intuitive (Type 1) and slow, deliberate (Type 2) processes (Kahneman 2011). Königs (1987), Hönig (1991), Lörscher (1991), Schaeffer and Carl (2013), Carl and Schaeffer (2017, 2019) and others made distinctions between automatized and strategic translation behaviors, under a variety of different nominations see (Alves and Albir 2025) for a recent overview.

The default-interventionist model of reasoning and decision-making (Evans and Stanovich 2013) posits that intuitive processing is the default procedure, while intervention only take place when difficulty or novelty demands attention. This idea is echoed across translation scholarship (e.g. Carl and Dragsted 2012; Dimitrova 2005; Tirkkonen-Condit 2005), and the Monitor Model (Schaeffer and Carl 2013), which assumes that automated routines are overseen by higher-level monitoring processes.

Robinson (2023), building on Peirce (1992), introduces the concept “emotional interpretant,” arguing that emotional awareness precedes conscious reasoning. Emotions influence cognitive load, attention, and decision-making (Hubscher-Davidson 2017), and shape how translators interpret and resolve ambiguity. Because emotional and cognitive states surface in observable behaviors – such as keystrokes or gaze – they may offer clues into translators' internal states. The next sections explore taxonomies to identify automated, reflective, and affective mental processes in translation process data.

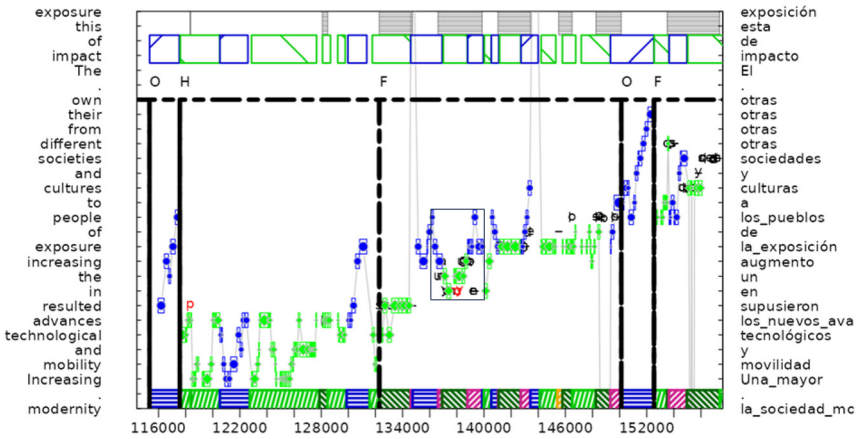


Figure 1: A progression graph of a small snippet of the translation session (BML12/P03 T5). The graph represents a segment of approximately 40 s (116,000–156,000 ms) of an English-to-Spanish translation. The vertical axis plots to the ST on the left side and the TT on the right side. ST and TT words are aligned on a word or phrase level. A single ST word that maps into TT phrase is marked as a multi-word unit on the right vertical axis, such as “Increasing → Una_mayor”. An ST multi-word phrase that is translated into a single word appear as TT repetitions, such as “different from their own → otras otras otras”. Blue dots and green diamonds indicate eye movements on the ST and TT respectively. The black and red characters are insertion and deletion respectively. Activity Units (AUs) fragment behavioral translation data into six categories, as marked in colored boxes at the bottom of the graph. The type (color) of the AU determines whether the translator is involved in reading the ST or TT, translation production, or simultaneously reading and writing (see Table 1). TSs are marked as gray boxes in the top of the graph. The rectangular box in the middle of the graph (around time 136,000–140,000) is reproduced in Figure 2 with a finer-grained segmentation of the TS into six (sub) Tasks.

3 Fragmenting Behavioral Translation Data

The temporal structure of translation has been central to Translation Process Research (TPR) since the 1980s (e.g., Königs 1987, see also Alves and Albir 2025). With the advent of keylogging tools like Translog (Jakobsen and Schou 1999) and InputLog (Leijten and Van Waes 2013), TPR has become increasingly technology-driven. With these technologies, it can be observed how translators alternate between rapid, automatic processing and more deliberate, reflective behavior. Interkey intervals (IKIs) can be measured to offer insights into the hidden cognitive states, and when combined with eye-tracking data (Carl 2012; Carl, Schaeffer, and Bangalore 2016; Hvelplund 2016), they reveal not only how translations are produced, but also what information translators take in.

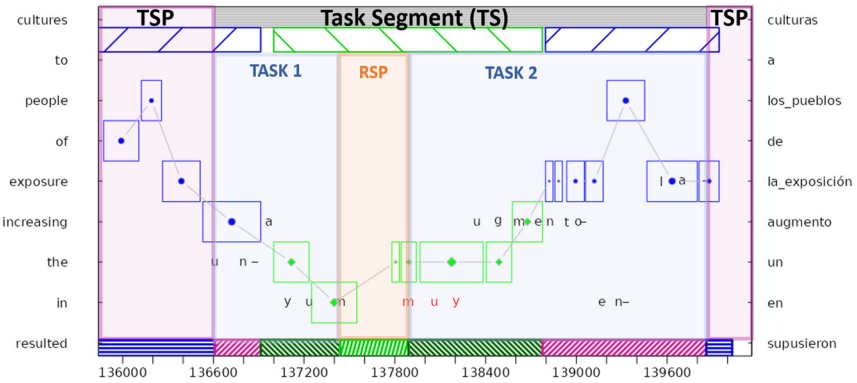


Figure 2: This Progression graph shows a segment of approximately 4 s (136,000–140,000) in which an English segment “in the increasing” is translated into Spanish “un aumento en la”. The duration of a TS is indicated as a grey bar at the top, which is preceded and followed by a TSP (violet boxes). The TS consists of two successive Tasks which are separated by an RSP. Each Task contains one or more insertion and/or deletion keystroke(s). In Task 1 the translator produces “un a yum”. The last three letters “yum” are presumably a typo, because these letters are successively deleted again in Task 2 (deletion “muy” is inverse order of “yum”). Task 2 then shows the correct continuation “ugmento” (to produce “aumento”) and the production of “en la”. As indicated by the “Fixation Units”, i.e., the blue and green striped boxes on the top, while the eyes of the translator fixate in the beginning and the end of this segment at several ST words (blue boxes are ST fixations), they move to the target window during the correction or the typo (green boxes are TT fixations). The Sequence of colored AUs at the bottom of the graph indicates the coordination of reading and writing behaviour (see Table 1). Note that Task 2 consists of two AUs of Type 6 and 5 which involve concurrent writing and reading of the TT and ST, respectively.

Table 1: Types of AUs and color code in Figures 1 and 2.

AU type	Reading/Writing activity	AU color in Figures 1 and 2
T1	ST reading	Blue
T2	TT reading	Light green
T4	TT production	Yellow (no occurrence in the graphs)
T5	ST reading with concurrent production	Red
T6	TT reading with concurrent production	Dark green
T8	No observed behavioral data for more than 1 s	Black (no occurrence in the graphs)

This section discusses segmentation methods of behavioral translation data that align with the three ABC layers of the translating mind. The HOF taxonomy, mainly based on gaze data, identifies affective states (A), while the TSF defines IKI thresholds to distinguish routinized processes (B) from reflective, cognitive processes (C).

3.1 The HOF Taxonomy

Carl et al. (2024) introduced the HOF taxonomy, identifying three emotional states during translation:

- Hesitation (H): Triggered by unexpected challenges, leading to pauses, re-reading, or revisions – indicating cognitive uncertainty or conflict.
- Orientation (O): Marked by prolonged ST reading, reflecting the translator's attempt to understand the text.
- Flow (F): Characterized by fluent, uninterrupted production, minimal reading, and short pauses, signifying full cognitive immersion.

Figure 1 shows a sequence of HOF states (OHFOF), each composed of one or more Activity Units (AUs). AUs are fine-grained segments of behavior (Hvelplund 2016; Schaeffer et al. 2016) characterizing eye-hand coordination. AUs are categorized by reading/writing behavior and visual ST/TT focus (see Table 1). For example, the Orientation state (O) may involve a single ST reading AU, while Hesitation (H) can involve multiple AUs alternating between reading and typing.

3.2 The Task Segment Framework (TSF)

Muñoz and Apfelthaler (2022) classify IKIs into:

- Delays (<200 ms): Indicate boundaries of motor programs – basic, automated sequences of keypresses.
- Respite (*RSP*): Unintentional pauses separating Tasks. Defined as $2 \times$ median within-word IKIs.
- Task Segment Pauses (*TSPs*): Intentional breaks between Task Segments (TS). Defined as $3 \times$ median between-word IKIs.
- Superpauses: Rare, prolonged breaks, corresponding to Orientation states in the HOF taxonomy.

Figure 2 zooms into a Flow state, showing a Task Segment (TS) with two Tasks separated by an *RSP*.

The next section explores properties of Tasks, TSs, and HOF states based on large-scale behavioral data.

4 An Empirical Investigation

This section presents an empirical analysis of the TSF and the HOF taxonomy based on a fragment of the CRITT TPR-DB (Carl, Schaeffer, and Bangalore 2016). It is

partially a summary of data discussed in (Carl 2024) and (Carl et al. in print), here presented within a different perspective.

4.1 The Empirical Data

The data is part of the CRITT TPR-DB,² which is available under a CC BY-NC-SA license and hosted on SourceForge with full documentation.³ The CRITT TPR-DB includes over 5,000 sessions and 600+ hours of text production from written translation, authoring, and spoken modes. Many sessions include both keystroke and gaze data.

The database processes raw logging information into 11 summary tables per session, with a total of 300+ features. This study focuses on the KD tables, detailing information about keystroke their timing, text alignment, and more. The data is part of the MultiLing sub-corpus – six short English source texts (totaling 847 words) in various genres, translated into several languages and under different modes (e.g., from-scratch, post-editing, sight translation).

This study uses only from-scratch translations of English to Arabic and English to Spanish, logged with Translog-II. Table 2 summarizes session stats, including number of keystrokes, session durations, and IKI metrics. Spanish translators were fastest (493 ms avg. IKI) while Arabic translators were slowest (844 ms). Arabic data was collected from 22 Arabic PhD students at Kent State University (Almazroei 2025); Spanish data came from native students, collected in 2012 (Mesa-Lao 2014), and has been widely used since.

Table 2: Properties of the empirical data used in this study. The study e.g., AR20 is the internal name in the CRITT TPR-DB, and has no further meaning in this article.

Study name	AR20	BML12
Target language	ar	Es
#Keystrokes	37,171	73,619
Total duration (h)	8.72	10.10
#Sessions	40	60
#Translators	22	32
Mean IKI. In ms (log ms)	844 (6.7)	493 (6.2)
Median IKI, in ms (log ms)	265 (5.6)	156 (5.0)

² See <https://sites.google.com/site/centretranslationinnovation/tpi-db/getting-started>.

³ A full description of the Features in the CRITT TPR-DB is provided on the CRITT website: <https://sites.google.com/site/centretranslationinnovation/tpi-db/features>.

4.2 Pauses and Segments

It is generally assumed that translators mentally chunk the ST into portions that they can keep in memory and translate as a coherent typing segments (Malmkjær 1998). This mental chunking is reflected in the structure of IKIs. As pointed out in Section 3.2, Muñoz and Apfelfthaler (2022) define two IKIs thresholds that are considered here. *RSPs* and *TSPs* depend on the median within-words IKI (*WP*) and the median between-word IKI (*BP*) of individual translators, respectively. The distinction between *WP* (within-words inter-keystroke pauses (IKIs)) and *BP* (between-words inter-keystroke pauses) is well-established in TPR. It has been shown that *WPs* are shorter than *BPs* (e.g. Kumpulainen 2015), indicating different cognitive/mental activities at the boundaries of different levels of linguistic production. These translator-specific IKI thresholds may thus help separating those distinct mental processes.

4.3 Within-word and Between-word IKIs

In the keystroke logging data, every recorded keystroke is associated with a time-stamp (Carl et al. 2016). In this study, we define a *word boundary* to occur with any of the following keystrokes:

Word-boundary keystrokes: ` “ _ . ! ? : = @ \$ % & * () [] { } ,

where blank spaces are mapped into an underscore ‘_’.

A keystroke is classified as *within-word* if it is not a word-boundary keystroke and it is neither preceded nor followed by a word-boundary keystroke. A *word-initial* keystroke is the first (non word-boundary) keystroke of a new word. Every IKI can then be classified according to whether it occurs within a word or whether it is word initial, and the pause before these keystrokes are *WPs* (within-word IKI) or *BPs* (before word IKI). A within-word IKI (*WP*) is preceded by a within-word keystroke, while the IKI preceding a word initial keystroke is defined to be the between-word IKI (*BP*).⁴

⁴ In a forthcoming study (Carl et al. in print) we follow an easier definition, defining a *WP* as the IKI between two successive alphanumerical keystrokes and a *BP* as the IKI between a non-alphanumerical and a successive alphanumerical keystroke. The two methods produce slightly different but highly correlated *RSPs* and *TSPs* values.

4.4 Respite and Task Segment Pauses

As translators have different typing skills and translation styles different *WPs* and *BPs* can be expected for every translator. Since the *IKI* distributions are heavily right skewed, Muñoz and Apfelthaler (2022) suggest computing a median value, rather than a mean, as a basis for translator-relative pausing values. Following Muñoz and Apfelthaler, we define RSP_i and TSP_i for each translator i separately:

$$RSP_i = 2 * \text{median} (WP_i)$$

$$TSP_i = 3 * \text{median} (BP_i)$$

Table 3 shows the summary information for *RSPs* and *TSPs* for the 32 Spanish and the 22 Arabic translators. As already discussed above, Table 3 shows that the various inter-keystroke pausing values for Arabic translators are much higher (almost twice) than those for Spanish.

The minimum *RSP* duration in our data is 220 ms in the Spanish data, just above the assumed value for a Delay (200 ms, see Section 3.2), while the maximum *RSP* duration is 1,032 ms (in the Arabic data). The minimum *TSP* duration is 423 ms and the maximum is 2,388 ms. Note that this maximum is still below the assumed third peak in the *IKI* distribution, which ought to be around 2,697 ms Muñoz and Apfelthaler (2022).

4.5 Relating *RSPs* and *TSPs*

Figure 3 shows the distribution of *RSPs* on the left and *TSPs* on the right for 32 Spanish and 22 Arabic translators, respectively. As is the case for all *IKIs*, also *RSPs* and *TSPs* show larger variability for Arabic, i.e., a flatter distribution, than Spanish. However, all *RSPs* are – for every translator – shorter than their *TSPs*.

Table 3: *RSP* and *TSP* values for Arabic and English data.

ar	Min	Max	Mean	Median
<i>RSP</i>	312	1,032	563	546
<i>TSP</i>	795	2,388	1,288	1,077
es				
<i>RSP</i>	220	470	301	281
<i>TSP</i>	423	1,686	697	609

Figure 4 shows that *RSPs* tend to correlate with *TSPs*. This correlation is significant for Spanish (Spearman τ :0.68, $p < 0.0001$), while it is not significant for Arabic (Spearman τ :0.40 p :0.065).

Interestingly, as plotted in Figure 5, there is a strong correlation between the number of Tasks (as delimited by *RSPs*) within a TS and the number of keystrokes produced in that TS (τ :0.74 and τ :0.73, p :0.000 for Arabic and Spanish respectively). While, on average, Arabic and Spanish translators engage in the same number of 2.2 Tasks per TS, Arabic translators show a larger variation (between min:1.2 and max:3.9, median:2.1) than Spanish translators (between min:2.1 and max:3.4, median 1.94).

Spanish translators also produce more keystrokes per TS than Arabic translators do. A Spanish TS contains between 8 and 18 keystrokes (mean 11.2) while an Arabic TS has between 5 and 16 keystrokes (mean 9.4). A Spanish Task has between 3.9 and 7.4 keystrokes (mean 5.3) while an Arabic Task has between 2.7 and 6.0 keystrokes (mean 4.3).

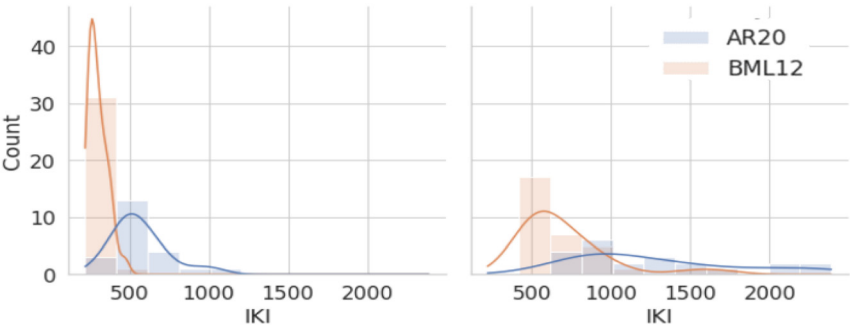


Figure 3: Distribution of *RSPs* (left) and *TSPs* (right) for Spanish and Arabic translators.

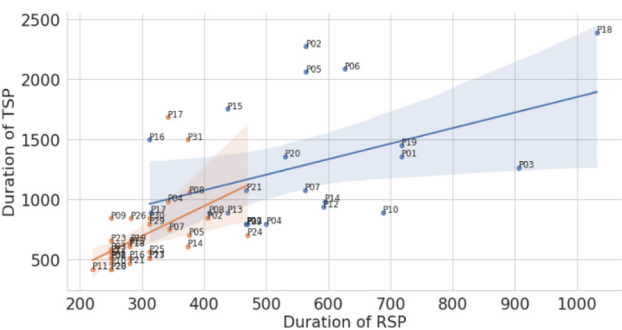


Figure 4: Correlation of *RSPs* and *TSPs*.

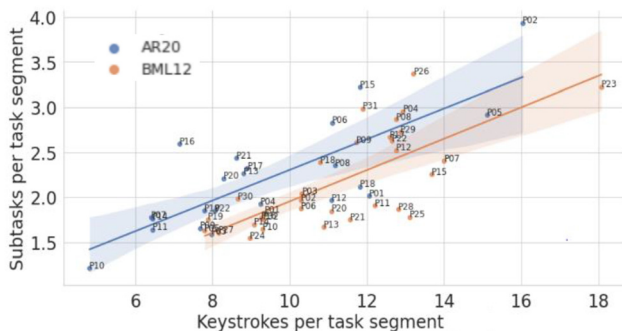


Figure 5: Correlation of total number of keystrokes per task segment and number of subtasks.

We also observe a slightly negative effect of TS length on the number of keystrokes produced per Task: As the number of Tasks per TS increases, the number of keystrokes per Task decreases. This effect is significant for Spanish ($\tau: -0.52$, $p: 0.002$) but not for Arabic ($\tau: -0.18$, $p: 0.41$), which may have to do with the larger variability in the data and the smaller number of observations for our Arabic data set.

4.6 Types of Tasks

Following Muñoz and Apfelthaler (2022), we distinguish between three types of Tasks that involve different types of keystrokes:⁵ an insertion Task, **A**, has only insertion keystrokes (corresponds to Muñoz and Apfelthaler’s ADD), a deletion Task, **D** (not considered in Muñoz and Apfelthaler) has only deletions, and a change Task, **C**, has insertions and deletions (corresponds to Muñoz and Apfelthaler’s CHANGE). We omit the SEARCH Task, since in our translation sessions we have no external research.⁶

Figure 6 shows average duration and keystrokes for the three Tasks, for Spanish and Arabic. The figure shows that there are systematic differences between the Spanish and the Arabic tasks. It can be expected that differences exist also between individual translators, and presumably also for different text types and translation goals. We showed that IKI profiles seem to be typical for specific translators, so that translators can be recognized (to some extent) by their IKI distributions. Figure 6

⁵ Muñoz and Apfelthaler (2022) suggest the following subtasks: ADD (adding new text, it was not clear to this author whether this is any insertion keystroke or only keystrokes at the end of the text), CHANGE (changing the text), and SEARCH (searching for information), HCI (human computer interaction), or it can consist of a combination of those. But the list seems to be open to further extension.

⁶ Note that Tasks **A**, **C** and **D** are different from the embedded architecture layers ABC.

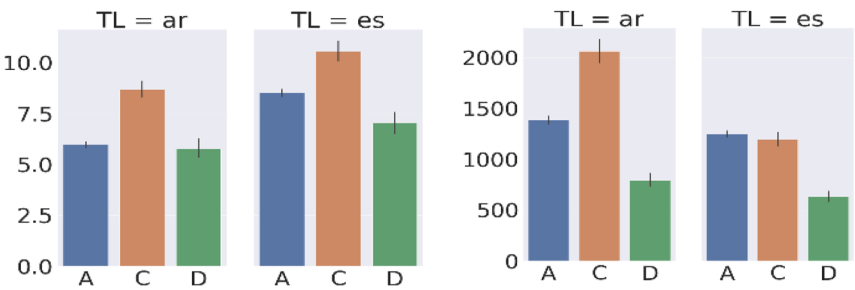


Figure 6: Number of keystrokes (left) and duration (right) for the three types of Arabic and Spanish Tasks. There are more keystrokes and shorter timespans in the Spanish data.

shows that on average all types of Tasks **A**, **D**, and **C** have more keystrokes for Spanish as compared to Arabic and the average duration is longer for Arabic than for Spanish.

4.7 Types of Task Segments

A TS consists of sequences of Tasks, where each Task has a label (in our current taxonomy one of **A**, **C**, or **D**). We consider the sequence of Tasks labels realized within a TS to characterize the type of TS. Table 4 gives a summary of the 11 most frequent TS labels which make up 75 % and 71 % percent of Spanish and Arabic data respectively.

There are all together 10,356 TSs in the Arabic and English data with 892 different TS labels. More than 93 % of these TS labels, that is 833 different labels, occur less than 10 times. They account for 13.8 % of the data (i.e., 1,426 TSs). The 20 most frequent types of TS labels make up 90 % of the data. The mean and median duration for all TSs

Table 4: The 11 most frequent types of TS and their percentage for Spanish and Arabic. The column #Occur shows the total number of TSs and %Spanish and %Arabic the proportion in the two languages. Dur of TS provides the averages duration of the TS in ms. The table shows the Average IKI and average Keystrokes per Task (Key/Task).

TS label	#Occur.	%Spanish	%Arabic	Dur. Of TS	Average IKI	Key/Task
A	3,870	37.95	36.46	921	173	5.33
AA	1,398	13.94	12.81	2,167	211	5.13
D	753	7.71	6.59	504	121	4.16
AAA	543	5.49	4.86	2,740	190	4.81
AAAA	263	2.72	2.25	4,365	233	4.67
DA	194	2.15	1.44	1,593	196	4.07
AD	164	1.35	1.96	1,607	226	3.56
C	164	1.27	2.08	641	152	4.23
DD	116	1.42	0.64	1,183	122	4.84
AAAAA	107	1.06	0.99	5,300	230	4.61
CC	84	0.62	1.11	1,181	160	3.70

is 6,777 ms and 5,781 ms respectively and the median, mean, and maximum number of Tasks per TS is 11, 14, and 61 respectively. In contrast, the mean and median duration for the 90 % most frequent TSs, is 3479s and 3183s respectively and the number of Tasks is, on average, 3.0. Thus, most TS are relatively short, while there is a long tail of very long and diverse TS.

Table 4 provides labels of the 11 most frequent TSs, the total number of occurrences per TS, the percentage in Spanish and Arabic data, as well as their duration (in ms), the average IKI, and average number of keystrokes per Task. The most frequent TS, 38 % and 36 % of the Spanish and Arabic data, consists of a single Task A. There are on average 5.33 keystrokes for this Task with an average IKI of 173 ms.

As previously mentioned, the average number of keystrokes per Task decreases as the number of Tasks in the TS increases. There are 5.13 keystrokes per Task if the TS consists of two A Tasks, 4.81 keystrokes if the TS has three A Tasks, 4.67 for four Tasks, etc. On the other hand, the IKIs tend to increase as the TSs become longer, which suggests that typing becomes more interrupted.

Note the very strong correlation between frequencies (percentages) of the Spanish and Arabic TS labels ($r = 0.998$). This indicates that Spanish and Arabic translators in our dataset engage in very similar production processes (i.e., sequences of Tasks) which results in very similar relative number of occurrences. This certainly needs verification in other datasets, but it might show a language and translator independent translation universal.

Olalla-Soler (2023) investigates successive ADD tasks within a TS, separated by RSPs. He defines *default translations* to be a sequence of fluent typing which consists of one or more ADD tasks that have, among other things, only a few RSPs (fewer than that of 75 % of all TSs). Olalla-Soler (2023) observes that 67.8 % of his TSs were ADD-only. These ADD-only segments contained 69.5 % of the words. Our observations show that slightly more than 60 % of the TSs are A-only and they cover around 44 % of the keystrokes.

4.8 HOF States

This section assesses a subset of the Spanish and Arabic data that was manual annotations with HOF states. It consists of eight Spanish sessions and six Arabic translation sessions, as described in detail in (Carl, Sheng, Al-Ramadan 2024). Table 5 provides an overview of the number of annotated states in the eight Spanish sessions and six Arabic sessions. Despite the different absolute numbers, it is interesting to note that the percentages of H, O and F states is almost identical in the two languages.

Table 6 shows a transition matrix between HOF states for the Arabic and Spanish data. The first row indicates the state at time i from where the transition starts, while

Table 5: Number and Percentages of HOF translation states in the annotated Spanish and Arabic data. There are approximately half the number of states for Arabic for 25 % less annotated data.

	O	%O	F	%F	H	%H	Total
ss	183	30 %	284	47 %	139	23 %	606
ar	93	32 %	132	45 %	67	23 %	292

Table 6: Transition matrix between HOF states for Arabic (left and Spanish (right)). Rows add up to 100 %.

		ar			es		
		O	F	H	O	F	H
From	O	–	0.84	0.16	–	0.86	0.14
	F	0.60	–	0.40	0.60	–	0.40
	H	0.21	0.79	–	0.09	0.91	–

the columns indicate the transition probability into the next state at time $i+1$. As can be seen, the most frequent pattern is a loop over Orientation (O) and Flow (F) states. Only in 16 % and 14 % of the cases for Arabic (ar) and Spanish (es) respectively, is an Orientation state followed by a Hesitation. Both transition matrices are quite similar, with the only obvious exception that Arabic translators transition more often from a Hesitation to a successive Orientation (21 %) while this is much more unlikely for Spanish translator (9 % of the cases). In both cases, perhaps not surprisingly, the highest chances are that a translator will try to arrive at a Flow state (F).

4.9 Distribution of Tasks in H and F States

Table 7 shows the distribution of **A**, **D**, and **C** Tasks in Hesitation (H) and Flow (F) states for the two languages.⁷ According to this table, as can be expected, Flow states are clearly dominated by **A** Tasks while deletions and additions are more equally distributed during Hesitation.

⁷ One assumption in this framework is that every Task is completed within one TS and every TS is completed within one HOF state. That is, Tasks are not supposed to overlap between two (or more) TSs and every TSs must be completed within one HOF state before transitioning to the next HOF state. However, presumably due to the manual annotation, in 6.4 % of the cases (666 of 10,356) a TS crossed a HOF state boundary. Most common overlapping TS were observed in the transitions $H \rightarrow F$, $F \rightarrow O$, $F \rightarrow H$ and $O \rightarrow F$ with 136, 133, 132, and 131 occurrences respectively. These Task Segments were cut at the transition between HOF states, which resulted in more and slightly shorter average TSs. However, this issue has now been resolved in Carl et al. (in print).

Table 7: Percentage of Tasks in Flow and Hesitation states for the Spanish and Arabic data. There is clearly a higher proportion of addition (**A**) Tasks in Flow states but proportionally more deletion (**D**) Tasks during Hesitation. (Columns add up to 100 %).

	ar		Es	
	H	F	H	F
A	0.54	0.84	0.53	0.81
D	0.34	0.08	0.41	0.08
C	0.12	0.08	0.06	0.11

Table 8: Six most frequent TS labels for Flow in Hesitation states in the Arabic and Spanish. Note the identical ranking of TS frequencies in the Flow state.

F:ar	F:es	H:ar	H:es
A	A	A	A
AA	AA	D	D
AAA	AAA	AA	C
AAAA	AAAA	C	AA
C	C	DD	DA
D	D	DA	CA

Table 8 confirms the assumption that different TS patterns are realized in H and in F states. The table shows the six most frequent TS labels of F and H states in the two languages. This accounts for roughly 75 % of the adjusted TSs. The table shows a very strong correlation ($r = 0.993$, for the first 20 labels) between the Arabic and Spanish Flow states and between the Arabic and Spanish Hesitation states ($r = 0.968$). The correlation between Flow and Hesitation states is slightly lower, $r = 0.85$ and $r = 0.76$ when changing both language and type of state.

5 Discussion and Conclusion

This article proposes a hierarchically embedded model for simulating the translating mind, composed of three interacting layers: (A) an affective layer addressing emotional states, (B) a behavioral layer for automated routines, and (C) a cognitive layer simulating reflective thought. The model integrates two taxonomies: the HOF taxonomy, which categorizes affective translation states, and the TSF, which

identifies behavioral markers of routine and reflective processing. Using these frameworks, the article analyzes keystroke and eye-tracking data of 100 Arabic and Spanish translation sessions to scrutinize these ABC-layered processes.

Human translation production is structured into sequences of motor programs and Tasks – that is, actions such as adding, modifying, or deleting text. Tasks are separated by short pauses (respites, *RSPs*), while Task Segments (TSs) are separated by longer Task Segment Pauses (*TSPs*). Following Muñoz and Apfelthaler (2022), *RSPs* indicate involuntary breaks (which we locate here on the B-layer), while *TSPs* reflect conscious, planned pauses (i.e., C-layer units). Tasks and TSs thus signal routine and reflective behavior respectively, which depend on the typing speed of the translator.

The study shows that translators exhibit individual, but consistent pausing patterns suggesting personal, recognizable translation styles. While typing/pausing styles differ widely across translators, the structure of HOF states (A-layer units) seems surprisingly consistent across translators.

Thus, although typing speed may vary significantly between Arabic and Spanish translators, the frequency and type of translation actions (e.g., insertions, deletions) are remarkably similar. This suggests that while the “how” of translation (its temporal structure) is highly individual, the “what” (the nature of changes made) remains relatively consistent across languages and translators.

The proposed ABC architecture of the translation mind resonates with Robinson’s (1991, 2023) ideosomatic theory of translation, which views translation as embodied, affective, and cognitive. This ideosomatic theory emphasizes the translator’s bodily and emotional involvement, in addition to cognition and reasoning. The term *ideosomatic* combines the cognitive (*ideo*) and the physical (*somatic*), positing that translators’ decisions are often driven by intuitive, affect-laden reactions to text – e.g., what “feels right” – rather than purely analytic reasoning.

Robinson (2023) draws from Peirce’s (1992) triadic model of interpretants – emotional, energetic, and logical – which closely align with the ABC layers:

- Emotional interpretant (A): the immediate, intuitive feeling response that shapes attention and meaning.
- Energetic interpretant (B): embodied or motor reactions, expressed in typing and gaze behavior.
- Logical interpretant (C): reflective reasoning that regulates and reinterprets emotional input.

Robinson argues that translation involves a “feeling-becoming-thinking” process: smooth translation arises when emotional and motor states align, but reflective thought may be called upon when there’s a mismatch. Though feelings and thoughts are internal, Robinson insists they are also transcranial – partly observable through

social and sensorimotor behavior, including gaze and typing patterns. The internal processes can thus be traced through behavioral data.

This study builds on Robinson's ideosomatic framework analyzing how the sequencing of HOF states, Tasks, and Task Segments reflects these layered processes. While the temporal structure of translation seems to be highly individual, the underlying actions and affective states remains relatively consistent – suggesting that shared cognitive-emotional mechanisms are common across translators. These findings, in combination with the ideosomatic theory, offer a nuanced understanding of how individual styles emerge from common/shared mental architectures.

Future research may investigate how the mental layers underpinning emotional states like Flow, Hesitation, and Orientation relate to cognitive concepts, such as attention shifts, working memory load, or retrieval processes. A more granular analysis of how different task types (ADD, DELETE, CHANGE) correlate with cognitive demands and emotional responses may also yield valuable insights, especially for training and process optimization. Moreover, fuller integration of eye-tracking data – through analysis of gaze fixations and saccadic patterns – could reveal how visual attention mediates emotional states and task complexity. Finally, translating these findings into practical guidelines for translator training and the development of emotion-sensitive translation tools would increase the model's real-world impact, enabling more adaptive and cognitively informed approaches to translation practice and pedagogy.

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