Problem-solving activity during the foreign language writing process: A proposal for categorisation and visualisation of source use and a new take on fluency in multilingual writing

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Abstract: Writing processes constitute a complex interplay of planning, formulation and revision. Ideas take shape through the activation of previous knowledge and, when permitted, also its synthesis with information from sources that help to complement it and resolve doubts and shortcomings arising during writing. The possibility to use external help can be especially useful to those writing in a foreign language, and questions about the nature of the sources consulted can contribute new insights into language processing in the multilingual mind, as well as expand our notion of fluency. While leaving the target text is often considered a distraction, a 'breakdown' in fluency, it is, in fact, a part of language processing and text creation.

This article proposes a novel way to use keylogging data from Inputlog (Leijten and Van Waes 2013) to visualise the crosslinguistic nature of solving language and content problems in L3+ writing: creating process graphs to display the temporal dynamics of different types of sources used. The example data comes from a university-level course on Spanish linguistics, where Spanish was a third or subsequent language for the participants. Evidently, the vast majority of their external activity was language-related and brief, and, interestingly, a great part of it recurs to a *lingua franca*, English. Some social context and reasoning is offered to explain such an observation.

Keywords: problem-solving, writing processes, keystroke logging, multilingualism, searching behavior, fluency

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1. Introduction

Multilingualism is omnipresent in today's academic and professional world (Aronin and Hufeisen 2009, García 2014, Stein-Smith 2016, Blackwood and Røyneland 2022). The personal and social implications of this multilingualism are key in research, but just as much in teaching and policymaking. It is therefore essential that we get to know the different learning trajectories and practices of language use that terms like 'multilingualism' and 'crosslinguistic interaction' comprise. Crosslinguistic interaction has mostly been investigated in the context of code switching, code mixing or borrowing within a conversation or within a text (i.e., in output), influenced by pragmatic choices and linguistic competence (Dewaele 1998, Hoffmann 2001, Androutsopoulos 2013, Orcasitas-Vicandi 2021). It is also at the center of the concept of translanguaging (Canagarajah 2011; Wei 2017; Skein, Knospe and Sullivan 2020; Cenoz and Gorter 2021) which advocates the use of all available resources for communication, independently of the "language" these resources are from). However, similar patterns also arise within individual language use, even without the presence of interlocutors. In other words, crosslinguistic interaction does not only, or perhaps not even mainly, concern output, being a conversational phenomenon or a stylistic choice of self expression. After all, as Weinreich (1953/2010:71) points out, it is the person who speaks multiple languages that constitutes the locus of contact. Therefore it is unsurprising that constant interaction between a person's languages also occurs during the production of monolingual text. This is also consistent with the dynamic view of multilingualism (Herdina and Jessner 2002, Jessner 2008, De Bot *et al.* 2007). Such interaction is highly idiosyncratic and depends on many intrinsic and extrinsic variables, such as the characteristics of the languages involved (language typology, proficiency, frequency and recency of use) and individual and contextual factors (e.g., anxiety, metalinguistic awareness, and task-related variables) (Cenoz 2003).

The objective of this paper is to portray the interplay of different languages in multilingual (L3+) writing processes; not only the weight of the mother tongue (L1, defined in this paper as the language a writer is most competent in, be it grammatically, lexically or pragmatically), dominant or first foreign language (L2 and target language (TL)[1], but also the purpose for their use. The primary distinction between L1 writing and writing in additional languages lies in the necessity to compensate for deficiencies in proficiency. How great is this need, and how does it manifest itself? Hence, whereas most research on fluency has treated external problem-solving activities as pauses in writing, it is also pertinent to inquire about their specific nature. Therefore, this article has two objectives:

(1) propose a categorisation and ranking for the various problems encountered and solutions found, thus providing the means to visualize crosslinguistic interaction during problem-solving activities with dynamic process graphs;

(2) describe the data and tools necessary for said visualisation.
In the course of presenting our theoretical argumentation, procedure and empirical results, a proposal is made for expanding the notions of fluency and crosslinguistic interaction. Finally, future research and application paths that emerge from this novel perspective are discussed.

2. Frameworks for (multilingual) writing processes

Flower and Hayes can be considered the "parents" of modern writing process research. It was their proposal to view writing as a cognitive process for solving problems (Flower and Hayes 1977, 1981): achieving a writing goal through planning, formulating and revising. A problem, in this context, is defined as "the existence of a gap (between an initial state and an intended goal or final state) that cannot be bridged without a search process" (Manchón *et al.* 2009: 106). The Flower and Hayes model (1977, 1981) has set the basis for subsequent models and studies; the simple recursive interaction they propose between these three activities is entirely relatable. However, if one starts to delve deeper into the intricacies of this interaction, it soon becomes clear that, much like any good general model, such simplification makes it difficult to grasp the complexity of the mental processes involved, especially in computerised settings where authors need not limit themselves to their existing knowledge, but can also look for additional information and clarifications. Such a situation is a good example of Baaijen and Galbraith's dual-processing model (2018), which supposes that writing is not picture-telling where we reproduce a complete account of a topic or an idea, but rather it is an interactive synthesis of activation of previous knowledge with the discovery of new complementary information at the moment of formulation. In contrast with former task/experiment designs that investigated writing in pen-and-paper test situations (see section 5), technological and methodological innovation make it possible to construe more authentic conditions: keyloggers, screen recorders and eye-trackers can be used to monitor writing processes in an unobtrusive manner. In a revised model, Hayes (2012, see Figure 1) has also reformulated the three major components of the writing process to be the resource level (before, planning), process level (formulation) and control level (revision).

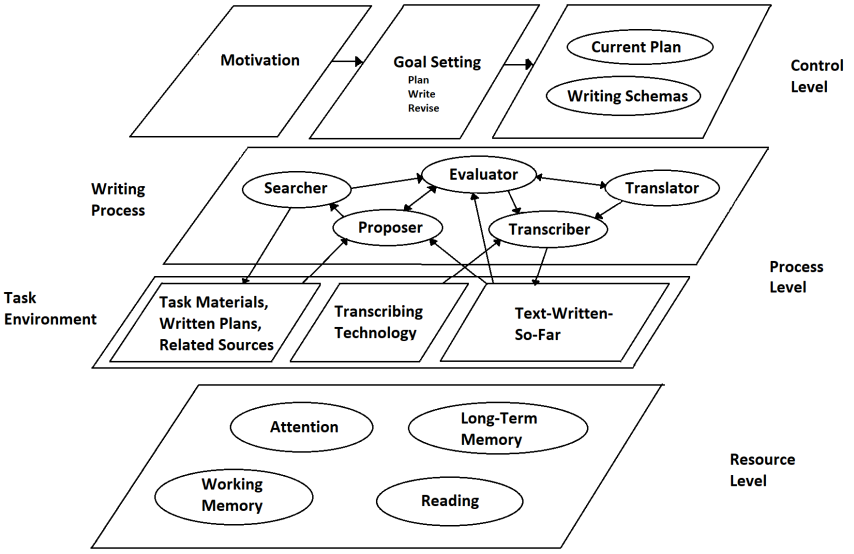

Figure 1. Model of text composition adapted from Leijten et al. (2014) with authors' permission.

This model can easily be expanded to include the reading of texts other than the one that is being written by the author (in Leijten *et al.* 2014 where the Hayes 2012 model is adapted for professional communication, this is called the 'Searcher') and sources related both to language and content ('Related sources' in the Task Environment). However, it is more challenging to incorporate the different languages which multilinguals have at their disposal to consult such sources, or also make their plans and write drafts, mostly because of our limited knowledge of multilingual writing processes. This is reflected in the following literature overview. Rinnert and Kobayashi (2016) have devised a comprehensive model of factors that influence authors' problem-solving behavior: their decisions depend on their "repertoire of knowledge" (transferable skills, experiences, facts) and "social context" (individual and situational factors: language proficiency, task-related variables, attitudes and perceptions, etc.). Writing, especially multilingual writing, is a very personal and individual process. Crosslinguistic activity arising from different possible language repertoire combinations (L1/L2/L3+) is far too complex and underresearched to be able to incorporate it into the model at this point. Some of these complexities will also be addressed in section 5.1.

3. Crosslinguistic interaction

A decade ago, multilingualism was in the spotlight of applied linguistics and sociolinguistic research, increasingly challenging traditional notions of language competence and shifting the focus from the idealised native speaker to multicompetent users with highly idiosyncratic practices (May 2013). Herdina and Jessner (2002, also in Jessner, 2008), refer to the need to view transfer phenomena, i.e., the interactive relation between a multilingual person's languages, as a 'coherent set of phenomena', and therefore 'crosslinguistic interaction' offers the most precise description for behavior during text production in foreign languages. 'Translanguaging' is also a frequently used term, which Canagarajah (2011) uses in a conversational and pedagogic context, where the oral or written result is also multilingual. Further, he describes translanguaging as "creative improvisation according to the needs of the context" (Canagarajah 2011:5), which is in concordance with Hoffmann (2001). Hoffman states that trilingual competence (used as an umbrella term for plurilingual systems of L3+) "enables speakers to create their own linguistic means in order to master particular communicative situations." This definition brings us much closer to describing the sort of multilingual writing processes that form the core of this article.

The interaction between a multilingual's languages forms an inseparable part of what Herdina and Jessner (2002, chapter 7) and Jessner (2008) call the M-factor (multilingualism factor) characteristic of people who know several languages: "the behaviour of each individual language system in a multilingual system largely depends on the behaviour of previous and subsequent systems and it would therefore not make sense to look at the systems in terms of isolated development." (Herdina and Jessner 2002:92). The problem-solving skills acquired before, alongside, and as a result of foreign language learning are valuable transferable skills (Nshiwi and Jessner 2021) and therefore form a part of "common underlying (language) proficiency" (Cummins 1984, 1991). In other words, the idea of translanguaging (Canagarajah 2011, Skein, Knospe and Sullivan 2020) or multicompetence (Cook 1992, 2007, also Cummins 2007) needs to include the individual language processing and problem-solving activities that lies behind the creation of any text by multilingual individuals.

As Herdina and Jessner point out (2002:69), multilinguals have the obvious advantage of language choice. They refer to choosing the language of communication, but, in fact, the same choice also applies for any productive activities, especially problem solving, as also indicated in Rinnert and Kobayashi (2016:376). The big question is which language(s) a multilingual chooses in a given situation, be it intentionally or unintentionally. Speakers of different L1 (as well as L2, L3+) have different points of departure when learning a language (Wesche and Paribakht 2010, Lindqvist 2015, Kruse 2018), which would also suggest their behavior differs depending on specific configurations of L1+L2+L3+. Factors that have been noted to affect the choice are recency, proficiency, and L2 status (Williams and

Hammarberg 1998, Bardel and Lindqvist 2007, Falk and Bardel 2010). Most importantly from our perspective, however, studies on transfer have determined that a factor of great importance is typological comparability, namely psychotypology or perceived distance between a given set of languages (Kellerman 1983, Ringbom 1986, Williams and Hammarberg 1998, Bardel and Lindqvist 2007, Llama *et al.* 2010, Lindqvist 2015, Fuster and Neuser 2020, Nelson *et al.* 2021, and Rothman's Typological Primacy Model (Rothman 2010, 2015)). Structural and lexical similarities perceived while comparing languages also mean recognising cognates (Hall *et al.* 2009). The source of transfer is therefore based on whether users deem a pair of languages to be similar enough to expect transferability. This can be compared with typological distance (Viberg 1998), but, from the perspective of a language user with no background in linguistics, is more pertinent because their notion of transferability depends precisely on their perception, not an etymological analysis (Kruse 2018, Nelson *et al.* 2021).

Earlier studies had participants produce language without being able to consult any resources. It is therefore natural that the default supplier language hypothesis has mostly been tested for more or less unconscious choices for which language to use and not as part of writing strategies. Nevertheless, a task design that does permit external help for problem solving adds a pragmatic aspect that is based on the perceived usefulness of a language according to the experiences of the user, in addition to their competence in the language combinations involved, as well as their recency. To an extent, this pragmatic perception of usefulness is related to the typological/perceived distance between languages, but more so it is a structural aspect that correlates with the availability of resources for a language pair or a topic area.

4. Previous studies on multilingual writing processes and external source use

In a context where multilingualism is in the spotlight (May 2013), it is curious to note that even academic writing in FL English has not been studied notably in environments where English is not the surrounding language (Langum and Sullivan 2020), not to speak of writing in other languages. Studies on the activation of other languages in L3+ use have almost exclusively designed tasks where the use of external help is not allowed; Chau *et al.* (2022) also point to the lack of process-oriented research on source use in writing, which complicates explaining and contrasting findings. In studies of crosslinguistic interaction, picture telling and argumentative tasks based on personal opinion and knowledge have been popular (Cenoz and Gorter 2011, Orcasitas-Vicandi 2021). A case study by Kobayashi and Rinnert (2013) used stimulated recall interviews (asking about pauses longer than 5s) and had their participant produce several argumentative texts in L1 Japanese, L2 English and L3 Chinese over a period of two and a half years, allowing dictionary use, but no internet access. Their case study showed that L3 writing involved more

compensatory problem-solving than L1 and L2 writing, which focused on higher-order concerns such as upgrading lexical choices or avoiding repetitions. Overall, crosslinguistic interaction seems to have had a notably secondary role in the study. Tullock and Fernández-Villanueva (2013) used think aloud protocols to study multilingual students writing in L4 English, finding evidence of all background languages (L1, L2 and L3) being activated during the writing processes, but L1 (Spanish) being the most active. However, all 10 participants also recurred to L3 German at some point, leading the authors to interpret the writers' behavior as indicating at least a tacit awareness of language distance (German being closer to English than Spanish).

In studies on multilingual writing processes, keyloggers have apparently not yet been used very extensively despite their potential as an unobtrusive and precise method of investigation. Some of the following example studies have been selected because of they focus on multilinguals, and specifically source use during writing. Others are not necessarily multilingual, but have proportioned means to visualise the process and, therefore, serve as examples of approaches taken so far:

Chau *et al.* 2022 had a research design quite similar to the one reported in this article. They used Inputlog for a synthesis writing task whose aim was to compare students' behavior writing texts in three languages (L1 Dutch, L2 English, L3 French, each text in a different target language). In addition to the source texts necessary for the writing task itself, and the target text, the researchers also recorded the use of other sources, which would be the sources used for solving problems. Among these, they established the categories of "content" (background information), "language" (distinguishing between "general" and "synonym" queries), "search", "task" (genre requirements) and "other". Their results made it clear that the need to consult such external sources was the smallest in L1, increased by 19% for L2 and was yet greater in L3 (65% increase compared to L1). Most of the problem-solving activities were language-related, although it was not specified if it took place in the target language or another language, i.e. crosslinguistic activity was not noted. These results indicate that proficiency and resulting automaticity play a role in the extent to which external help is needed to aid planning and/or formulation.

As far as could be found, the study with the closest design and objective to the present study has been that of Knospe (2017, with results also presented and discussed in Knospe *et al.* 2019). Her objective was to analyse external source use for multilingual participants (N=7, L1 Swedish, L2 English, L3 German) writing in German. They were allowed to consult internet sources at will, but it was seen as "a disruptive factor" to writing fluency and, between the sessions, students received instruction to reduce it because the instructors considered it kept them from applying their own linguistic analysis skills and knowledge. Figure 2 represents the visualisation of the writing processes offered in Knospe's study, which is the one available in the Process Graph in the analysis module of Inputlog (Leijten and Van Waes 2013). This overview provided of external source use is very general and

mostly serves to illustrate whether the excursions outside the target text were scarce or numerous, brief or more extensive. Information on the nature of these queries must be obtained from the Source Analysis module and requires qualitative analysis, which the author also provides.

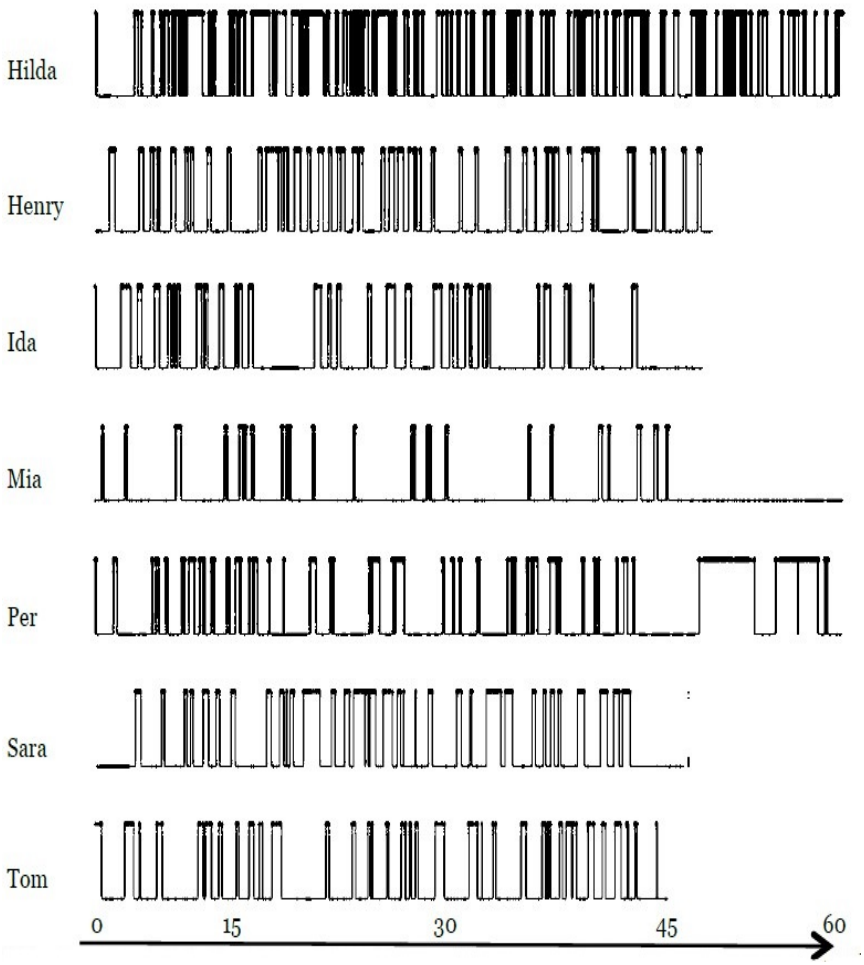

Figure 2. Visualisation of switches between the main document and online sources for the seven participants from Knospe (2017). For each participant, the lower line represents the time spent in the main document, and the upper line represents external source use. Reproduced from Knospe (2017: 144) with author's permission.

It becomes clear that the participants exhibited different behavioral patterns: some 'controlled the sources' (Ida, Mia, and Sara: deliberate, fruitful and scarce source use) and others were 'controlled by the sources' (Hilda, Henry, Per, and Tom: ample yet accidental source use). As the task used supposed that participants have an opinion they were not required to sustain with external references, nearly all problems that needed external solving were linguistic. The students 'controlling the sources' used bilingual dictionaries to look up specific words in uninflected forms, which showed their awareness of both L1 and TL grammar. Additionally, most of their queries were successful, or they found alternatives easily themselves. The opposite can be said about those 'controlled by the sources': they used longer phrases, inflected forms and, in some cases, translation tools; their lack of grammatical analysis resulted in many fruitless queries, which meant that external source use did not serve the purpose of solving problems and was just an interruption. These observations highlight the necessity for both qualitative and quantitative analysis. On the other hand, Knospe's results indicated that when writing in L2 (and not L3), also students 'controlled by the sources' wrote more fluently, consulted fewer sources and needed fewer revisions. Furthermore, during the 10-month experiment their writing in L3 became notably more like L2 writing. Therefore, in lines with the conclusions drawn by Chau *et al.* (2022), an increase in proficiency gave L3 writing traits characteristic of L2 writing, which is a conclusion that warrants further exploration. Furthermore, given how Manchón *et al.* (2009) concluded from their study on L1 and L2 writing processes that advances in L2 proficiency made the time distribution between planning, formulation and revision more balanced and more similar to writing in L1, this could lead to think that differences in L1/L2/L3 composition processes are mostly dependent on proficiency, but this has not yet been explored.

As to visualising source use during writing, a more detailed view is offered in Leijten *et al.* (2014). They studied internet source use in L1 professional writing, distinguishing between work on the target document, other relevant documents, e-mails, project management tools and other external sources. Figure 3 shows an enhanced version of Inputlog's Process Graph: in addition to the relation between all the text produced (solid top line) and the advancement in the final text excluding deletions (lower, dotted line), which are always provided, they added 'Comments' and 'Points of Interest' that are discussed in their analysis. The bottom part of Figure 3 displays interaction between sources and target text like the graphs provided in Knospe (2017), i.e., Figure 2. To render a more qualitative and detailed visualisation of this interaction, they also include a source analyses matrix (Figure 4) created from Inputlog data with Pajek (Mrvar and Patagelj 2016). In this graph, each source category is represented by a 'vertice'; the size of the vertices is proportional to the time spent on them, and the arrows represent the direction in which the source interaction proceeded.

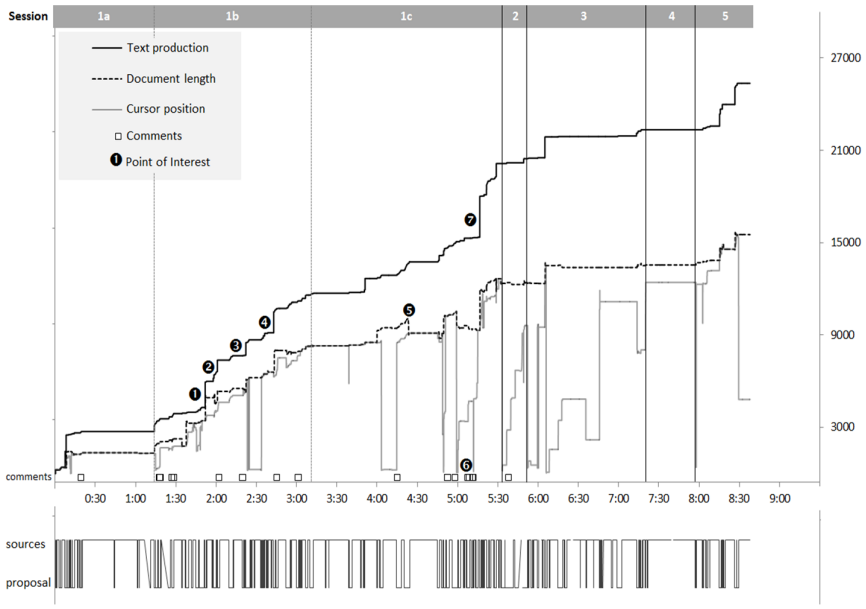

Figure 3. Enhanced process graph that combines the five analysed writing sessions (top part) and the use of digital sources therein (bottom). Reproduced from Leijten et al. 2014:298 with authors' permission.

This visualisation enables the user to distinguish between different source categories and get a neat outline of which were the most used sources and which of them had mutual interaction. However, if we were interested in analyzing different parts of the writing process or studying the nature of the linear progression of source use during writing, we would need a different type of visualisation: a dynamic process graph.

As indicated above, observations by Leijten and colleagues (2014) led them to suggest an 'integrated approach to fluency' because the activity between S-bursts, i.e., source use during writing, forms an integral part of computer-mediated online writing. Later, an analysis of MA students' writing in L1 and L2 (Leijten *et al.* 2019) provided more evidence of the fact that the interaction with digital sources is also a part of the L1 planning or revision process (often being impossible to distinguish between the two). Hereafter, a proposal will therefore be made to address the notion of fluency from a broader angle.

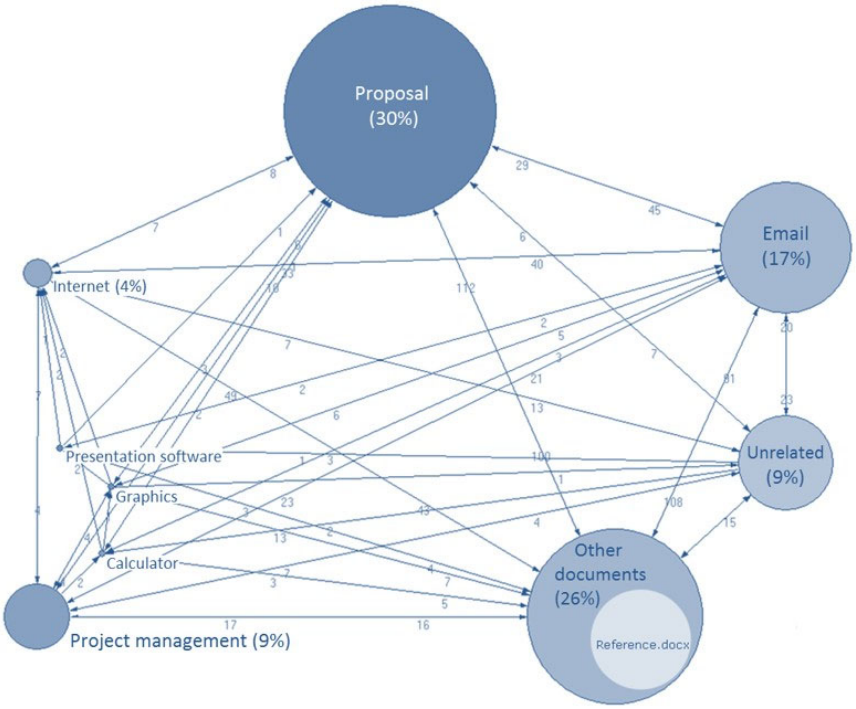

Figure 4. Interaction between source types represented in the recorded sessions and the proportion of their use as reflected in the size of the vertices. Reproduced from Leijten et al. 2014:317 with authors' permission.

5. A revised view of fluency

In product-oriented studies, fluency has been operationalised as token count, errors per 100 tokens and overall text quality as assessed by the evaluator, produced in a given amount of time (Nguyen 2015). Although there is an novel attempt to analyse pausing behaviour and fluency from a qualitative point of view and relate them to argument type (Tian *et al.* 2023), other writing log research (Spelman Miller *et al.* 2008, Kim *et al.* 2021) has similarly viewed fluency as a quantitative matter in terms of pausing behavior and language bursts, i.e. chunks of characters produced between two consecutive pauses (length of run in oral output, as in Skehan 2003, 2009 or Derwing 2017). Kowal (2014) focuses on transition time (meaning typing speed) as well as length of burst. Van Waes and Leijten (2015) center on fluency within both the target text document and the writing process, defined by words per minute, pauses or revisions, but also point to the intention of extending this to "interaction with digital sources", i.e. interruptions in text production. Apparently,

this is the first call for an integrated approach to fluency, and it is precisely such an approach that best reflects current digital writing practices.

External problem-solving activities are often considered interruptive to target text formulation; Knospe (2017) repeatedly refers to leaving the target document as an interruption and describes her attempts to dissuade her participants from resorting to such disruptions. However, as demonstrated by the highly skilled and professional writer in Leijten *et al.* (2014), and the MA students in Leijten *et al.* (2019) writing in L1 and L2, the interaction with digital sources is also a part of the L1 planning or revision process (often being impossible to distinguish between the two). Leijten and colleagues call the activity between external source uses S-bursts, as opposed to P-bursts (bursts between pauses) and R-bursts (bursts between revisions) (Leijten *et al.* 2014, Leijten *et al.* 2019). The activity between S-bursts reveals the use of strategies to complement information, find inspiration and, in the case of multilinguals more than for L1 users, compensate for the lack of linguistic knowledge or verify hypotheses. As such, it forms an essential part of any computerised and dynamic writing process and reveals some of the cognitive activity that takes place during what has so far been considered a pause or an interruption. Given that most research design still requires participants to only use their existing knowledge, such a view is also most natural because it eliminates the external problem-solving activities and, therefore, has no use for an extended view on fluency. Yet, any person who has written texts on the computer and with internet at hand can testify that these conditions are not authentic. Bearing this in mind, the proposed revision of fluency expands our knowledge of what writing has become in the workplace or in academia.

The model of writing proposed above, where the process level also comprises problem-solving behavior outside the target text, requires an expansion of what is commonly understood as fluency. As Schmidt (1992) indicates, this term is used both in non-linguistic context, roughly equalling proficiency, as well as in scientific literature (for a discussion, see Palviainen *et al.* 2012). In sum, it is Schmidt's definition of fluency as "the processing of language in real time" (1992: 358) that is most adequate and sufficiently broad for our purposes. However, Schmidt also states he prefers "to identify fluency with skill rather than knowledge, again emphasising the performance aspect of actually doing something in real time rather than the knowledge of how something is to be done". At least when producing written output in authentic conditions, it is impractical to separate skill from knowledge: the external problem-solving activities that constitute the focus of this article comprise practices related to both. It is an inherent part of computer-mediated writing prevalent in our everyday practices, and, therefore, also a distinct aspect of fluency as the real-time processing of language. Or, rather, such interruptions can be viewed as non-fluency, but still form a part of the processing of language (both for grammar and lexis) and information (for content, but also by the means of language) in text production. As such, it is a part of what Skehan (2009)

and Housen *et al.* (2012) call 'breakdown fluency' (pausing behavior), which, alongside speed fluency (rate and density of linguistic units produced) and repair fluency (amount of self-corrections, misformulations or false starts) forms a three-dimensional view of fluency.

A crosslinguistic take on breakdown fluency

On the one hand, turning to sources outside the target text is a part of the writing process that is often viewed as a disruption or activity that breaks down the fluency of text generation. On the other hand, it complements the thought process and, therefore, forms a helpful part of digital text composition, a sort of scaffolding at moments when it is needed. As such, it is a fascinating question what writers are doing when they are not formulating their target text, because this activity sheds new light on text planning, as well as formulation.

The writing process can be viewed as a continuum, where the writer starts with a blank sheet (and a more or less vague idea of the desired result), and finishes with completed text. If we were to visualise this process in conditions where there are no distractions, it would move from start to end in a straight line:

thinking up an idea → formulating → product

This would entail we already possess all the necessary knowledge and do not need to revise anything. However, even in L1 writing, authors do constantly ponder, reformulate and revise, as well as look to outside sources for help if these are not unaccessible for some reason (consider the professional writer in Leijten *et al.* 2014). This is because the idea or plan is more or less abstract and still needs to take form. It is expected that planning prevails before starting to write and in the initial phases, formulation is prominent in the middle and, towards the end, we mostly revise and change; yet, there is constant interaction between these three processes (e.g., Roca de Larios *et al.* 2008, Barkaoui 2015, Michel *et al.* 2020). If the writing occurs in L3+, the formulation of a specific phrase can pass through several stages, involving several languages from the author's repertoire.

The logic behind the dygraphs proposed hereafter for visualisation supposes that formulating clear and coherent text in TL is a writer's goal, represented by (0), and problem-solving activities outside the target document take them further from this goal. In this section, a potential reasoning is offered to divide external activity into categories and later use these for visualisation. A more visual representation of this is provided in Figure 5 (section 6.2.).

- If we had no problems at all in organising and formulating our ideas, a timeline of the writing process would advance toward our goal following a straight line (the 0-line, represented by the x-axis on the dygraphs displayed in Section 6.4., i.e. Figures 7-10).

- In real life, however, lesser or greater detours always occur, especially if we write in foreign languages. Some issues are related to formulation, i.e. the idea has already been conceived:
    - Sometimes we just need to refine the way we formulate our thoughts, meaning looking for specific linguistic information such as the context of use of a word, their collocations (as in corpora, for example) or synonyms.
    - Oftentimes, language information chunks of different size (from less to more complicated) are missing to formulate an idea in TL:
    - an expression, in which case the writer is aware that they are looking for an idiomatic unit,
    - a single word, or
    - an entire phrase that has been thought up in another language, but needs to make its way to TL.
- At times, ideas need clarification or outside sources are needed to complement existing knowledge on the topic. These are content problems, meaning they relate to planning and are further yet from the goal.
- For the particular writing session that is described below, an extra category was needed for activity that combined content-related and language-related problem-solving, given that the essay topic was linguistics. For example, words like "canguro" (*cangaroo/nanny*) or "ojo de buey" (*porthole*, literally *bull's eye*[2]) were used as illustrative examples of lexical phenomena, making them content-related items, but the related searches came from the need to specify their meaning or use, hence qualifying as deficiencies in linguistic knowledge and calling for a separate category. In settings where the writing topic is not language-related, such distinctions probably will not be necessary, but they also illustrate the fact that planning and formulation are intertwined and making discrete distinctions between the two is challenging.
- Both language and content problems can require help from languages other than TL. Problem-solving activities can therefore be divided into different tiers; in the example categorisation displayed in Figure 5 these are four, moving from bottom to top:
    - TL: in the same language as the text being written, so no interlinguistic activity involved (green in Figure 5);
    - L1 and L1-TL: the most automatic and cognitively least demanding way of solving any problems related to content or formulation (cream-colored in Figure 5);

- LF: recurring to a *lingua franca*, i.e. a foreign language different from TL. For language processing, it requires more effort than L1 activity (tan-colored in Figure 5).
- L1-LF: sometimes, lexical information between L1 and TL is not available, but LF knowledge is not sufficient to use this language directly. It is then necessary to first use L1 to find the missing lexical information in a dominant or more accessible foreign language and thereafter in the text TL. This situation is undoubtedly the most demanding and gravitates farther from (0) (pink in Figure 5).

6. Present study

Data collection for this study aimed to gain insights into multilingual writing, especially the way external sources are used to solve problems during the writing process. For this purpose, a writing task was devised that served both as an evaluation method in a university FL linguistics course and an experimental task. The writing process of the first version of the final paper for a course on Spanish Lexicology was recorded with Inputlog 8.0 (Leijten and Van Waes 2013). For the participants, Spanish is L3+ and the whole course, which gives an overview of different morphological, semantic and collocational characteristics and patterns of words in the Spanish language, therefore has elements of CLIL (Content and Language Integrated Learning): although the main purpose is to concentrate on the intricacies of language and the organisation of linguistic knowledge in the human mind, also elaborating on different dictionaries and corpora, the underlying aim is to refine the students' knowledge of the Spanish language and get advanced practice. The title/topic of the essay is "La riqueza del léxico, una bendición y un dolor de cabeza" (Eng: *Lexical richness, a blessing and a headache*). This piece of writing mostly serves the purpose of providing students with an opportunity for meaningful text production, acting as a rehearsal for writing the final BA paper that takes place during Year III, more intensively in the spring semester. The aim is to practice setting objectives and structuring text, meanwhile including course contents to prove the participants have reflected upon them. Therefore, it is an inherent part of the intent to immerse students in Spanish during their studies.

The extent of the essay is roughly two pages, and all participants, including those not taking part in the study, have 90 minutes to write it. Evaluation criteria are provided beforehand to give them a better idea of what is important for the writing task, and they can prepare an outline to use while writing. After the first draft, they receive feedback from their peers and the teacher, and proceed with revising the draft and presenting a final version of the same essay. This final version, however, is written at home over a more extended period of time, so that students need not worry as much about time constraints. For the experiment, i.e., the first version, the

setup of the writing task aims for maximum authenticity and the motivation to perform well is as high as can normally be expected. The data collection method described hereafter is also chosen to interfere as little as possible in the way students normally write their texts in Spanish.

6.1 Participants and data collection

During three academic years (2018-19, 2019-20, 2020-21), writing logs were collected from 16 students enrolled in the course of Spanish Lexicology (Year 3 in the BA program) at the University of Tartu in Estonia. According to the background survey completed before the writing task, nearly all the participants had Estonian as L1, while one was L1 Russian and one was Russian-Estonian bilingual. All but one participant were female, with ages between 21 and 43 years (median 21.5, SD = 5.4). Their proficiency in Spanish ranged from B1 to C1+ according to the placement test by Instituto Cervantes (AVE), and all had English as L2. Other foreign languages in the group were Russian, Estonian, Italian, French, Finnish, and German, but these were not used to a mentionable degree during the recorded writing sessions.

Being Year 3 BA students, and considering that during their university studies they received roughly the same input from their teachers, the disparity in target language proficiency between the participants is noteworthy. Some of the divergence can be explained by the fact that some students had learned Spanish before coming to the university. However, the degree to which they had been exposed to the language before and alongside their BA studies is unknown, and a group that could be expected to show a similar level of proficiency is, in fact, very diverse.

Before the essay, the students participating in the course of Lexicology received a call to take part in the writing experiment with the recording of their writing process, and had time to familiarise themselves with the information sheet provided both in Spanish and Estonian. Those willing to contribute signed a consent form, took the Spanish proficiency test and completed the background questionnaire.

All students wrote the essay in a computer lab at the university (except the only participant from 2020 who downloaded Inputlog on their computer and wrote at home because of pandemic restrictions), to give all students equal conditions when time and technological resources are concerned. For participating students, the screen recording software Panopto was distance activated, while they themselves had to initiate a recording with the keylogger Inputlog (Leijten and Van Waes 2013) pre-installed on the computers. After finishing they sent the log file to the author by e-mail. While writing, they were free to use any internet sources and their notes, just like their peers, so participating in the experiment was as unobtrusive as possible.

6.1.1 Contextualisation of linguistic background

To put into context the crosslinguistic interaction displayed in the following dygraphs, the role of English in Estonian education and society needs some explanation. Estonian, for being a language with only about a million speakers, is, in fact, very well equipped with digital resources for everyday use and research (such an estimation was made back in 2012 by Liin *et al.* and since, the situation has kept improving). However, resources directly between Estonian and Spanish are scarce. Dictionaries proper are on paper and therefore rarely used by students, as they have repeatedly confirmed within the course of Lexicology, where we discuss language resource use. The main online resource between Estonian and Spanish could therefore be Google Translate, but the results it renders are unreliable. Resources between English and Spanish on the other hand, being two of the most used languages in the world alongside Mandarin Chinese, are abundant and being developed continually. As Zabrodskaja and Kask (2017) state, English is widely used in Estonia, especially in information technology. The authors even claim Estonia is becoming a trilingual country, with English as the most popular foreign language in schools. A report by the Ministry of Education and Research (Kirtsi *et al.* 2011: 28) asserts that English is not viewed as a foreign language, but as a main competence that every student has a right to develop, and society expects schools to offer this opportunity. Moreover, young Estonians (secondary school students, especially those from urban areas and wealthier families) see high instrumental value in English and would hypothetically even choose to educate their own children in this language instead of Estonian (Ehala and Niglas 2006). It is also noteworthy that, according to the results presented in Zabrodskaja and Kask's report (2017), young Russians have a slightly lower proficiency in English. This might be explained by the fact that speakers of L1 Russian have to acquire their secondary education in a foreign language and English is L3 for them, so they are somewhat disadvantaged (Soler-Carbonell and Karaoglu, 2015). In the results and discussion, some light will be shed on how such linguistic backgrounds affect writing habits.

6.1.2 Categorisation of crosslinguistic activity in external source use

Based on the reasoning put forth in section 5.1. on different types of crosslinguistic activity evidenced in the writing processes of our multilingual participants, Figure 5 proposes numeric values for the source use types, combining the increasing complexity of the language/information gap with the proposed language tiers. These values are needed to facilitate a new type of visualisation by generating dygraphs and simply to distinguish between different types of activity, but are not intended to indicate absolute evaluations as to the cognitive complexity of each activity type. The proposed logic can be adjusted according to the needs of other research designs and questions.

LF-L1 area	whole phrase translations, no intent of independent LF formulation	22
	word search	21
	expression search (idiomaticity)	20
	LF-L1 word search (back-check)	19
LF-TL area	content search in LF	18
	content+language issues	17
	whole phrase translations, no intent of independent TL formulation	16
	word search	15
	expression search	14
	TL-LF word search (back-check)	13
L1-TL area	content search in L1	12
	content+language issues	11
	whole phrase translations, no intent of independent TL formulation	10
	word search	9
	expression search	8
	TL-L1 word search (back-check)	7
TL area	content search in TL	6
	content+language issues in TL	5
	word search	4
	expression search	3
	search for lexical context, word uses (syn-ant)	2
	fine-tuning: grammar, corpora, hedges	1
	writing in TL	0
technical area	saving, opening, formatting, etc.	-1

Figure 5. Categories for problem-solving activities. L1=language of highest competence, LF=lingua franca, TL=target language.

Figure 5 is read from bottom to top, with each of the language tiers represented by a different color: target language area is green and writing the target text equals 0 (in the dygraphs introduced in section 6.4., it is represented by the x-axis), using L1 is cream-colored, the *lingua franca* area is tan, and problems that require solutions involving L1 + LF (i.e., not using TL) are pink. In each area, formulation problems are placed closer to 0 and content problems are further up. At the very bottom, there is also a 'Technical issues' category which needs clarification: in the experiment at hand, some of the activity was not related to formulating the target text nor solving language or content problems that had arisen, but rather had to do with the fact that the writing process was computerised and required the writer to take action to format their writing (not to be confused with revising or editing!), save it, open new windows or tabs, sign in to services, etc. As such, these were the real distractions from the writing process. The rest of the activity, however, served to complement the planning, formulation and revision process.

6.3 Method of analysis for keylogging data

As explained, our proposed dygraphs are based on keylogging data from Inputlog (Leijten and Van Waes 2013). This program provides several different types of analyses: General, Pause, Linear, Source, Revisions, Process Graph, Fluency, and Summary; also, Target Words, Bigrams, and, for English, Linguistic Analysis. Furthermore, the results can be merged with Tobii logs when experiments use a Tobii eyetracker (this was not the case in the present study). These were the steps followed for processing data from the experiment:

1. The 'Recode' function in the Preprocessing module was used to classify activity outside target text document (i.e., the use of external sources) based on the language used, and sorted into categories of 'content problems' and 'language problems' of different degrees (see Figure 6 for screenshot). After regrouping the sources, Inputlog creates an xml logfile with all categories and sources they contain, which can then be opened with MS Excel and saved as a worksheet that can be manipulated for further analysis.

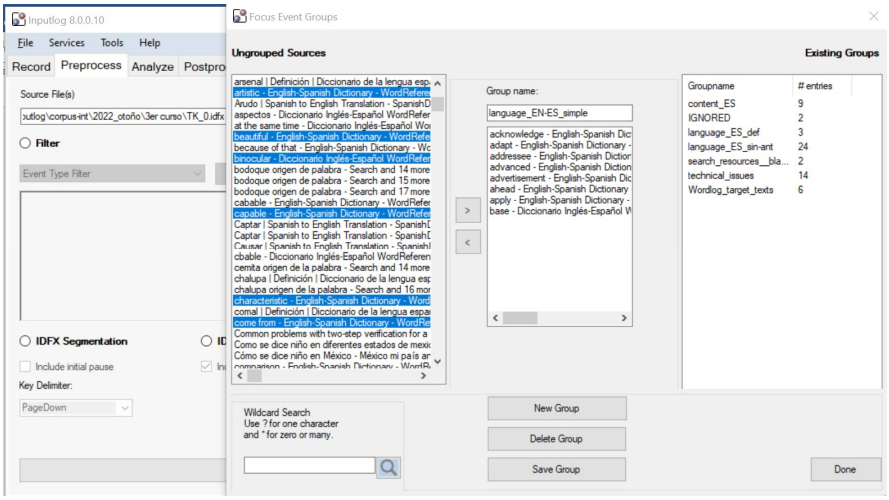

Figure 6. Screenshot of the source grouping window open over Inputlog's preprocessing module, with sources still ungrouped on the left, the group being manipulated in the center and groups saved so far on the right. These source group titles were later further grouped into categories with numeric values as detailed in Figure 5.

2. Whereas Inputlog's Source Analysis does provide information on the interaction among different sources, as well as total times spent consulting each of them, it does not display a timeline log of source use and, in order to

use it for a dynamic process graph, it needs to be manipulated. To create such a timelog, these were the steps taken:

2.1. In Inputlog's Postprocessing module, General Analysis output from the original (unaltered) writing process logs was combined for all participants and saved as a MS Excel worksheet.

2.2. This data was filtered for 'focus switches', i.e. changes between windows or tabs, thus excluding keyboard and mouse activity that was not pertinent to the analysis.

2.3. The combined General Analysis data was complemented with information on which source belonged to which category, using MS Excel's Index function and data from the logfile in Step 1.

An external source type that deserves special attention here is the online machine translator (in the data at hand, Google Translate and Yandex Perevodchik were used). Their results mostly do not show on logs as dictionary searches do, they do not have their own web addresses like dictionary entries. Inputlog registers them as separate sources if the user presses 'Enter' after finishing typing their sentence, but given that they already see the translation on the screen automatically without doing so, they hardly ever do. Keystrokes from the Inputlog General Analysis give some idea of the languages that were used in such cases, whereas screen recordings paint a complex picture: some participants switched back and forth between languages to compare translations, sometimes even involving three languages at the same time. Therefore, in Step 1, such sources received the classification 'machine translator use', which was then complemented manually with category information with the help of screen recordings in combination with mouse clicks in the General Analysis log.

2.4. The duration of each focus use was calculated.

2.5. Finally, the data was densified. The original General Analysis provided information on the moments where focus switches took place. This was taken to a timeline with data points at 100ms intervals, where external source category information was filled in, adding the moments of focus switching and then repeating the focus number until the next switch. In this manner, different participants could be taken to the same scale because it was known which kind of activity was taking place at any given moment for any given participant. This resulted in a new log of the writing process that could be used to generate interactive process graphs for problem solving during the writing process, which will now be shown in more detail.

6.4 Dynamic visualisation of crosslinguistic activity in source use during writing

To create a graph that displays the consecutive sources used, all that is needed is a table where, in one column, there is the timestamp of the focus/source switch in 100ms (or preferred unit of time) as a numeric value and, in the second column, the category of the source used at that moment, represented by a numeric value. With this data and using the dygraph package (Vanderkam *et al.* 2018), R (R Core Team 2021) can generate interactive graphs, the static images of which are shown in Figures 7-10.

The interactive versions of these graphs, as well as the code for their creation in R can be found at https://sisu.ut.ee/multilingualwritingprocesses (adapted from Lee 2018). There, the user can zoom in on different parts of the process and hover over any focus point to see its category and timestamp in seconds. In group graphs, ticking or unticking checkboxes above the graph allows to select which participants to display. In a sense, these graphs are a more sophisticated and detailed version of the external problem-solving diagram displayed on Inputlog's Process Graphs (see Figures 2 and 3).

On example dygraphs, the x-axis is the time and the y-axis shows the activity in determined areas; for visual consistency, these have the same colors and placement as in Figure 5: Categorisation. Therefore, the higher the external source is located on the graph, the further the writer is gravitating from (0). In each language tier, content problems, i.e. issues related to planning are in the upper portion (either on the top border or directly below it). In the following discussion, suggestions are offered as to what information can be gained from visualisation via the proposed dygraphs, and what are the blanks of knowledge that can be expected to be addressed.

Figure 7 displays text creation by a highly proficient and knowledgeable L3+ user, 'Ursula'. In addition to excellent language proficiency, she also had a clear understanding of genre requirements, was very well prepared and produced an essay of excellent quality, so she represents an 'Expert Writer'.

Her incursions outside the target document are few, and in those cases she consults language-related sources: in the earlier stages she executes a few word searches between LF and TL (so English-Spanish, category 15)[3]; later on, she mostly checks the meaning of specific Spanish words (category 13) and searches for synonyms to common Spanish words (category 2).

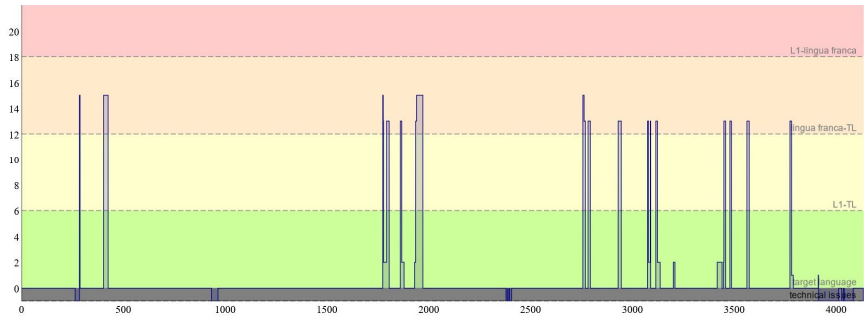

Figure 7. Dynamic source interaction graph in L3 writing based on proposed categorisation. 'Ursula', L1 Estonian, C2 in Spanish, experienced writer. Figure created by author.

Notably, there is no activity in her L1, Estonian. This suggests that she wrote fluently without practically any interruptions and was completely in charge of her writing, using sources with purpose. She also found it unnecessary to consult content-related sources, which indicates that she had prepared a mental outline for the essay; going further, considering also her participation in the whole course before, it is reasonable to suppose she had had no trouble following its contents and navigated the complex topic with confidence and ease. The duration of the process displayed at the bottom of the graph also shows she needed less time than the other participants selected as examples.

In Figure 8, we have the visualisations of the writing processes of two novice writers with lower intermediate (B1-level) proficiency in TL: 'Grete' (top), whose L1 is Estonian, and 'Elena' (bottom), whose L1 is Russian. It is evident that neither of them were fluent writers, they needed to interrupt the formulation process frequently to solve problems. It can be seen that their activity is located in different areas. 'Grete' mostly operated in the LF-TL area (so English-Spanish), searching for words (category 15), expressions (14) and checking the meaning of Spanish words in English (13). Toward the beginning of the session, around seconds 1200–1400, she consulted some content-related sources in TL (6), but the rest of the problems were language-related; at some points, her knowledge gaps required her to search between L1 and LF. Evidently, the external activity took place in short spurts and complemented the TL writing process. This suggests some degree of independence and deliberation in her source use, and also we can see that in the middle of the writing process and later toward the end there were sections where she could concentrate on writing and revising her text. Specifically, the longer continuous sections around seconds 4500–5000 and 5150–5500 represent monitoring and revision behavior typical of the final stages of writing.

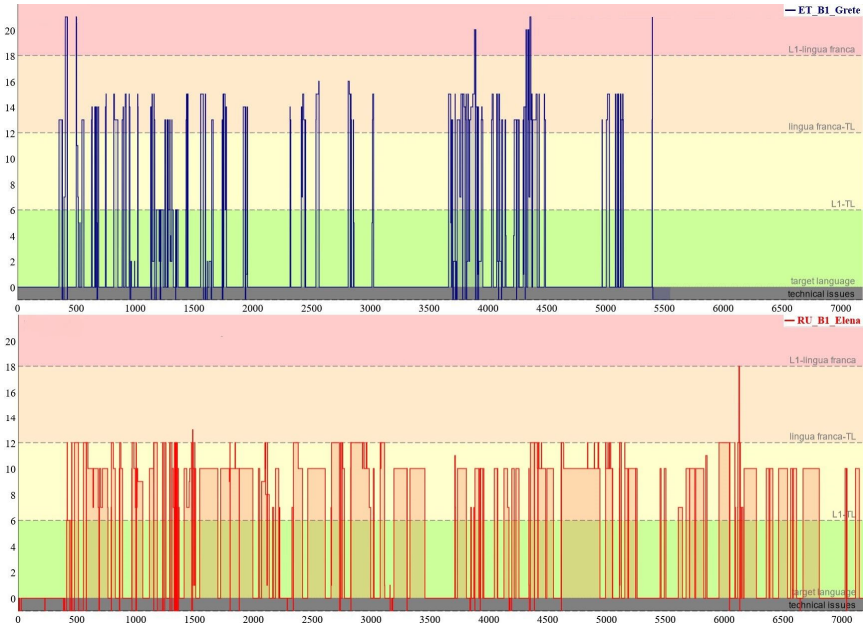

Figure 8. Dynamic source interaction in novice L3 writing: 'Elena' (red), L1 Russian, and 'Grete' (navy), L1 Estonian, both B1 in Spanish.

The session ended at around s. 5500. In contrast, 'Elena' actually spent more time outside her target document than within, and in longer stretches. Notably, all her problem-solving activities are located within the cream-colored L1 area: at times, she consulted content materials in her L1 (category 12), but mostly she used a machine translator (category 10) to write her essay. Her source use persisted throughout the whole process, there are no noteworthy sections where she did not leave her text document. Rather than suggesting that the time she spent formulating her text was significantly more limited than for her Estonian counterpart, this is indicative of the fact that she actually used the translator to compose her text, so a great deal of the formulation process took place outside the target document. It can therefore be concluded that she either did not have the skills or the confidence to write the essay in the target language, and her behavior was heavily controlled by the availability of external help.

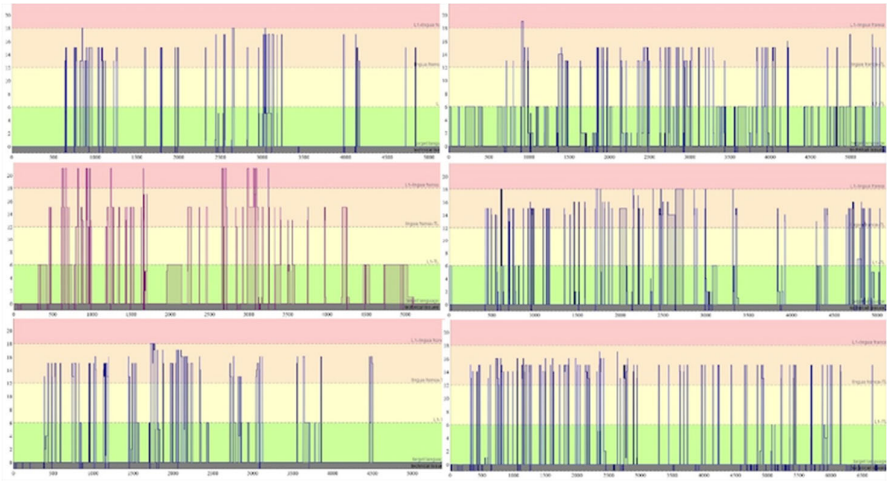

Figure 9. Dynamic source interaction for intermediate (B) proficiency participants Top row: L1 ET lower intermediate (B1) writers 'Fiona' and 'Heili'. Centre row: RU-ET bilingual participant 'Darina' and L1 ET author 'Inga', both higher intermediate (B2) in TL. Bottom row: L1 ET participants 'Jana' and 'Kristi', both B2 in TL.

Figure 9 (intermediate TL proficiency) and Figure 10 (advanced TL proficiency) give a bird's-eye-view of the source interaction for the rest of the participants. The graph for the one Russian-Estonian participant is purple, whereas all the others are blue (Estonian). A significant observation that can be made is that none of these participants, including the RU-ET bilingual one, used their L1 to a notable degree in their problem solving. Instead, many of them used content-related sources in TL (the upper edge of the green area, category 6), and, to some extent, also in LF (categories 17 and 18). Language problems were generally solved with the help of LF. It can also be seen that, as logic would suggest, content-related problem solving took place in longer stretches, whereas language problems took little time.

7. Discussion and conclusions

Dynamic process graphs for crosslinguistic activity during external problem solving allow to gain novel insights into auxiliary languages multilingual participants choose to use during writing. For example, in the dygraphs displayed in Figures 7–10, it becomes clear that there is an outlier in the group: Elena (L1 RU, B1 in TL) demonstrates behavior completely different from that of her peers. Her proficiency (and, for that matter, confidence) was low, but there were also other participants who were struggling with the course contents and the essay they were tasked with.

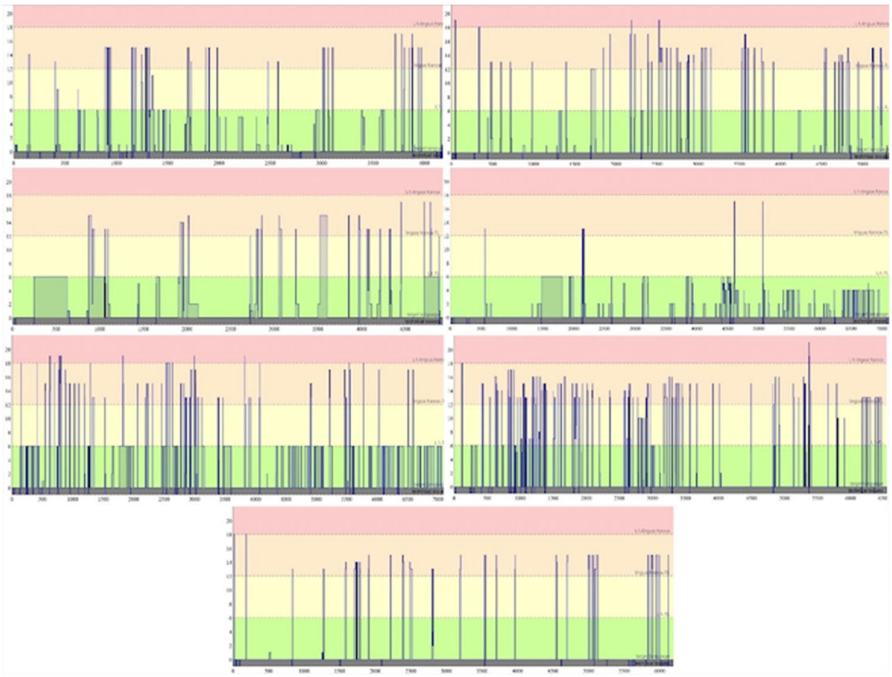

Figure 10. Dynamic source interaction for advanced (C1) TL proficiency participants, all L1 ET: Top row: 'Liisa' (left), 'Maarika' (right); second row: 'Nele' (left), 'Olivia' (right); third row: 'Raili' (left), 'Signe' (right) and bottom: 'Tanel'.

Why is it that Elena was the only one to recur to her L1 for problem solving? Based on years of teaching and tutoring experience with students from the same background, I suggest that Estonian students have no expectations for the usefulness of their L1, because there are few relevant materials in Estonian (or rather there are none specifically about Spanish; comparable materials about linguistics could be found). Also, Google Translate between Estonian and Spanish is unpredictable and unreliable. Meanwhile, our Russian participant is evidently used to recurring to Russian pages about Spanish linguistics, and Yandex Perevodchik, which produces excellent quality results between Russian and Spanish (both directions). It is difficult to say to what extent the (psycho)typological closeness of Estonian or Russian with either English or Spanish is of consequence in this context because our interest lies in the language of choice for dictionary and source use; therefore, it is more important that the consulted resource be reliable and accessible, not that the language pair involved necessarily be very similar. However, in general, similarities between English and Spanish make it a far more useful point of departure than Estonian (or Russian, for that matter). English, even

though not considered Romance language, shares a lot of vocabulary with these (Coxhead and Byrd 2007, Tullock and Fernández-Villanueva 2013), plus there is a wealth of resources available online between English and Spanish. Moreover, returning to the role English plays in Estonian education and society (see section 6.1.1.), young Estonians are highly proficient in English and immerse themselves in this language daily, so using it during L3 writing comes both from necessity (no comparable resources between L1 and TL) and from convenience and habit. Note also that the participants' proficiency in English was sufficient to not have to search for English words to use those for looking up Spanish words they did not know or remember: there is hardly any activity in the pink L1-LF area in Figures 9 and 10. If we add to this that, as indicated above, Zabrodskaja and Kask (2017) and Soler-Carbonell and Karaoglu (2015) state that young Russians tend to be in a slightly disadvantaged position while acquiring English and consequently have lower proficiency, it can help explain Elena's discrepant writing behavior to a great degree. Compared to the most similar study, Knospe (2017), it is noteworthy that none of her participants showed source use patterns similar to the Estonian students taking part in the present investigation, i.e., none of the Swedish speakers made a habit of recurring to LF while writing. Only one of them, Sara, used English a few times, explaining in her interviews that her extensive instruction in English had led to a situation where she knows some words in English and not in Swedish, her L1 (her English writing session was also very different from the other participants, showing a very high proficiency and an extensive and sophisticated use of online sources). Such a conclusion supports the idea that students' writing and searching behavior is influenced by the languages in their repertoire and the availability of online resources for these languages.

Through categorising sources used and creating dygraphs, new insights can be gained into breakdown fluency and into the interaction of different languages in multilinguals' repertoire. To a great extent, it has provided opportunities for testing hypotheses about the default supplier language and its dependence on factors of influence such as expectations for availability of resources, in addition to structural similarities or differences between language combinations, or proficiency and recency.

Considering Knospe's distinction between participants 'controlling the sources' and those 'controlled by the sources' (2017, Knospe *et al.* 2019), the visualisation of source use can take such analysis to a new level, especially combining the dygraphs with Pajek graphs such as those displayed in Figure 4, which give an idea of the proportions to which a source type was consulted, and which type interacted with which. In a way, just by looking at the dygraphs one can already get an idea about the degree to which a writer is 'controlled by the sources', i.e., have more external problems to solve and gravitate further from independent TL formulation. Also, this view can complement existing knowledge on pausing locations (such as Révész *et al.* 2019 and Chukharev-Hudilainen *et al.* 2019) and the interplay of planning,

formulation and revision (e. g. Révész *et al.* 2022, 2023), but it would require a fundamental change in task conditions in comparison with the vast majority of L2 writing process studies: allowing participants to consult sources when in doubt, as they normally would when writing. In such circumstances, a writer's actions while pausing within words, and between words, sentences and paragraphs give additional information on the nature of the problem that keeps them from continuing to formulate text. Also, importantly, this new insight comes without the need to have them verbalise their intentions and thus disrupt the train of thought.

8. Limitations and further research

The categorisation presented in this article is one possible take on crosslinguistic activity during writing and can certainly be challenged. Which is "further" from producing target text, searching for a missing word via L1 or via LF? However, the aim of this article has not been to provide an undisputable partition for specific sources used, but rather to suggest a novel way to consider and visualise activity between S-bursts. The areas for TL, L1 and LF can be substituted for other categories of interest, and the items numbered following a different rationale.

For researchers considering the expanded view of fluency proposed here, a question of great interest is when do we control the sources and when do they control us. If writing fluency is "writers' ability to produce texts in large chunks or spans" as suggested by Abdel Latif (2013), which is more prominent (and for whom), external source use as an aid for deblocking or as a distraction? This question has not yet been asked and probably has multifaceted answers that expand our knowledge of modern writing processes.

More specifically related to the results of the experiment described above, a question that needs careful further exploration is the degree to which the language and content problems encountered during advanced writing assignments relate to the overall L2 and L3 proficiency of the participating students. Considering that the course for which they wrote the essay used in this experiment is taught entirely in Spanish, their understanding of the content matter involved is undoubtedly influenced by their TL competence. Trying to investigate such CLIL problems, however, is a particularly complex matter and research design needs careful consideration.

9. Final words

Lourdes Ortega and Joan Carson ask: "How can theoretical insights about the multicompetent and social nature of writing better inform and guide research practices in SLA oriented investigations of L2 writing? The challenge, at least in part, involves crafting new investigative prisms that might allow researchers to more fully investigate L2 composing as a multicompetent (i.e., biliterate and bilingual) act that is situated and understood in its social context." (2010:52, emphasis added) They

also advocate for "developing analytical systems to be applied to a writer's two or more languages" and "engaging in empirical research programs across systematically diverse contexts and populations, with an emphasis on understanding the contextual bounds of disciplinary findings and theoretical interpretations." Categorising and visualising external problem-solving activities, or, in other words, adding a qualitative dimension to 'breakdown fluency' [Skehan (2009) and Housen *et al.* (2012)] is a valuable means to do just that and get a bird's-eye view on L3+ writing processes. Considering the bulk of the different sources used, especially at lower levels of proficiency, a dynamic view of the interplay of resources for and in different languages active during L3+ writing can help to better understand the idiosyncratic and varied nature of these intricate processes. Once the categorisation is done, it is easy to compare writers' behavior both qualitatively and quantitatively, if there is a larger body of data. A noteworthy point is that this way, the idiosycratic writing processes of the writers whose L1 are smaller languages can also get more attention, and be recognised for their creative problem-solving activities that compensate for the lack of resources in L1 and between L1 and TL. Also, for teachers, getting to know what kind of source users their students are could help tailor feedback and make more informed decisions when planning lessons and materials.

The results presented as an example of the kind of analysis that becomes possible through such procedures make it evident that even when the result is monolingual, the process of its creation can and will be bi- or multilingual if TL=L3+. Whereas Hoffmann (2001) notes that there is very scant evidence of trilinguals using all three of their languages and they normally operate in different bilingual modes, perhaps this lack of evidence is rather a result of lack of data and task designs that need reconsideration, rather than the actual lack of such activity? Yet again, operating between TL and LF would be an example of a 'bilingual mode' as L1 is not used, so it is for future research to determine which is the case. Also, groups with different characteristics are likely to show diverse patterns, especially when smaller languages with diverging available resources and different degrees of perceived distance, recency and proficiency are concerned.

Notes.

[1] The participants also stated they had other languages in their repertoires, but these were not used to any significant degree or effect during the writing sessions.

[2] Compare with bull's-eye (one word), i.e., the center of the target. The Estonian equivalent "härjasilm" (spelled together) shows a similar pattern of polysemy, meaning *fried egg* as well as *Leucanthemum*, whereas "härja silm" (two words) means *bull's eye*.

[3] For the explanations of Figures7–10, the numbers in parentheses indicate category numbers shown in Figure 5.

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References

Androutsopoulos, J. (2013). 27. Code-switching in computer-mediated communication. In Herring, Susan; Dieter Stein and Tuija Virtanen (Eds.), *Pragmatics of Computer-Mediated Communication* (667–694). Berlin, Boston: De Gruyter Mouton
DOI: https://doi.org/10.1515/9783110214468.667

Aronin, L. and Hufeisen, B. (2009). *Exploration of Multilingualism: Development of research on L3, multilingualism and multiple language acquisition*. Amsterdam/Philadelphia: John Benjamins. DOI: https://doi.org/10.1075/aals.6

Baaijen, V. M. and Galbraith, D. (2018). Discovery through writing: Relationships with writing processes and text quality. *Cognition and Instruction*, 36(3): 199–223. DOI: https://doi.org/10.1080/07370008.2018.1456431

Barkaoui, K. (2015). Test takers' writing activities during the TOEFL iBT writing tasks: A stimulated recall study. *Research report no. RR-15-04.* Princeton, NJ: Educational Testing Service. DOI: https://doi.org/10.1002/ets2.12050

Blackwood, R. and Røyneland, U. (2022). *Spaces of Multilingualism.* Abingdon/New York: Routledge. DOI: http://doi.org/10.4324/9781003125839

Canagarajah, S. (2011). "Translanguaging in the classroom: Emerging issues for research and pedagogy." – *Applied Linguistics Review* 2: 1–27.
DOI: https://doi.org/10.1515/9783110239331.1

Cenoz, J. (2003). The additive effect of bilingualism on third language acquisition: A review. *International Journal of Bilingualism*, 7(1): 71– 87.
DOI: https://doi.org/10.1177/13670069030070010501

Cenoz, J. and Gorter, D. (2011). Focus on Multilingualism: A Study of Trilingual Writing. *The Modern Language Journal*, 95(3): 356–369. DOI: http://dx.doi.org/10.1111/j.1540-4781.2011.01206.x

Cenoz, J. and Gorter, D. (2021). *Pedagogical translanguaging.* Cambridge, New York, Melbourne: Cambridge University Press. DOI: http://dx.doi.org/10.1017/9781009029384

Chau, L. T., Leijten, M., Bernolet, S. and Vangehuchten, L. (2022). Envisioning multilingualism in source-based writing in L1, L2, and L3: The relation between source use and text quality. *Frontiers in Psychology*, 13.
DOI: https://doi.org/10.3389/fpsyg.2022.914125

Chukharev-Hudilainen, E., Saricaoglu, A., Torrance, M. and Feng, H. H. (2019). Combined deployable keystroke logging and eyetracking for investigating L2 fluency. *Studies in Second Language Acquisition*, 41: 583–604. DOI: https://doi.org/10.1017/S027226311900007X

Cook, V. (1992). Evidence of multicompetence. *Language Learning* 44(4): 557–591. DOI: https://doi.org/10.1111/j.1467-1770.1992.tb01044.x

Cook, V. (2007). Multi-Competence: Black Hole or Wormhole? In Han, Zhaohong and Eun Sun Park (Eds.) *Understanding Second Language Process* (16–26). Bristol: Multilingual Matters. DOI: https://doi.org/10.21832/9781847690159-004

Coxhead, A. and Byrd, P. (2007). Preparing writing teachers to teach the vocabulary and grammar of academic prose. *Journal of Second Language Writing*, 16(3): 129–147. DOI: https://doi.org/10.1016/j.jslw.2007.07.002

Cummins, J. (1984). Wanted: A theoretical framework for relating language proficiency to academic achievement among bilingual students. In Rivera, Charlene (Ed.), *Language proficiency and academic achievement* (2–19). Clevedon: Multilingual Matters.

Cummins, J. (2007). Rethinking monolingual instructional strategies in multilingual classrooms. *Canadian Journal of Applied Linguistics*, 10(2): 221–240.

de Bot, K., Verspoor, M. and Lowie, W. (2007). A dynamic systems theory approach to second language acquisition. - *Bilingualism, Language and Cognition* 10: 7–21. DOI: https://doi.org/10.1017/S1366728906002732

Derwing, T. M. (2017). L2 fluency development. In Loewen, Shawn and Masatoshi Sato (Eds.), *The Routledge handbook of instructed second language acquisition* (246–259). New York, London: Routledge.
DOI: https://doi.org/10.4324/9781315676968-14

Dewaele, J.-M. (1998). Lexical Inventions: French Interlanguage as L2 versus L3. *Applied Linguistics*. 19(4): 471–490. DOI: https://doi.org/10.1093/applin/19.4.471

Ehala, M. and Niglas, K. (2006). Language Attitudes of Estonian Secondary School Students. *Journal of Language Identity and Education*, 5(3): 209–227. DOI: https://doi.org/10.1207/s15327701jlie0503_2.

Falk, Y. and Bardel, C. (2010). The study of the role of the background languages in third language acquisition. The state of the art. *International Review of Applied Linguistics in Language Teaching*, 48(2–3): 185–219. DOI: https://doi.org/10.1515/iral.2010.009

Flower, L. S. and Hayes, J. R. (1977). Problem-Solving Strategies and the Writing Process. College English , Dec., 1977, Vol. 39, No. 4, Stimulating Invention in Composition Courses (Dec., 1977), 449–461. DOI: https://doi.org/10.2307/375768

Flower, L. S. and Hayes, J. R. (1981). A Cognitive Process Theory of Writing. *College Composition and Communication*, 32(4): 365–387. DOI: https://doi.org/10.2307/356600

Fuster, C. and Neuser, H. (2020). Exploring intentionality in lexical transfer. *International Journal of Multilingualism.* 17(4): 516–534.
DOI: https://doi.org/10.1080/14790718.2018.1559845

García, G. (2014). *Multilingualism and Language Education.* New York: Routledge.

Hall, C. J., Newbrand, D., Ecke, P., Sperr, U., Marchand, V., and Hayes, L. (2009). Learners' implicit assumptions about syntactic frames in new L3 words: The role of cognates, typological proximity, and L2 status. *Language Learning*, 59(1): 153–202. DOI: https://doi.org/10.1111/j.1467-9922.2009.00503.x

Hayes, J. R. (2012). Modeling and remodeling writing. *Written Communication*, 29(3): 369–388. DOI: https://doi.org/10.1177/0741088312451260

Herdina, P. and Jessner, U. (2002). *A Dynamic Model of Multilingualism: Perspectives of Change in Psycholinguistics.* Clevedon: Multilingual Matters.
DOI: https://doi.org/10.21832/9781853595547

Hoffmann, C. (2001). Towards a description of trilingual competence. *The International Journal of Bilingualism*. 5(1): 1–17. DOI: https://doi.org/10.1177/13670069010050010101

Housen, A., Kuiken, F., and Vedder, I. (2012). Complexity, accuracy and fluency. Definitions, measurements and research. In Housen, Alex; Folkert Kuiken and Ineke Vedder (Eds.). *Dimensons of L2 Performance and Proficiency. Complexity, Accuracy and Fluency in SLA. Language Learning and Language Teaching, Vol. 32,* 1–20. Amsterdam (Philadelphia): John Benjamins. DOI: https://doi.org/10.1075/lllt.32.01hou

Jessner, U. (2008). A DST model of multilingualism and the role of metalinguistic awareness. *The Modern Language Journal,* 92: 270–283.

DOI: http://dx.doi.org/10.1111/j.1540-4781.2008.00718.x

Kellerman, E. (1983). Now you see it, now you don't. In Gass, Susan and Larry Selinker (Eds.). *Language Transfer in Language Learning* (112–134). Rowley: Newbury House.

Kim, M., Tian, Y., and Crossley, S. A. (2021). Exploring the relationships among cognitive and linguistic resources, writing processes, and written products in second language writing. *Journal of Second Language Writing,* 53, 100824. DOI: https://doi.org/10.1016/j.jslw.2021.100824

Kirtsi, M., Klaas, B., Käosaar, I., Mere, K., Lipasti, J., Pärn, H., Soll, M., Zabrodskaja, A., Tender, T., Türk, Ü., Valge, J., and Vare, S. (2010). Language education policy profile. Estonia. Language education policy in a changing society: shaping the future. Translated by Kristel Weidebaum. Tartu: Ministry of Education and Research.

Knospe, Y. (2017). Writing in a third language. A study of upper secondary students' texts, writing processes and metacognition. Doctoral thesis. Umeå Studies in Language and Literature 36, Umeå: Umeå University.

Knospe, Y., Sullivan, K. P. H., Malmqvist, A., and Valfridsson, I. (2019). Observing writing and website browsing: Swedish students write L3 German. In Lindgren, Eva and Kirk Sullivan (Eds.). *Observing Writing*. Brill. (258–284) DOI: https://doi.org/10.1163/9789004392526_013

Kobayashi, H. and Rinnert, C. (2013). L1/L2/L3 writing development: Longitudinal case study of a Japanese multicompetent writer. *Journal of Second Language Writing*, 22(1): 4–33. DOI: https://doi.org/10.1016/j.jslw.2012.11.001

Kowal, I. (2014). Fluency in second language writing: A developmental perspective. *Studia Linguistica Universitatis Iagellonicae Cracoviensis*, 131(3): 229–246. DOI: https://doi.org/10.4467/20834624SL.14.013.2321

Kruse, M. (2018). La transferencia en personas plurilingües: los falsos amigos como un obstáculo y una oportunidad en la enseñanza y aprendizaje de lenguas extranjeras. [Doctoral thesis] Tartu: Tartu Ülikooli Kirjastus.

Langum, V. and Sullivan, K. (2020). Academic Writing: Doctoral Writing in Another Language. *Kulturella Perspektiv,* 3: 65–72.

Lee, C. (2018). Beijing PM 2.5 Line Charts. 2017/01 to 2018/03. [online resource] Available at https://rpubs.com/ceshine/beijing_pm25_201701_201803 (accessed Jan 24, 2023)

Leijten, M. and Van Waes, L. (2013). Keystroke logging in writing research: Using Inputlog to analyze and visualize writing processes. *Written Communication*, 30(3): 358–392. DOI: https://doi.org/10.1177/0741088313491692

Leijten, M., Van Waes, L., Schriver, K., and Hayes, J. R. (2014). Writing in the workplace: Constructing documents using multiple digital sources. *Journal of Writing Research, 5*(3): 285–337. DOI: https://doi.org/10.17239/jowr-2014.05.03.3

Leijten, M., Van Waes, L., Schrijver, I., Bernolet, S., and Vangehuchten, L. (2019). Mapping master's students' use of external sources in source-based writing in L1 and L2. *Studies in Second Language Acquisition, 41*(3): 555–582. DOI: https://doi.org/10.1017/S0272263119000251

Lindqvist, C. (2015). Do learners transfer from the language they perceive as most closely related to the L3? The role of psychotypology for lexical and grammatical crosslinguistic influence in French L3. In DeAngelis, Gessica; Ulrike Jessner and Marijana Kresić (Eds.) *Crosslinguistic influence and crosslinguistic interaction in multilingual language learning*, 232–251. London: Bloomsbury. DOI: https://doi.org/10.5040/9781474235884.0014

Liin, K., Muischnek, K., Müürisep, K., and Vider, K. (2012). Eesti keel digiajastul = The Estonian language in the digital age. META-NET report. Springer.

Manchón, R. M., Roca de Larios, J., and Murphy, L. (2009). The temporal dimension and problem-solving nature of foreign language composing processes. Implications for theory. In Manchón, Rosa (Ed.), *Writing in Foreign Language Context: Learning, Teaching, and Research* (102–129). Clevedon: Multilingual Matters. DOI: https://doi.org/10.21832/9781847691859-008

May, S. (2013). "Introducing the "Multilingual Turn"" in *The Multilingual Turn. Implications for SLA, TESOL, and Bilingual Education*, pp. 1–6. New York/Oxon: Routledge. DOI: https://doi.org/10.4324/9780203113493

Michel, M., Révész, A., Lu, X., Kourtali, N.-E., Lee, M., and Borges, L. (2020). Investigating L2 writing processes across independent and integrated tasks: A mixed-methods study. *Second Language Research*, 36(3): 1–28. DOI: https://doi.org/10.1177/0267658320915501

Mrvar, A. and Batagelj, V. (2016). Analysis and visualization of large networks with program package Pajek. *Complex Adaptive Systems Modeling*, 4:6. DOI: https://doi.org/10.1186/s40294-016-0017-8

Nguyen, L. T. C. (2015). Written fluency improvement in a foreign language. *TESOL Journal*, 6(4), 707–730. DOI: http://dx.doi.org/10.1002/tesj.186

Nshiwi, D. and Jessner, U. (2021). The Effect of Metalinguistic Awareness and the Previously Learned Foreign Languages on Fourth Language Acquisition by Adult Learners. *Alkalmazott Nyelvtudomány XXI*. 1–17. DOI: http://dx.doi.org/10.18460/ANY.2021.1.001

Orcasitas-Vicandi, M. (2021). Towards a multilingual approach in assessing writing: holistic, analytic and cross-linguistic perspectives. International Journal of Bilingual Education and Bilingualism, ahead-of-print, 1–22. DOI: https://doi.org/10.1080/13670050.2021.1894089

Ortega, L. and Carson, J. (2010). Multicompetence, social context, and L2 writing research praxis. In Tony Silva and Paul K. Matsuda (eds.), *Practicing theory in second language writing*, 48–71. West Lafayette, IN: Parlor Press.

Palviainen, Å., Kalaja, P., and Mäntylä, K. (2012). Development of L2-writing: Fluency and proficiency. *AFinLA-e Soveltavan kielitieteen tutkimuksia* 4: 47–59.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at https://www.R-project.org/ (accessed Jan 24, 2023)

Révész, A., Michel, M., and Lee, M. (2019). Exploring second language writers' pausing and revision behaviors: a mixed-methods study. *Studies in Second Language Acquisition*, 41(3): 605–631. DOI: https://doi.org/10.1017/S027226311900024X

Révész, A., Michel, M., and Lee, M. (2023). Exploring the relationship of working memory to the temporal distribution of pausing and revision behaviors during L2 writing. *Studies in Second Language Acquisition*, 45(3): 680–709. DOI: https://doi.org/10.1017/S0272263123000074

Révész, A., Michel, M., Lu, X., Kourtali, N., Lee, M., and Borges, L. (2022). The relationship of proficiency to speed fluency, pausing, and eye-gaze behaviours in L2 writing. *Journal of Second Language Writing*, 58, article 100927. DOI: https://doi.org/10.1016/j.jslw.2022.100927

Ringbom, H. (1986). Crosslinguistic influence and the foreign language learning process. In Kellerman, Eric and Michael Sharwood Smith (Eds.), *Crosslinguistic Influence in Second Language Acquisition* (150–162). New York, etc.: Pergamon Press.

Rinnert, C. and Kobayashi, H. (2016). Multicompetence and multilingual writing. In Manchón, R.M. and P. Matsuda (Eds.). *The Handbook of Second and Foreign Language Writing* (365–385). New York: Mouton de Gruyter. DOI: https://doi.org/10.1515/9781614511335-020

Roca De Larios, J., Manchón, R. M., Murphy, L., and Marín, J. (2008). The foreign language writer's strategic behaviour in the allocation of time to writing processes. *Journal of Second Language Writing* 17: 30–47. DOI: https://doi.org/10.1016/j.jslw.2007.08.005

Rothman, J. (2010). On the typological economy of syntactic transfer: Word order and relative clause high/low attachment preference in L3 Brazilian Portuguese. *International Review of Applied Linguistics in Teaching (IRAL)*, 48: 245–273. DOI: https://doi.org/10.1515/iral.2010.011

Rothman, J. (2015). Linguistic and cognitive motivations for the Typological Primacy Model (TPM) of third language (L3) transfer: Timing of acquisition and proficiency considered. *Bilingualism:Language and Cognition*, 18(2): 179–190. DOI: https://doi.org/10.1017/S136672891300059X

Schmidt, R. (1992). Psychological mechanism underlying Second Language Fluency. *Studies in Second Language Acquisition*, 14(4): 357–385. DOI: https://doi.org/10.1017/S0272263100011189

Skehan, P. (2003). Task-based Instruction. *Language Teaching,* 36: 1–14. DOI: https://doi.org/10.1017/S026144480200188X

Skehan, P. (2009). Modelling Second Language Performance: Integrating Complexity, Accuracy, Fluency, and Lexis. *Applied Linguistics*, 30(4): 510–532. DOI: https://doi.org/10.1093/applin/amp047

Skein, E., Knospe, Y., and Sullivan, K. P. H. (2020). Supporting Advanced Multilingual Speakers as Individuals: Translanguaging in Writing. In G. Neokleous, A. Krulatz, and R. Farrelly (Ed.), *Handbook of Research on Cultivating Literacy in Diverse and Multilingual Classrooms*, pp. 577–595. Hershey, PA: IGI Global. https://doi.org/10.4018/978-1-7998-2722-1.ch027

Soler Carbonell, J. and Karaoglu, H. (2015). English as an academic lingua franca in Estonia: students' attitudes and ideologies. In Linn, Andrew; Neil Bermel and Gibson Ferguson (Eds.), *Attitudes Towards English in Europe*. Berlin, Boston: De Gruyter. DOI: https://doi.org/10.1515/9781614515517-011

Spelman Miller, K., Lindgren, E., and Sullivan, K. P. H. (2008). The Psycholinguistic Dimension in Second Language Writing: Opportunities for Research and Pedagogy Using Computer Keystroke Logging. *TESOL Quarterly.* 42(3): 433-454 DOI: https://doi.org/10.1002/j.1545-7249.2008.tb00140.x

Stein-Smith, K. (2016). The role of multilingualism in effectively addressing global issues: the sustainable development goals and beyond. *Theory and Practice in Language Studies*. 6 (12), 2254–2259. DOI: http://dx.doi.org/10.17507/tpls.0612.03

Tian, Y., Kim, M., and Crossley, S. (2023). Making sense of L2 written argumentation with keystroke logging. *Journal of Writing Research*. 15(3): 435–461. DOI: https://doi.org/10.17239/jowr-2024.15.03.01

Tullock, B. D. and Fernández-Villanueva, M. (2013). The role of previously learned languages in the thought processes of multilingual writers at the Deutsche Schule Barcelona. *Research in the teaching of English* 47 (4), 420–441.

Vanderkam, D. Allaire, J., Owen, J., Gromer, D., and Thieurmel, B. (2018). dygraphs: Interface to 'Dygraphs' Interactive Time Series Charting Library. R package version 1.1.1.6. Available at https://CRAN.R-project.org/package=dygraphs (accessed Jan 25, 2023)

Van Waes, L. and Leijten, M. (2015). Fluency in writing: A multidimensional perspective on writing fluency applied to L1 and L2. *Computers and Composition*, 38: 79–95. DOI: https://doi.org/10.1016/j.compcom.2015.09.012

Viberg, Å. (1998). Lexical development and the lexical profile of the target language. In Albrechtsen, Dorte; Birgit Henriksen, Inger M. Mees and Erik Poulsen (Eds.), *Perspectives on Foreign and Second Language Pedagogy* (119–134). Odense: Odense University Press.

Wei, L. (2017). *Translanguaging as a practical theory of language.* Applied Linguistics 39 (1), 9–30. DOI: https://doi.org/10.1093/applin/amx039

Weinreich, U. (1953/2010). *Languages in Contact. Findings and Problems*. The Hague: Mouton Publishers. DOI: https://doi.org/10.1515/9783110802177

Wesche, M. B. and Paribakht, T. S. (2010). *Second Language Acquisition: Lexical Inferencing in a First and Second Language: Cross-linguistic Dimensions.* Bristol, Buffalo, Toronto: Multilingual Matters. DOI: https://doi.org/10.21832/9781847692245

Williams, S. and Hammarberg, B. (1998). Language switches in L3 production: Implications for a polyglot speaking model. *Applied Linguistics* 19, 295–333. DOI: https://doi.org/10.1093/applin/19.3.295

Zabrodskaja, A. and Kask, H. (2017). 4.2 Contacts of Estonian. In Tammaru, Tiit; Kristina Kallas, Raul Eamets (Ed.). *2016/2017 Human Development Report – Estonia at the age of migration.* Tallinn: SA Eesti Koostöö Kogu.