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Investigating differences between translation sessions and intervals using keystroke logging

Abstract

Recent evidence suggests that translation behaviour evolves as the task unfolds. However, most studies into the translation process employ short texts of 200 words or less, which could have led to an oversimplification of translation models by focusing only on a part of the process. To address this potential bias, this study used longer translation tasks and examined writing speed and pausing behaviour by session and by within-session intervals. Three texts ranging from 814 to 965 words were translated over two one-hour sessions per text. Comparisons of writing speed and pausing behaviour, both within and between translation session, revealed systematic and significant differences. We conclude this article by discussing the methodological implications of the results, as well as limitations and opportunities for future research.

1 Introduction

There is a consensus in translation literature that the translation process consists of three phases. While several authors have named these phases differently, the core definition of each phase remains consistent: the initial phase occurs before the text is written, the second unfolds when the text is written down, and the final phase takes place after the text has been written. However, emerging research suggests that this tripartite model may oversimplify the translation process. This oversimplification could stem from the length of the texts used in research on the translation process. While professional translators often engage with lengthy texts that can take days to translate, most studies investigating the translation process use texts ranging between 50 and 200 words (Muñoz 2012: 17–18). González (2023: 36) corroborated this observation after analysing a corpus of highly cited articles, revealing a prevalent trend of employing short texts of less than 200 words in keylogging studies. Given that translators typically translate 500 words per hour from scratch (e. g. Toral/Wieling/Way 2018), this means that such tasks usually take less than 25 minutes to complete. This is important as there is evidence that translation behaviour changes across the phases of a translation task (Breedveld 2002; Muñoz/Martín 2018). Therefore, it may be that keylogging studies on the translation process have predominantly focused on an initial translation stage, potentially overlooking the evolving dynamics and complexities that emerge in later phases.

The present study used keystroke logging to expand our understanding of potential differences in the translation process. Specifically, we examined whether writing speed and pausing behaviour differ across sessions and within-session intervals when translating three texts of approximately 900 words. Each text was translated in two one-hour sessions. These sessions were further divided into intervals to enable a more fine-grained analysis. If such differences exist, they may point to the need for methodological adjustments in the analysis of the translation process.

2 Background

Translation process research widely agrees that translation unfolds in three distinct phases. Though terminology may vary across studies, as seen in Table 1, the underlying functions of these phases remain conceptually aligned.

Author	**Phase 1**	**Phase 2**	**Phase 3**
Flower/Hayes (1981)	Planning	Translating	Reviewing
Krings (1986)	*Vorlauf*	*Hauptlauf*	*Nachlauf*
Jääskelainen (1999)	Pre-writing stage	Writing stage	Post-writing stage
Mossop (2001)	Pre-drafting	Drafting	Post-drafting
Jakobsen (2002)	Orientation	Drafting phase	End revision phase
Norberg (2003)	*Planungsphase*	*Rohübersetzungsphase*	*Revisionsphase*
Englund Dimitrova (2005)	Pre-writing phase	Writing phase	Post-writing phase
Gouadec (2007)	Pre-translation	Translation (transfer)	Post-translation
Angelone (2010)	Comprehension	Transfer	Production

Table 1: Phases of the translation process as outlined by several authors

An influential perspective in cognitive translation and interpreting studies, as proposed by Jakobsen (2002: 192–193), divides the translation process into three phases specifically defined for keylogging research. The first phase is termed *Orientation*, during which translators familiarize themselves with the context of the text. This phase corresponds to the time delay between the appearance of the source text (ST) on the screen and the first keystroke of text production. The next phase, called *Drafting*, involves the production of a raw version of the translation. This phase runs from the first text production keystroke until the insertion of the final punctuation mark. The third phase, *Revision*, is the phase in which the translator refines the draft. This phase lasts until the translator decides that the translation is ready to be submitted.

Tripartite models of translation have long served as a foundation for research into the translation process. However, these models may oversimplify that process for two reasons. First, although they do not explicitly portray the translation process as a linear activity, they may unintentionally suggest a sequential, linear progression. Instead, translation is widely acknowledged to be a non-linear, iterative process (Hurtado/Alves 2009), a view that aligns writing research findings in which cognitive processes are similarly understood as recursive and dynamic (Conijn et al. 2024). Second, analyses using longer texts have produced more nuanced models of the translation process: Göpferich (2010) mentioned that the translation process involves several post-translation phases; Johnsen (2014) identified an additional phase through the analysis of keylogging data; and Borg (2018, 2023) revealed complex phase structures in a literary translation study conducted *in situ*. Borg (2018) proposed five distinct phases, adding re-drafting, polishing of the style and self-proofreading to the first two phases. Later, Borg (2023: 175) expanded this framework to eight phases: five phases in the actual translation process and three phases in the post-translation process. Borg's expanded framework aligns with findings from writing research. For instance, Sala-Bubaré, Castelló and Rijlaarsdam (2021) identified seven different types of activities: text production, interaction with sources, editing (surface-level revisions), revising (deep-level revisions), reading text written so far, deleting (without insertions) and recursive reformulations (changes at the point of inscription). Adding to this evolving understanding, Muñoz and Martín (2018) suggested an extended orientational period at the beginning of the translation task, possibly involving contextualization and warming up to the task, which may last for the first 4 to 10 minutes. These alternative perspectives challenge the rigidity of traditional phase models and underscore the need for empirical investigations that capture a broader temporal arc of translation activity, while also encouraging a more nuanced segmentation of the translation process.

Writing research offers valuable insights into process analysis by dividing the writing process into phases, stages, segments, or episodes (e. g., Leijten et al. 2014; Sala-Bubaré/Castelló/Rijlaarsdam 2021; Xu/Xia 2021). Researchers typically adopt one of four major segmentation approaches (Conijn et al. 2024): time-based, content-based, version-based, and function-based segmentation. Some studies focus on micro-processes and fine-grained activities to investigate cognitive subprocesses and participant behaviour in greater detail (e. g. Conijn/Dux Speltz/Chukharev-Hudilainen 2024; Kruse 2024, in writing research; Muñoz/Apfelthaler 2022, in translation research). These segmentation strategies offer valuable tools that could be adapted to translation process research. Therefore, there is a clear need to further investigate how the translation process unfolds over time, particularly in tasks involving longer texts and multiple working sessions.

3 Research aim

The aim of this article is to explore whether there are differences in writing speed and pausing behaviour when translating texts of approximately 900 words, divided across different sessions and intervals. To achieve this goal, the study employs process and product measures traditionally used in writing research, while also introducing new analytical perspectives. By combining insights from writing studies with translation-specific methods, the study seeks to offer a more comprehensive understanding of the temporal dynamics involved in translation tasks.

Consequently, this study addresses the following research questions:

RQ1: Are there differences in writing speed between translation sessions of a text?

RQ2: Are there differences in writing speed across intervals between and within translation sessions of a text?

RQ3: Are there differences in interkeystroke intervals between translation sessions of a text?

In concrete terms, we first examined the impact of translation session and intervals on writing speed, analysing it from product and process approaches, but also using a behavioural approach. Secondly, as a complement to the first analysis, we examined pausing behaviour during each translation session, analysing two different types of interkeystroke intervals.

4 Materials and methods

4.1 Participants

Participants were recruited from one university in Spain during the first semester of 2020. Participants were 25 BA students (average age 20.3; min. 20, max. 24): 20 females, 4 males and 1 participant who responded “other”. We used the data from only 23 students, as 2 of the participants did not submit any translation. All the participants answered a self-reported language proficiency questionnaire, stating that their level of English was C2-C1 in the CEFR. All participants signed an informed consent for the processing of personal data.

4.2 Materials

Participants used MS Word documents, automatically opened by Inputlog, for translating the texts. They received instructions on installing Inputlog in a Word document and were requested to complete a short mock translation to ensure that Inputlog worked properly. Participants had no prior experience with Inputlog and worked at home using their own computers and Internet connection.

Three texts were selected for translation, using several parameters to ensure that they were similar in terms of complexity but different in terms of textual typology. Text A, taken from National Geographic, was about how 18th century people identified and tried to kill vampires. Text B, taken from Writers & Artists, featured an interview transcription with the writer Mary Watson. Text C, taken from the US Food and Drug Administration, was the full prescription information for the medication Natesto. The lengths of the texts were Text A: 922 words; Text B: 965 words; and Text C: 814 words.

4.3 Task procedure

Each text was translated over two one-hour sessions across three consecutive weeks, resulting in the division of each text into two halves. Participants were given the option to translate the second half on the same day, as long as there was a minimum gap of three hours between the sessions. On the other hand, participants were encouraged to complete both translation sessions within a maximum span of three days. Participants were free to use any online resources for their translation task, except machine translation tools such as Google Translator or DeepL. The texts were translated from English into Spanish.

4.4 Data coding, cleaning and analysis

Process data was collected with Inputlog 8.0.0.6. Inputlog is a keystroke logging program enabling researchers to observe writing process dynamics and collect fine-grained data (Leijten/Van Waes 2013). The program logs all keyboard, mouse and speech events in MS Word, together with a unique stamp, producing a log file containing linear storage of the keystroke data. Information such as events, timestamp, character position, pause time, etc. are stored unobtrusively for later processing. Inputlog records not only what is being written in the target text (TT), but also records searches in web browsers. This allows for a very ecological data collection, since participants can work using their own setup and computer, and look for information just as in a normal task, as long as they use MS Word to write the translation.

The first step was to check the quality of the logged data. The criteria to exclude translation sessions from the analysis were: (1) participants did not finish the translation in one of the translation sessions; (2) the log file was corrupted; (3) participants translated the wrong ST; and (4) the characteristics of the translation process made us suspect the participant had already translated the text using machine translation and simply rewrote it. The total dataset was reduced from 46 to 34 log files for Text A, 46 to 38 for Text B and 46 to 30 for Text C, totalling 102 log files to be analysed. The analysis focused on potential differences between the two sessions of each text. Additionally, each session was divided into six ±10-minute intervals to examine potential differences both within and between sessions. Table 2 presents a visual summary of the analytical structure, illustrating how the sessions and their intervals were organised.

Text	Session	Interval
A	A1	A1I1, A1I2, A1I3, A1I4, A1I5, A1I6
	A2	A2I1, A2I2, A2I3, A2I4, A2I5, A2I6
B	B1	B1I1, B1I2, B1I3, B1I4, B1I5, B1I6
	B2	B2I1, B2I2, B2I3, B2I4, B2I5, B2I6
C	C1	C1I1, C1I2, C1I3, C1I4, C1I5, C1I6
	C2	C2I1, C2I2, C2I3, C2I4, C2I5, C2I6

Table 2: Analytical structure of the translation tasks

4.5 Statistical analysis

All data was imported into jamovi 2.6 (The jamovi project 2025) and analysed using multivariate statistical methods. When data was not normally distributed, log transformation was applied. Due to the unbalanced nature of the dataset (as data from some participants was excluded from certain sessions as mentioned in section 3.4), linear mixed-effect models were used. For count-based variables, a generalized linear model with a negative binomial distribution was applied. Effect size was interpreted according to Cohen (1988).

5 Results

5.1 Traditional measures

This section presents the results derived from traditional measures in writing research from a product and a process perspective. We ran linear mixed effect models to examine the effect of sessions on writing speed measured using words per minute (WPM), characters per minute excluding spaces (CPMNS) and characters per minute including spaces (CPMS). Writing speed was included as the dependent variable and added fixed effects for text and session, and their interaction, as well as random intercepts for participants to account for interindividual variability.

5.1.1 Process analysis

Based on WPM, the model accounted for a substantial portion of the variance in writing speed (conditional $R^2 = .687$), with significant main effects for text, $F(2) = 9.44$, $p < .001$, session, $F(1) = 38.54$, $p < .001$, and the interaction between text and session, $F(2) = 4.71$, $p = .0012$. The effect size for session was large ($\eta^2_p = .341$), followed by a large effect for text ($\eta^2_p = .213$), and a medium effect for the interaction ($\eta^2_p = .119$). Fixed effect estimates indicate that the writing speed increased significantly from session 1 to session 2, $B = 0.09$, $SE = 0.01$, 95 % CI [0.06, 0.11], $t(74.4) = 6.21$, $p < .001$, and text C was significantly slower than text A, $B = -0.07$, $SE = 0.02$, 95 % CI [−0.10, −0.03], $t(78.6) = -3.71$, $p < .001$.

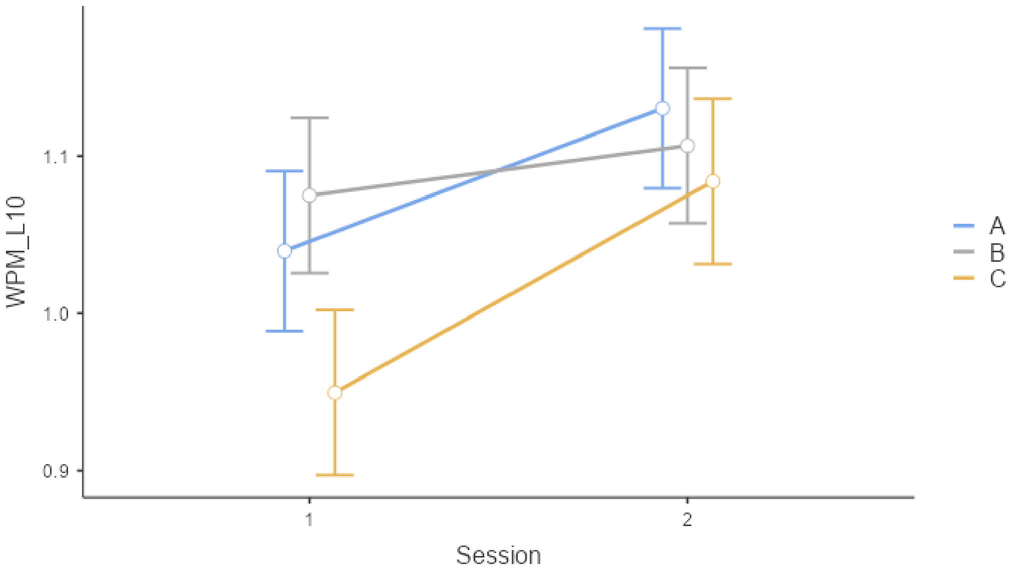

Fig. 1: Process-based session effects on words per minute (WPM) for text A, B and C

Post hoc comparison using the Bonferroni test showed that writing speed significantly improved from session 1 to session 2, $t(74.4) = -6.21$, $p < .001$, with a difference of - 0.086, $p < .001$. It also showed that writing speed was significantly lower for Text C than for Text A, $t(78.6) = 3.71$, $p = .001$, and Text B, $t(81.8) = 3.98$, $p < .001$, whereas Texts A and B did not differ significantly. However, the Text × Session interaction showed that this overall difference was primarily driven by Session 1: in that session, Text C was translated significantly more slowly than Texts A and B, whereas by Session 2 these differences were no longer significant. Thus, although Text C was the slowest overall, it also showed the greatest improvement across sessions.

Using CPM without spaces as indicator of writing speed, the model explained over half of the variance (conditional $R^2 = .566$), with a main significant effect size for session, $F(1) = 19.99$, $p < .001$. The effect for session was large ($\eta^2_p = .212$). Fixed effects indicated that writing speed increased significantly from session 1 to session 2, B = 0.0715, SE = 0.0160, 95 % CI [0.0398, 0.1033], $t(74.3) = 4.47$, $p < .001$. Fixed effects also showed that text C was significantly slower than text A overall, B = 0.0715, SE = 0.0160, 95 % CI [0.0398, 0.1033], $t(74.3) = 4.47$, $p < .001$.

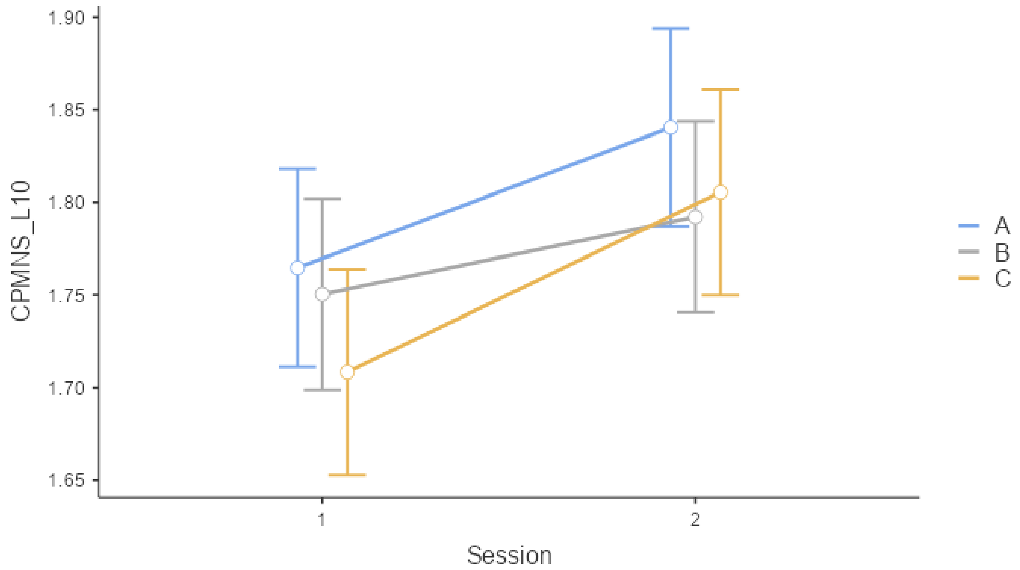

Fig. 2: Process-based session effects on characters per minute without spaces (CPMNS) for text A, B and C

Post hoc comparison using the Bonferroni test confirmed that writing speed was faster in session 2, $t(74.3) = -4.47$, $p < .001$. Interaction effects showed that writing speed in Text C during Session 2 was significantly higher than in Text C during Session 1, $t(74.3) = -3.31$, $p = .022$.

Based on CPM with spaces, the model accounted for a considerable portion of the variance in writing speed, as measured in (conditional $R^2 = .607$), with a significant effect for text, ($F(2) = 3.13$, $p = .049$), session ($F(1) = 23.52$, $p < .001$). The effect size for session was large ($\eta^2_p = .240$), and a medium effect for text ($\eta^2_p = .075$). Fixed effects estimates indicate a main effect on session, B = 0.0726, SE = 0.0150, 95 % CI [0.0429, 0.1023], $t(74.3) = 4.85$, $p < .001$. It also showed that writing speed was significantly lower for text C compared to text A, B = −0.0496, SE = 0.0199, 95 % CI [−0.0891, −0.0102], $t(79.3) = -2.50$, $p = .015$.

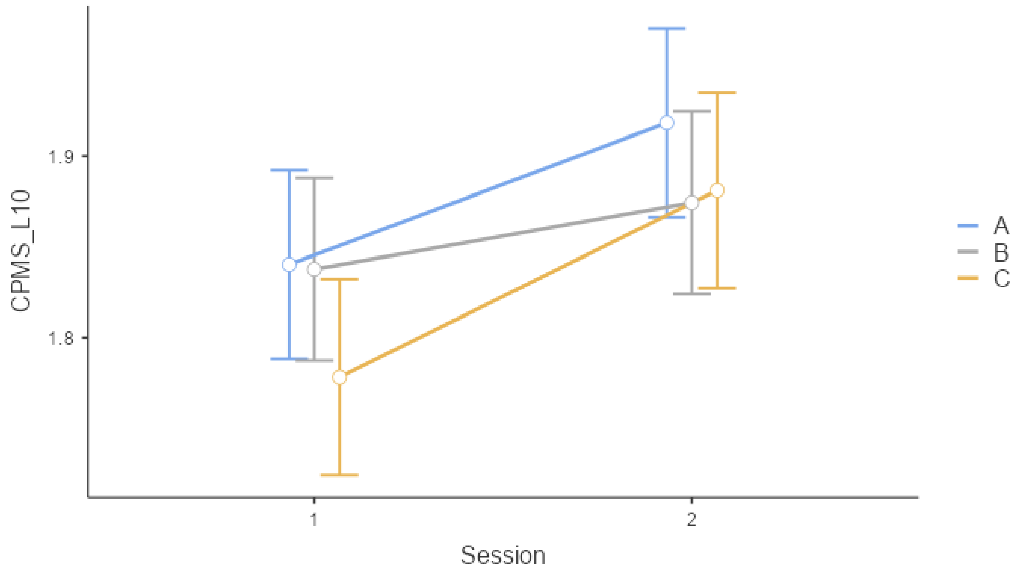

Fig. 3: Process-based session effects on characters per minute with spaces (CPMS) for text A, B and C

Post hoc comparison using the Bonferroni test confirmed the difference between text A and C, t(79.3) = 2.50, $p = .044$, and between sessions, t(74.3) = −4.85, $p < .001$. Interactions also showed that participants wrote significantly faster in Text C during session 2 as compared to session 1, t(74.3) = −3.75, $p = .005$.

5.1.2 Product analysis

Using WPM as the indicator of writing speed, the model accounted for a substantial portion of the variance (conditional $R^2 = .687$), with a significant effect for text (F(2) = 5.29, $p = .007$) and session (F(1) = 30.54, $p < .001$). The effect size for session was large ($\eta^2_p = .301$), and a medium effect for text ($\eta^2_p = .119$). Fixed effects showed that writing speed was significantly higher in session 2, B = 0.1065, SE = 0.0193, 95 % CI [0.0682, 0.1447], t(70.8) = 5.53, $p < .001$, and that writing speed for text C was significantly slower overall compared to text A, B = −0.0699, SE = 0.0260, 95 % CI [−0.1216, −0.0182], t(76.6) = −2.69, $p = .009$.

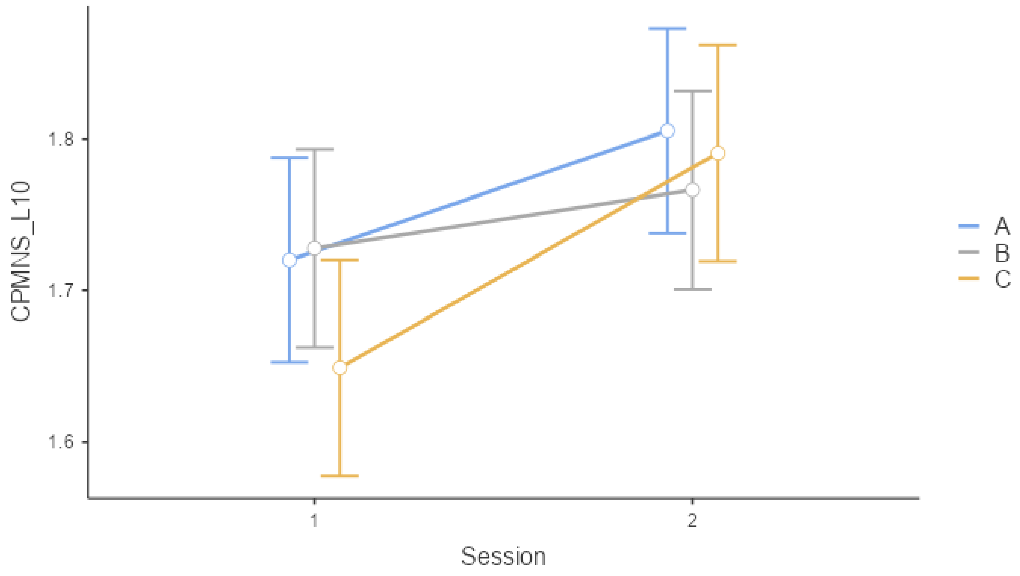

Fig. 4: Product-based session effects on words per minute (WPM) for text A, B and C

Post hoc comparison using the Bonferroni test confirmed the difference between sessions, $t(70.8) = -5.53$, $p < .001$. It also showed that the difference between texts was modulated by sessions, indicating that the writing speed for text C improved significantly during session 2 when compared to text A, $t(76.6) = 2.685$, $p = .027$, and text B, $t(80.0) = 3.082$, $p = .008$.

Based on CPM without spaces, the model explained over half of the variance in writing speed (conditional $R^2 = .566$), with a significant effect for session, $F(1) = 21.44$, $p < .001$. The effect size for session was large ($\eta^2_p = .232$). Fixed effects confirm that session 2 was significantly faster than session 1, $B = 0.0886$, $SE = 0.0191$, 95 % CI [0.0506, 0.1266], $t(70.8) = 4.63$, $p < .001$.

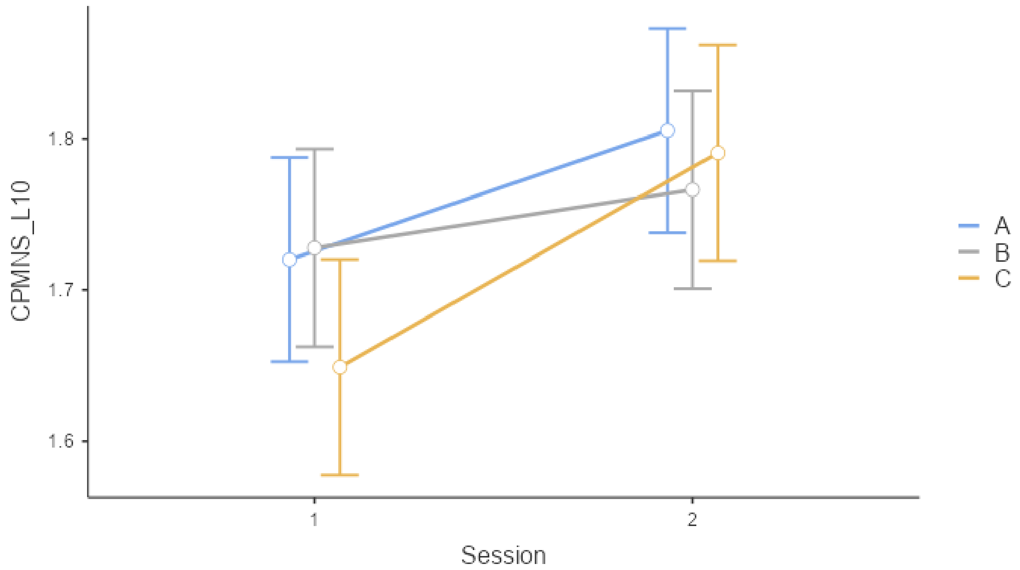

Fig. 5: Product-based session effects on characters per minute without spaces (CPMNS) for text A, B and C

Post Hoc comparison using the Bonferroni test confirmed the difference between sessions $t(70.8) = -4.63$, $p < .001$.

Based on CPM with spaces, the model accounted for a considerable portion of the variance in writing speed (conditional $R^2 = .607$), with a significant main effect for session, $F(1) = 22.74$, $p < .001$. The effect size for session was large ($\eta^2_p = .243$). Fixed effects showed that session 2 was significant faster, B = 0.0913, SE = 0.0192, 95 % CI [0.0533, 0.1294], $t(70.8) = 4.77$, $p < .001$.

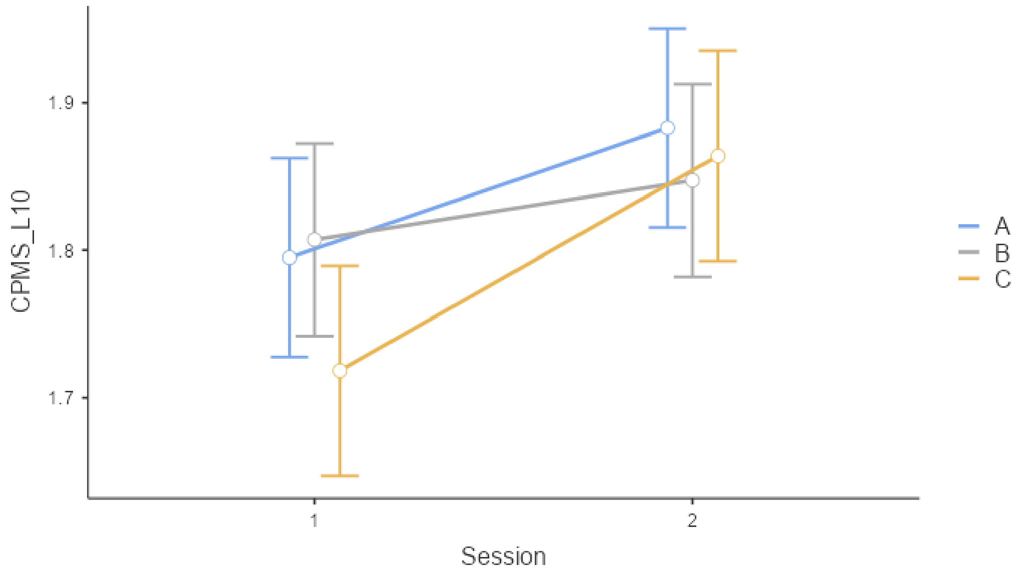

Fig. 6: Product-based session effects on characters per minute with spaces (CPMS) for text A, B and C

Post hoc comparison using the Bonferroni test confirmed the difference between sessions, $t(70.8) = -4.77$, $p < .001$.

5.2 Behavioural writing speed analysis

This study sought to extend beyond an examination of writing speed based solely on the number of characters and words produced by each participant: it also takes into account all the events elicited during the tasks. An event is any minimal action that was recorded and time-stamped by the keylogger. It encompasses a broad spectrum of actions such as letter keystrokes, mouse clicks, dead keys and modifiers (e. g. accents, Shift, Alt), deletions, mouse scrolls, changes of focus, web searches, etc. This analytical approach will be referred to as behavioural writing speed and is quantified in events per minute (EPM).

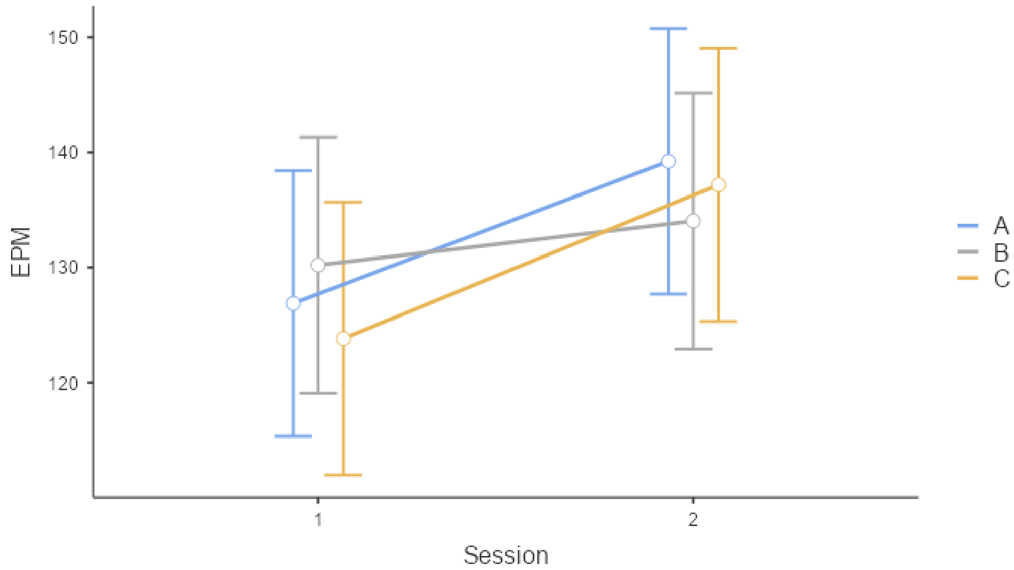

Fig. 7: Session effects on events per minute (EPM) for text A, B and C

Therefore, we ran a linear mixed-effect model to examine the effect of sessions on writing speed measured using events per minute (EPM). Writing speed was included as the dependent variable and added fixed effects for text and session, and their interaction, as well as random intercepts for participants to account for interindividual variability. The model explained a substantial portion of the variance in behavioural writing speed (conditional R^2 = .676), with a significant main effect on session, F(1) =11.577, p = .001. The effect size for session was medium (η^2_p = .131). Fixed effects showed that the number of events per minutes was significantly higher in session 2 compared to session 1, B = 9.85, SE = 2.89, 95 % CI [4.10, 15.59], t(76.9) = 3.40, p = .001. Post hoc tests confirmed this effect, showing that more events were produced in session 2 compared to session 1, t(76.9) = -9.85, p = .001.

5.3 Interkeystroke intervals analysis

In studies on the translation process using keylogging, there is no consensus as to what counts as a relevant pause, and the selection of a pause value tends to be arbitrary. For instance, Krings (1986) used 3000 ms, Angelone (2010) set it at 2000 ms, Jensen (2000) analysed pauses over 4000 ms and Jakobsen (2005) suggested 2400 ms. In the context of writing research, Van Waes and Leitjen (2015) mention that the most common pause threshold is 2000 ms. However, having an arbitrarily predefined pause threshold is problematic because it does not consider differences in writing ability (Rosenqvist 2015: 19).

To analyse pauses, we adopted the operationalization of interkeystroke intervals (IKIs) from the task segment framework (TSF; Muñoz/Apfelthaler 2022), which calculates

IKIs individually for each participant rather than applying a fixed threshold.[1] The TSF also classifies IKIs based on their length and motivation. Pauses are long IKIs that are assumed to be voluntary interruptions of the typing flow, during which translators reallocate their cognitive resources to subtasks typically not captured by keyloggers, such as reading, planning, assessment, etc. Respites are medium-length IKIs that are assumed to be involuntary, indicating shifts in attentional states, often linked to processing difficulties. This approach offers a complementary perspective for analysing the writing process in translation.

A generalized linear model with a negative binomial distribution was used to analyse the number of pauses between sessions. The model included fixed effects of text, session, and their interaction, with participant entered as a covariate. This model was chosen due to significant overdispersion in the Poisson model ($\chi^2/df = 21.3$), which was resolved in the negative binomial model ($\chi^2/df = 1.10$). The model showed good fit (AIC = 1197.24, LogLik = –590.62), and overdispersion was no longer a concern.

The model showed a significant main effect of session, $\chi^2(1) = 28.54$, $p < .001$. No other main significant effects were found. Fixed effect showed that participants made significantly fewer pauses in session 2 compared to session 1, $B = -0.286$, $SE = 0.053$, 95 % CI [−0.390, −0.183], $Exp(B) = 0.752$, $z = -5.35$, $p < .001$).

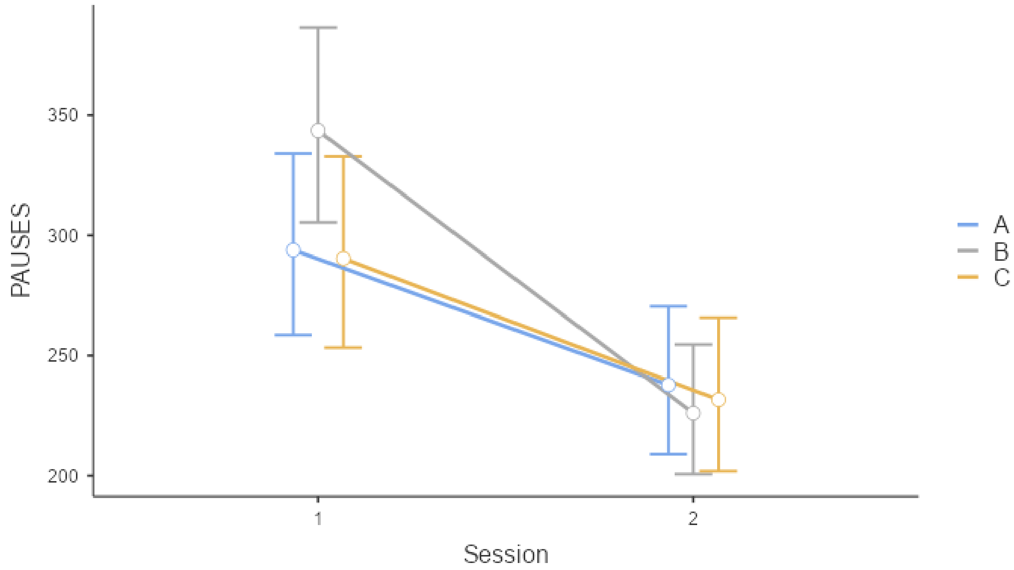

Fig. 8: Session effects on pauses for text A, B and C

[1] For each participant and session, we calculated IKI thresholds as follows: The upper threshold was set to three times the median IKI between words, and the lower threshold to two times the median IKI within word. The upper threshold is used to distinguish pauses from respites. For a comprehensive explanation of the calculations see Muñoz and Apfelthaler (2022: 23–25).

Bonferroni-adjusted post hoc pairwise comparisons confirmed this effect (Rate Ratio = 1.33, SE = 0.071, z = 5.35, p < .001).

A generalized linear model with a negative binomial distribution was fitted to the number of *respites* to account for overdispersion in the data. The model included fixed effects of text, session, and their interaction, with participant entered as a covariate. The model showed modest explanatory power ($R^2 = 0.0783$, Adj. $R^2 = 0.0259$), and overall fit was acceptable (AIC = 1334.66.4; LogLik = −659.33).

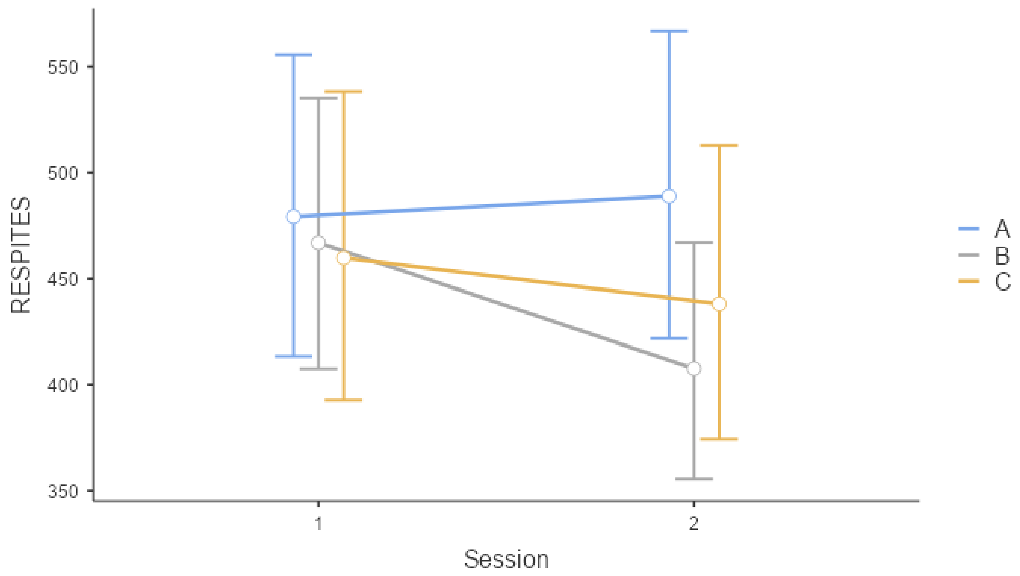

Fig. 9: Session effects on respites for text A, B and C

The model showed significant main effects for participant, $\chi^2(1) = 5.04$, $p = .025$, indicating a high inter-individual variability in respites. The fixed effect for participant was significant (B = 0.010, SE = 0.004, 95 % CI [0.002, 0.020], Exp(B) = 1.010, z = 2.32, p = .020). No significant main effects were found for text, session, or their interaction, and no post hoc pairwise comparisons were statistically significant.

5.4 Sessions and intervals analysis

To examine the effect of intervals and sessions on writing speed, we ran a linear mixed effects model. We included CPM as the dependent variable and added fixed effects of session, interval, and the interaction between session and interval. We also included participants as random effects.

The model accounted for a moderate portion of the variance in writing speed (conditional $R^2 = .288$), with a significant main effect for session, $F(1) = 18.13$, $p < .001$, interval, $F(5) = 14.92$ $p < .001$, and for the interaction between session and interval, F(5)

= 2.39, p = .037. The effect size for session was small (η^2_p = .032), followed by a medium effect for interval (η^2_p = .133) and a small effect for text (η^2_p = .022).

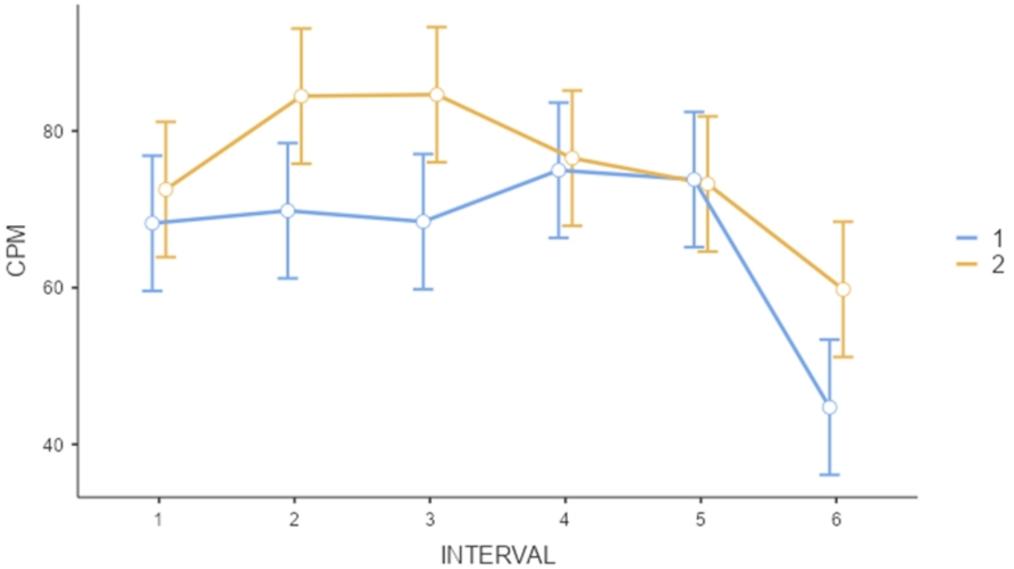

Fig. 10: Interval effects on characters per minute for sessions 1 and 2

Fixed effects estimates indicate that the writing speed was significantly faster in session 2, B = 8.53, SE = 2.00, 95 % CI [4.59, 12.46], t(546.3) = 4.26, p < .001, and that there was a significant decrease in interval 6 compared to interval 1, B = −18.11, SE = 3.47, 95 % CI [−24.93, −11.30], t(546.3) = −5.22, p < .001. Bonferroni-corrected post hoc comparisons confirmed the difference between sessions, *t*(546) = −4.26, *p* < .001, with a mean difference of −8.53 (SE = 2.00). It also revealed that writing speed in interval 6 was significantly and consistently different than all previous intervals in both sessions (*p* < .001). No other interactions were statistically significant.

We also ran a linear mixed effects model with EPM as the dependent variable, and added fixed effects of session, interval, and their interaction. We included participant as random effects. The model accounted for a moderate portion of the variance in writing speed (conditional R^2 = .299), with a significant effect for session, F(1) = 14.50, p < .001, and interval, F(5) = 11.20, p < .001. The effect size for session was small (η^2_p = .026), followed by a small effect for interval (η^2_p = .100).

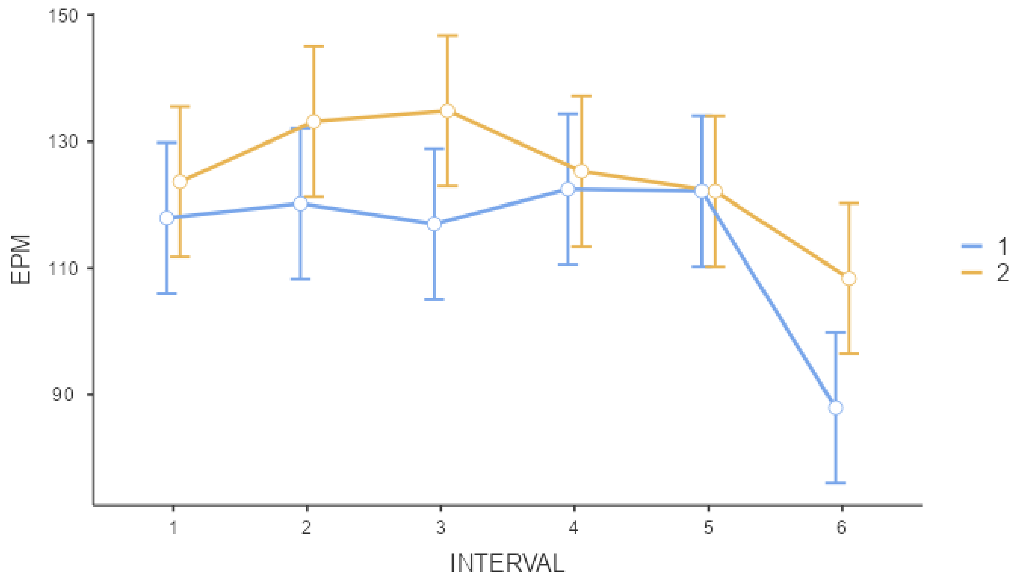

Fig. 11: Interval effects on events per minute for sessions 1 and 2

Fixed effects estimates show that the writing speed between sessions is significantly different, B = 9.98, SE = 2.62, 95 % CI [4.83, 15.10], t(546.5) = 3.81, p < .001. It also showed a significant decrease in writing speed in interval 6 compared to interval 1, B = −22.65, SE = 4.54, 95 % CI [−31.56, −13.70], t(546.5) = −4.99, p < .001. Bonferroni-corrected post hoc comparisons confirmed the difference between sessions, *t*(547) = −3.81, *p* < .001, with a mean difference of −9.98 (SE = 2.62). It also revealed that writing speed in interval 6 was significantly different than all previous intervals in both sessions (*p* < .001). No other interactions were statistically significant.

6 Discussion

In this study, we examined whether translation sessions and intervals affect writing speed and pause behaviour by analysing keystroke data from texts of approximately 900 words. The analyses conducted in the preceding section allowed us to reject the null hypotheses in most cases. These findings suggest a statistically significant difference in writing speed, behavioural writing speed and pauses when the translation sessions are compared.

6.1 RQ1: Writing speed across sessions

The data showed that there are consistent and significant differences between the translation sessions of a text. All analyses of writing speed from a process, product and behavioural perspective consistently showed that participants wrote significantly faster in session 2. This was also true whether measured as words per minute, characters per minute with spaces, characters per minute without spaces or events per minute.

The effect sizes for the results were large, except for EPM, which was medium. This might be because EPM captures broader behaviour, taking into account all the events recorded by the keylogger, including actions which are often overlooked in writing process research, such as editing and information search (Leijten et al. 2014). Therefore, behavioural writing speed is a more diffuse but holistic measure of activity, sensitive to strategic behaviour. The differences between EPM and the different measures of CPM indicate that writing became not only faster but more efficient in session 2, as the broader interaction patterns of the participant did not increase as markedly.

Not all measures yielded significant text or interaction effects, indicating that, overall, participants' writing speed improved similarly across all texts. However, text C showed a significant increase in words per minute from session 1 to session 2 based on product and process perspectives, matching the writing speed of the other texts in session 2. This finding is important given that text C is a technical text, often regarded as more challenging to translate. Our results may indicate that this difference was driven by unfamiliarity with the subject rather than by an inherent difficulty of technical texts. As a result, writing speed for text C in session 2 matched the speed of the other texts. This difference would have been overlooked if we had only compared the first session of each text.

These results allow us to robustly confirm that writing speed differs significantly from session to session, with translators typing faster during the second session. This increase may indicate a general learning or adaptation effect through the translation task as participants become more familiar with the text. This aligns with the results in Bhattacharya and Gwizdka (2018) and Lo Sardo et al. (2023). The former found an evolving behaviour during search tasks aligned with information uptake, while the latter found a clear evolution from exploratory planning and revision cycles to a more exploitative drafting mode over time during writing tasks. Since the whole translation process is "driven by top-down and bottom-up mental processes, where successive readings of text stretches foster the emergence of formulations in the target language that will then be assessed as candidate translations" (Muñoz/Apfelthaler 2022: 9), translators were faster in their translations during the second session because they had already made decisions in the first session that affected the rest of the text. This seems to also be confirmed by the findings of the analysis of pauses in RQ3.

6.2 RQ2: Translation sessions and intervals

The analysis of writing speed across translation sessions and intervals revealed a complex interaction between temporal progression and writing speed. Data showed significant differences across sessions and intervals for CPM and EPM, and their interaction for CPM, suggesting that writing speed varied not only between sessions, but also across the defined intervals. Fixed effects showed that session 2 was faster than session 1, and showed that interval 6 was slower than interval 1. Post hoc tests allowed us to know that writing speed dropped sharply in interval 6, consistently and significantly, as compared to all other intervals, highlighting a robust end-of-task effect.

These results suggest that writing speed does not increase nor decrease uniformly over time, and that the final segment of a session may be affected by cognitive fatigue, reduced focus, or end-of-task disengagement, particularly in longer translation tasks. One possible explanation is that this difference indicates revision behaviours, such as revising, refining, and proofreading their text. This aligns with the third phase of the translation process as defined by all authors in Table 1. However, it is important to note that not all translators revise their draft when they finish their translation: some revise while translating (Witczak 2021). Alternatively, another explanation may be attributable to translators beginning to relax as they approach the completion of the translation task. It may also be linked to attention decay during the task. Indeed, the observed differences may be attributable to a combination of all these factors. Further research is needed to elucidate this finding.

If we analyse these results from another perspective, they show that intervals 1 to 5 are statistically indistinguishable in terms of writing speed. Particularly interesting is that interval 1 did not exhibit a different behaviour compared to following intervals. This interesting and unexpected result suggests that there was no orientation phase as operationalized by Jakobsen (2002): participants maintained a relatively stable writing speed throughout most of the session. If such behaviours (e. g., reading or planning before translating) occurred, they did not meaningfully impact writing speed during the first interval. Instead, translators appear to familiarize themselves with the ST before and after the first production keypress, i. e. while translating, as Muñoz and Martín (2018) argue. Furthermore, given the differences between sessions, the faster performance in session 2 may result from translators having completed contextualization during the first translation session (reflecting practice or familiarity effects), thereby eliminating the need for additional contextualization in the second session and accelerating their translation process. This also seems to be confirmed by the analysis of interkeystroke intervals in RQ3.

6.3 RQ3: Interkeystroke intervals

Xu and Qi (2017) argue that pausing is a strategy that writers adopt to free up attentional resources. Angelone and Marín (2022) refer to these strategic breaks as cognitive suspension, which are refresh mechanisms throughout the task. Muñoz and Apfelthaler (2022) also argue that pausing is a strategic behaviour, but that (long) pauses are voluntary interruptions of the typing flow when translators recruit the mental resources they devote to typing and reallocate them to other subtasks. Research has shown that long pauses occur due to switching from the ST to the translation (Dragsted/Hansen

2008: 25), due to scrolling and moving the cursor (Angelone 2010), or because participants are reading the ST, or both the ST and their own draft (Dragsted 2012: 92; Kruger 2016: 48). It has also been shown that long pauses host all major cognitive processes such as planning and revision (Olive/Alvez/Castro 2009).

The results of interkeystroke intervals analysis showed a statistically significant difference between the two translation sessions, but they differ depending on the interkeystroke interval analysed. Pauses indicate a strong session effect, showing a significant decrease in their number in session 2. Thus, participants had to rely on pauses more frequently during the first session. This may indicate that participants spent more time reading, familiarizing themselves with the text, or making decisions during the first session. In contrast, during the second session, they were more focused on translating as they were already acquainted with the context and requirements of the text for its potential audience. This is also corroborated by the results in RQ1 and RQ2, as writing speed was always faster in the second session. The analysis of EPM as compared to CPM also showed less engagement in tasks other than producing text. As participants were translating the same text divided into two sessions, it is reasonable to conclude that the variation in this case was not because of linguistic experience (Friedlander 1989; Chenoweth/Hayes 2001) or working-memory capacity (Chenoweth/Hayes 2003), but more likely related with contextualization or decision-making processes as also shown by Wang, Li and Rasmussen (2025).

For respites, there were no significant differences between sessions or texts, but participants. As respites are assumed to indicate processing difficulties and attentional changes (Muñoz/Apfelthaler 2022) and are related to increased cognitive effort, the fact that significant effects were found only across participants (and not across sessions or texts) suggests that these cognitive processes are more strongly influenced by individual differences than by task-related variables. Consequently, addressing for individual differences is important when analysing respites, and future research should investigate which individual traits drive these effects.

Taking all these results together, this distinction highlights that deliberate planning and monitoring behaviours (i. e. pauses) decreased with task familiarity and progression, while involuntary disruptions (i. e. respites) did not, suggesting greater control and cognitive efficiency in session 2.

7 Conclusion

This study examined whether there were differences in writing speed and pausing behaviour between translation sessions and intervals in longer translation tasks. To this end, we analysed keystroke logging data from three texts translated from English into Spanish. The texts were approximately four times longer than those typically used in keylogging studies. The results revealed significant and consistent differences between translation sessions. Specifically, writing speed increased significantly in the second translation session (RQ1); writing speed again increased significantly in the second session when analysing it by dividing each session into intervals. Moreover, writing speed remained stable across intervals, with only the last interval showing a significant difference (RQ2); and interkeystroke interval patterns evolved, showing a reduction in voluntary pauses in session 2, while involuntary respites remained consistent throughout the task, though not across individuals (RQ3). These results support the idea that behaviour changes across extended translation tasks.

7.1 Methodological implications

Most studies in cognitive translation studies propose that the translation process is divided into three translation phases. Our results showed that both translation sessions and intervals differ in terms of product, process, and behavioural measures. This is particularly important given that most translation process research employs short texts, "sometimes very short [texts] indeed which means that duration of the translation amounts to only a few minutes" (Borg 2023: 30). As Breedveld (2002: 93) observes, if small chunks of text reveal important findings, then exploring the translation processes of larger segments or complete texts appears to hold promise.

The *first methodological implication* is that research into the translation process should use longer texts of around 900 words to avoid focusing solely on an initial translation phase. By not focusing on the first 200 words, research will be able to capture the full range of translation behaviours, thereby incorporating familiarity and contextualization effects into the analyses.

A *second methodological implication* is that translation process research should complement product and process measures with behavioural and pause analyses of the tasks performed. Behavioural measures, expressed in events per minute, enable researchers to observe dynamics that are not readily captured by traditional metrics such as drafting and correcting activities. Complementing these measures with pause analyses yields more robust results, as demonstrated in this study.

A *third methodological suggestion* concerns the choice of measures. Both product and process measures showed large session effects, but process measures were more sensitive to text differences and the only ones showing interaction effects. WPM proved to be the most robust metric. WPM and CPM with spaces were sensitive to text variations. EPM is sensitive to session effects and less tied to content, which makes it useful for assessing temporal and strategic dynamics. Respites are sensitive to individual differences. Ultimately, the selection of measures should be guided by the specific research aim as some measures excel at capturing overall trends, others at comparing sessions, and others at revealing individual variability.

Finally, our findings call for a rethinking of the orientation phase. Sun, Li and Zhou (2021) analysed the duration of the orientation phase in passages of 100–140 words and found three behaviours: reading the ST before translating, skimming the ST quickly before translating, and reading the first couple of words of sentences before translating. Our results show that independently of the behaviour of the participant, the characteristics of the initial moments of a translation did not differ appreciably from most subsequent intervals, contradicting Jakobsen's operationalization of the orientation phase. If that operationalization had been correct, we would have observed that interval 1 differed markedly from the other intervals, as we did observe for interval 6. Translation pedagogy often advises students to read the entire text before translating, but in practice it seems that translators start translating almost immediately, contextualizing, and adjusting their decisions while translating, a view consistent with Muñoz and Martín's (2018) definition of the initial phase.

7.2 Limitations and future research

This study has certain limitations that should be addressed in the future. First, the restricted and homogenous sample of participants (BA students) makes it difficult to generalize our results to other populations; however, it is still relevant as most research in cognitive translation and interpreting studies is done with translation students. It is recommended that future studies replicate this research with more advanced translation students and professional translators to ascertain whether the distinctions observed in this study persist. Additionally, we analysed the translation process without subtracting the pause values from the total sessions, in line with customary practice. However, this approach may affect the calculation of typing speed by as much as 20 % (Muñoz/Olalla-Soler 2022: 17). We recommend that future studies take this into account when calculating typing speed, as (long) pauses may not be part of the typing flow but rather reflect a strategic behaviour.

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