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ANA PAULA SCHOLL

THOUGHT ORGANIZATION AND COGNITIVE FUNCTIONS IN HIGH SCHOOL STUDENTS' FIRST AND SECOND LANGUAGE WRITING

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Ana Paula Scholl

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BANCA EXAMINADORA

_____

Erica dos Santos Rodrigues - Pontifícia Universidade Católica do Rio de Janeiro

_____

Janaína Weissheimer – Universidade Federal do Rio Grande do Norte

_____

Natália Bezerra Mota - Universidade Federal do Rio de Janeiro

_____

Ingrid Finger – Universidade Federal do Rio Grande do Sul

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ABSTRACT

Thought organization, the ability to express one's thoughts logically, has been investigated by studies analyzing oral reports of clinical (MOTA *et al.*, 2014) and typical (MOTA *et al.*, 2016a, 2019) populations. These studies make use of *SpeechGraphs*, a computational tool that applies graph analysis to measure connectedness in oral discourse. More recently, the tool has also been used to analyze written production (KAHN, 2021; LUZ, 2018; LEMKE *et al.*, 2021). Since writing is a means for expressing our thoughts in L1 and L2, the investigation of thought organization in written production is warranted. Whether it is in one or more languages, writing is a highly complex cognitive activity that requires the coordination of numerous constraints and considerations and in which various demands compete for attention (MANCHÓN, 2013; WEIGLE, 2005). For this reason, different cognitive functions are involved in writing processes and performance. These cognitive resources appear as essential parts of cognitive models of writing (HAYES; FLOWER, 1980; HAYES, 2012; KELLOGG, 1996), which, in general, give a central role to WM. Studies investigating the relationship between L1 and L2 writing and cognitive functions have yielded inconclusive results. In this context, the main goal of the present research was to investigate long and short-range recurrence patterns associated with thought organization in the written production of high school students and the relationship between thought organization and cognitive functions (short-term memory, working memory, and attention). For this purpose, we developed 2 studies. Study 1 applied graph analysis to explore recurrence patterns in L1 and L2 narrative and argumentative texts of 71 high school students. Results show that texts in the participants' L1 were more connected and had fewer repetitions than their texts in the L2. Moreover, connectedness in narrative texts was correlated in the two languages, whereas this correspondence was not found in argumentative texts. Regarding type of text, there were no statistically significant differences between narrative and argumentative texts in terms of long and short-range recurrences both in the L1 and in the L2. In addition, the long-range recurrence measures correlated significantly in the two types of texts in both languages, meaning that participants who had more connected narrative texts also presented these characteristics in argumentative texts. Finally, results indicate L2 proficiency is a predictor of thought organization in English narrative and argumentative texts. Study 2 explored the relationship between thought organization in the written production of high school students' L1 and L2 narrative and argumentative texts and measures of cognitive performance (WM, STM, and attention). In addition to the texts written for Study 1, 30 high school students performed 3 cognitive functions measures (Nonword Repetition, Listening Recall, and the ANT). Results show that only the verbal STM measure (Nonword Repetition task) correlated positively with the graph attributes (LSC, RE, and PE) in the L1. No associations were found between WM or attention with long and short-range recurrence measures in the L1 or any of the attributes in the L2 and cognitive measures. Overall, this dissertation adds to the literature on thought organization in written performance in L1 and L2, in two types of text, and on the relationship between cognitive resources and writing.

KEYWORDS: Thought Organization; Graph Analysis; Writing; Cognitive Functions.

RESUMO

A organização do pensamento, ou seja, a capacidade de expressar os pensamentos de maneira lógica, tem sido investigada por estudos que analisam relatos orais de populações clínicas (MOTA *et al.*, 2014) e típicas (MOTA *et al.*, 2016a, 2019). Esses estudos fazem uso do *SpeechGraphs*, uma ferramenta computacional que aplica a análise de grafos para medir a conectividade no discurso oral. Mais recentemente, a ferramenta também passou a ser utilizada para analisar a produção escrita (KAHN, 2021; LUZ, 2018; LEMKE et al., 2021). Considerando que a escrita é um meio de expressar nossos pensamentos tanto na L1 quanto na L2, justifica-se a investigação da organização do pensamento também na produção escrita. Seja em uma ou mais línguas, a escrita é uma atividade cognitiva altamente complexa que exige a coordenação de vários recursos e considerações e na qual várias demandas competem por atenção (MANCHÓN, 2013; WEIGLE, 2005). Por esta razão, diferentes funções cognitivas estão envolvidas nos processos e no desempenho da escrita. Esses recursos cognitivos aparecem como partes essenciais de modelos cognitivos de escrita (HAYES; FLOWER, 1980; HAYES, 2012; KELLOGG, 1996), que, em sua maioria, conferem um papel central à memória de trabalho. Estudos que investigam a relação entre a escrita em L1 e L2 e as funções cognitivas têm produzido resultados divergentes. Nesse contexto, o objetivo principal da presente pesquisa foi investigar padrões de recorrência longas e curtas associados à organização do pensamento na produção escrita de alunos do ensino médio e a relação entre organização do pensamento e funções cognitivas (memória de curto prazo, memória de trabalho e atenção). Com esse propósito, desenvolvemos 2 estudos. O Estudo 1 aplicou a análise de grafos para explorar padrões de recorrência em textos narrativos e argumentativos na L1 e L2 de 71 alunos do ensino médio. Os resultados mostram que os textos na L1 dos participantes foram mais conectados e tiveram menos repetições do que seus textos na L2. Além disso, a conectividade em textos narrativos foi correlacionada nas duas línguas, enquanto essa correspondência não foi encontrada nos textos argumentativos. Em relação ao tipo de texto, não houve diferenças estatisticamente significativas entre textos narrativos e argumentativos em termos de recorrências longas e curtas tanto na L1 quanto na L2. Além disso, as medidas de recorrência longa correlacionaram-se significativamente nos dois tipos de textos em ambas as línguas, significando que os participantes que tiveram textos narrativos mais conectados também apresentaram essas características em textos argumentativos. Finalmente, os resultados indicam que a proficiência em L2 é um preditor da organização do pensamento em textos narrativos e argumentativos em inglês. O Estudo 2 explorou a relação entre a organização do pensamento na produção escrita de textos narrativos e argumentativos em L1 e L2 de alunos do ensino médio e medidas de desempenho cognitivo (memória de trabalho, memória de curto prazo e atenção). Além dos textos escritos para o Estudo 1, 30 alunos do ensino médio realizaram 3 testes que avaliaram funções cognitivas (Nonword Repetition, Listening Recall e ANT). Os resultados mostram que apenas a medida de memória de curto prazo verbal se correlacionou positivamente com os atributos dos grafos (LSC, RE e PE) na L1. Não foram encontradas associações entre memória de trabalho ou atenção com medidas de recorrências longas e curtas na L1 ou qualquer um dos atributos na L2 e medidas cognitivas. No geral, esta dissertação contribui para a literatura sobre organização do pensamento na escrita em L1 e L2 e em dois tipos de texto e sobre a relação entre recursos cognitivos e escrita.

PALAVRAS-CHAVE: Organização do Pensamento; Análise de Grafos; Escrita; Funções Cognitivas

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LIST OF ABBREVIATIONS

ANT	Attentional Network Test
AWMA	Pearson's Automated Working Memory Assessment
CEFR	Common European Framework of Reference
E	Edges
L1	First Language
L2	Second Language
LCC	Largest Connected Component
LSC	Largest Strongly Connected Component
LTM	Long-term memory
N	Nodes
PE	Parallel Edges
RE	Repeated Edges
SLA	Second Language Acquisition
STM	Short-term memory
WC	Word Count
WM	Working memory

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1 INTRODUCTION

1.1 OVERVIEW

Thought organization can be seen as the ability to express one's thoughts logically, demonstrating the relationship between one's ideas. We organize and express these thoughts through language. Thus, well-organized thought in speech is expressed when a message follows a logical progression and can be easily understood by the receiver.

Formal thought organization analyzed from free speech is a key feature for psychiatric evaluations (MOTA *et al.*, 2014) and has recently started to be investigated in typical development (MOTA *et al.*, 2016a; 2019). The idea is that thought organization improves progressively from early childhood to adulthood and different factors such as years of formal education (MOTA *et al.*, 2018) and reading skills (MOTA *et al.*, 2016a) play a role in its development.

Computational approaches have been used to assess thought organization, allowing for high precision in the evaluation of language markers. More specifically, graph analysis has been applied to measure connectedness in the oral discourse of clinical populations in comparison to control groups (MOTA *et al.*, 2012; 2014), in cognitive decline (MALCORRA *et al.*, 2021), and in typical development (MOTA *et al.*, 2016a; 2019). Even though the main focus has been the assessment of oral production, considering that writing is also a means for expressing our thoughts and communicating with others, it would make sense to examine how thought organization is expressed in writing production using graph analysis.

Writing is a part of our everyday lives. We write for varied purposes to different readers to express thoughts, feelings, and beliefs. For instance, we write to express our ideas and to communicate with others; we write when we are in a learning context at school as well as to complete school assignments; we also write to perform different tasks at work. In order to be able to do that, we must acquire a set of different types of knowledge and skills that do not come easily or naturally and develop with practice.

Mastery of the writing skill is of critical importance to succeed in academic contexts as well as in the workplace (CROSSLEY; MCNAMARA, 2016). Although it is such an important skill, expertise in writing is attained only rarely and with great effort (WEIGLE, 2005). According to Kellogg (2008), becoming an accomplished writer is parallel to becoming an expert in other complex cognitive domains, such as learning how to play chess or a musical

instrument. In this sense, writing expertise appears to require more than two decades of maturation, instruction, and training.

Adding to the complexity of writing in the first language, multiliteracy development, that is, the development of reading and writing in more than one language, is a common phenomenon due to globalization, mobility, and the implementation of varied educational programs (MANCHÓN, 2013). Brazilian public and private schools, for example, are required by law to offer the English language as a subject for their students from the sixth grade on (BRASIL, 2017). It is also very common for individuals to choose to study an additional language in other contexts, such as private language courses, with English being the most frequent choice. Even though writing may not be the main focus in some of these contexts, it is an essential part of learning a language.

Writing in a second language can be seen not only as a product of mastering the language but also as a language-learning opportunity (MANCHÓN, 2011). In that regard, students can learn how to write in a second language in addition to learning the target language while writing. According to Vasylets and Gilabert (2022), the availability of time and the self-paced nature of writing, the visibility and permanence of output, in addition to the problem-solving nature and depth of processing essential to some types of writing tasks are some facets of written production that allow it to have great language-learning potential. Therefore, writing can also be seen as an important tool to promote second language proficiency.

Despite the fact that both oral and written language use represent potential language-learning opportunities, in the field of Second Language Acquisition (SLA) research, oral production has been prioritized over written production (VASYLETS; GILABERT, 2022). Nevertheless, according to Manchón and Cerezo (2018), it is fundamental for SLA theory and research to regard the critical role that literacy practices play in the learning experience of second language learners and the relevance of writing as a site for promoting second language proficiency. More recently, the connection between second language writing and second language learning has developed into an active research area (MANCHÓN; POLIO, 2022). Within this context, studies investigating second language writing can add to this ongoing body of research.

Whether it is in one or more languages, writing is a highly complex cognitive activity that requires the coordination of numerous constraints and considerations and in which various demands compete for attention (MANCHÓN, 2013; WEIGLE, 2005). Cognitive models of writing (HAYES, 1996; HAYES, 2012; KELLOGG, 1996) purport that writing places demands on the cognition of the writer, especially on working memory. Working memory refers to the

ability to store and manipulate information for short periods of time (BADDELEY; HITCH, 1974), functioning as a mental workspace. It supports our capacity for mental work and coherent thought. In writing, as well as in other complex cognitive tasks, working memory provides a means for momentarily holding knowledge in an accessible form so it can be effectively applied (KELLOGG *et al.*, 2013). Additionally, temporary storage and processing are demanded as a writer plans ideas, translates these ideas into sentences, writes or types these sentences, and monitors all these activities (KELLOGG, 1996).

Therefore, it is possible that problems students have in writing (e.g. coherence, grammar, and spelling) might be explained by working memory deficits or overload during the writing process (KELLOGG *et al.*, 2013). That is to say that individuals with less working memory capacity may find it more difficult to coordinate the various demands placed by writing. Furthermore, writers may experience an overload of working memory during writing due to different factors, such as a lack of knowledge of the topic and insufficient proficiency in the language of the text.

In addition to working memory, there are other cognitive functions involved in writing, including, but not only, short-term memory and attention, which are explored in the present dissertation. Short-term memory, a component of the working memory system defined as the capacity to store small amounts of information over brief intervals (BADDELEY *et al.*, 2020), allows us to remember what was just written at the beginning of a sentence, for example. Moreover, given that various demands compete for attention during the writing process, attentional control becomes crucial for writing. A writer has to choose which aspect of writing to give attention to at each point in the composing process (MANCHÓN, 2013) and, the more demands involved in a writing task, the more the attention needs to be divided between them. Due to the relevance of these cognitive functions to the writing process, short-term memory, working memory, and attention are examined in their association with writing in the present dissertation.

Within the school context, in particular, knowledge of the cognitive resources that underlie writing can result in an improvement in students' writing learning experiences. In that sense, cognitive models of writing, such as the ones proposed by Hayes and Flower (1980) and Kellogg (1996) can provide a theoretical basis for developing new ways of teaching children - and teenagers - to write in a more proficient manner. A better understanding of the writing processes in the first and second language, in addition to the role cognition plays in these processes, can generate more efficient pedagogical interventions which take into account the cognitive functions that are involved in the act of writing. More specifically, teachers can design

tasks that focus learners' attention on monitoring the developing text, for example, thus resulting in greater accuracy. As an alternative, the task could be designed to focus students' attention on translating ideas into language, hence yielding greater complexity and/or fluency (JOHNSON, 2022). In other words, with science-based information in hand, educators may be able to design writing tasks in a more well-planned manner, with raised awareness of their own goals for proposing each assignment.

Writing performance and writing processes have been largely investigated in the fields of Linguistics and Psycholinguistics. There are approaches that focus on the process of writing while others study the product, that is, the written text. Research focusing on the process studies writing using think-aloud protocols, for instance, in which participants communicate what goes through their minds while they are writing (e.g., LÓPEZ-SERRANO *et al.*, 2019). Furthermore, a tool that can be used to investigate the processes involved in writing is keystroke logging, which records the keys struck on a keyboard, thus providing information about different processes that occur during writing (e.g. LEIJTEN *et al.*, 2019; RODRIGUES, 2019). Regarding the product, different aspects of a text can be measured, such as writing quality, complexity, accuracy, and fluency. For example, syntactic complexity (CROSSLEY; MCNAMARA, 2014) and text cohesion (CROSSLEY; MCNAMARA, 2016; CROSSLEY *et al.*, 2016) have been explored. In the present research, our focus is on the product, the written text, and not the process.

Many of the studies investigating writing performance and processes make use of computational tools to carry out their research and there are numerous possibilities for studying writing using them. One computational tool that analyzes speech based on graph theory has been very recently employed in the analysis of written production by Lemke and colleagues (2021), who used the tool *SpeechGraphs* (MOTA *et al.*, 2014) in the analyses of written texts in Portuguese and English by middle-school children immersed in a bilingual school and by Kahn (2021) who investigated the oral and written performance of translators and non-translator bilinguals.

In the studies reported in the present dissertation, we used *SpeechGraphs*, which will be further detailed in the fourth section of the literature review chapter, to investigate thought organization (long and short-range recurrence patterns) in high school students' texts written in both their first (Portuguese) and second language (English) as well as the association between thought organization and cognitive functions (short-term memory, working memory, and attention).

1.2 STATEMENT OF PURPOSE

In light of these considerations, the main goal of this exploratory and original research is to investigate long and short-range recurrence patterns associated with thought organization in the written production of high school students, the relationship between thought organization and cognitive functions (short-term memory, working memory, and attention) and whether proficiency moderates this relationship. More specifically, we look into connectedness patterns in students' first and second languages, Portuguese and English, respectively, in narrative and argumentative texts. To that extent, two empirical studies were carried out and will be reported in this dissertation.

The first study investigated thought organization (long and short-range recurrence patterns) in the written production of high school students in Portuguese and English. For that purpose, we analyzed the narrative and argumentative texts of 71 participants using the *SpeechGraphs* tool.

The second study had the goal of exploring the relationship between the long and short-range recurrence patterns associated with thought organization in the written production of narrative and argumentative texts in Portuguese and English and measures of cognitive performance of a group of 30 high school students. More specifically, we analyzed the long and short-range recurrence measures in the participants' texts in Portuguese and English in association with their performance in a short-term memory task, a working memory task, and an attention task.

This research was designed after having to change course in my doctoral research due to the Coronavirus pandemic. Given the uncertainties of the moment, in which we could not be sure when face-to-face classes and interactions could be resumed, it was necessary to think of ways in which the tasks could be conducted remotely. Both of the studies reported in this dissertation could be done via video calls. Fortunately, that was not necessary and data collection was carried out in person.

Before the start of data collection, the writing tasks to be used for the narrative and argumentative text production were designed. In order to prompt participants to write a narrative, two comic strips set in the school environment were created. Of the four frames in the strip, the third one was left blank so students would have to come up with a situation or explanation that led to the image in the last frame, encouraging students to be creative. For the argumentative task, we chose prompts related to school life in which students had to state and support their opinion. In order to help students prepare for the argumentative writing task, a

preparation activity was created for each topic and done with each group one class prior to data collection in the language of the text they would write. Data collection was done by the researcher in numerous sessions over the course of 7 months at the school participants attended and where the researcher was also the participants' English teacher.

It is important to mention that, due to being a broad subject, with this dissertation we aimed at opening the floor for discussion about the topic, not closing it. That is, the present dissertation presents an initial examination of thought organization (measured as long and short-recurrences attributes) in L1 and L2 narrative and argumentative texts written by high school students and its relationship to different measures of cognitive performance.

1.3 SIGNIFICANCE OF THE STUDY

The present dissertation adds to the ongoing research using graph analysis to investigate thought organization in typically developing populations. Given that *SpeechGraphs* has been used mainly to examine the oral production of clinical populations (MOTA *et al.*, 2012; 2014), the studies presented in this dissertation make a contribution to the literature on graph analysis as a measure of thought organization in the written production of typically developing adolescents.

This work also adds to the existing literature in writing research. More specifically, we used the *SpeechGraphs* tool to investigate thought organization in the writing of high school students in the two languages spoken by the participants, Portuguese and English, and in two types of texts, narrative and argumentative. Moreover, we looked into the relationship between connectedness in writing and cognitive functions.

An important aspect of the research reported in the present dissertation is that it makes use of a graph analysis tool to investigate writing. Even though *SpeechGraphs* has already been used to explore first and second-language oral production (BOTEZATU, 2022; LEANDRO, 2021), connectedness in children's writing both in Portuguese and in English (LEMKE *et al.*, 2021) and is currently being used to investigate English teachers' writing performance in Portuguese and English (MURICY, to be published) the novelty of the present dissertation lies in the adoption of graph theory to examine the written production of high school students by investigating thought organization (long and short-range recurrence patterns) in two different types of text - narrative and argumentative. These types of texts were chosen, first, given students' familiarity with them during their high school years. The first is the main type of text students write from primary to middle school, while the latter becomes more present in high

school, especially in preparation for college entrance exams. Moreover, narrative and argumentative texts present different levels of complexity and impose different requirements on cognition while also sharing some similarities (OLIVE, 2012, XU *et al.*, 2021). The comparison between the two types of text can provide us with an opportunity to investigate whether these similarities and differences are expressed in thought organization measures as well as in the relationship of these measures with cognitive performance. To our knowledge, no study has compared narrative and argumentative texts written in the participants' first and second languages using a graph-based tool such as *SpeechGraphs*. In this sense, we assume that graph analysis could offer an alternative form of investigating writing performance.

Regarding the relationship between cognitive functions and writing, research has yielded inconsistent results so far. Some studies found correlations between working memory and writing in the first language (e.g., CORDEIRO *et al.*, 2020; VANDERBERG; SWANSON, 2007) and in the second language (e.g., BERGSLEITHNER, 2010), while others were unable to find such a relationship (e.g., KORMOS; SÁFÁR, 2008; LU, 2015). There were also studies that found an association between short-term memory and second language writing only with pre-intermediate learners, but not with beginners (e.g., KORMOS; SÁFÁR, 2008), and others which encountered a positive relationship of working memory only with some dimensions of L2 writing (e.g., VASYLETS; MARÍN, 2021).

This discrepancy might be due to various factors. For instance, different writing tasks were used in the studies. Also, written performance was not operationalized in the same way in all the studies. Some used holistic measures of writing quality while others used the complexity, accuracy, and fluency dimensions. Lastly, the cognitive tasks may not have required the same effort from the participants, some of them yielding ceiling effects. These factors should be taken into consideration and the use of more quantitative measures of writing performance, such as graph analysis, in addition to different cognitive performance measures, might help in this debate.

Another aspect that deserves attention is the role of proficiency in the relationship between writing and cognition. Previous studies suggest that different proficiency levels may produce different results (KORMOS; SÁFÁR, 2008; VASYLETS; MARÍN, 2020). This dissertation, therefore, brings a contribution to the field by investigating whether proficiency moderates this relationship.

These contrasting results evidence a need for more research in the area in order to better establish the relationship between cognitive resources and writing, especially in a second language, in which proficiency may be a moderator. Moreover, working memory has been more

extensively studied, while short-term memory and attention have received less consideration. Hence, we hope that the present research will contribute to a further understanding of the association between writing and cognition, more specifically, the relationship that short-term memory, working memory, and attention have with the connectedness of written texts produced by high school students and whether they are moderated by second language proficiency.

Lastly, while considerable research has been carried out on the relationship between writing and cognition, this is the first study to examine this association with the help of graph theory. So far, *SpeechGraphs* has been used to look into the association between connectedness in oral reports and memory measures (MOTA *et al.*, 2019), in which a correlation between connectedness and short-term memory was found, but not with working memory. In another study, Malcorra and colleagues (2021) found a correlation between semantic memory performance and connectedness measures in oral reports of elderly participants with Alzheimer's disease and between episodic memory performance and connectedness in oral reports of the control group (cognitively healthy older adults). In their study, working memory was not associated with connectedness in oral reports for either of the groups. Thus, this dissertation aims to expand the research on the association between connectedness and cognition by analyzing written texts.

1.4 ORGANIZATION OF THE DISSERTATION

This doctoral dissertation is divided into five chapters, being the first one this introductory piece. Chapter 2 offers an overview of the theoretical background that substantiates the present research. Firstly, the processes, knowledge, and skills involved in writing are explored, both in the first and second languages, along with some important considerations for the study of writing performance. Secondly, an overview of the three cognitive functions that are investigated in the second study reported in the present dissertation will be given, namely short-term memory, working memory, and attention. Next, the association between writing and cognition will be explored, and empirical studies on both writing in the first and in the second language will be presented. Lastly, a brief account of *SpeechGraphs*, the computational and analytical tool used to assess written performance in the research described in this dissertation, will be provided.

Chapter 3 presents details of the first study that was carried out, including the specific objectives and hypotheses that guided the study. The methods used in the experiment will be described, with an account of the participants, instruments, and procedures for data collection

and analyses, followed by a presentation of the results and a discussion of their interpretations. Similarly, Chapter 4 describes the second study that was conducted, providing details regarding specific objectives, hypotheses, participants, instruments, and procedures for data collection and analyses, followed by a presentation of the results and a discussion of their interpretation. Finally, in Chapter 5, a summary of the main findings of the present research will be followed by a discussion related to its contributions and limitations, in addition to suggestions for future work.

2 LITERATURE REVIEW

This chapter presents the literature review that supports the empirical studies that were conducted and are reported in this dissertation. It is divided into four main sections. In the first section, writing is explored, both in the first and second languages, along with some important considerations for the study of writing performance. The second section deals with some cognitive functions that are essential for our everyday activities, including writing, namely short-term memory, working memory, and attention, which are investigated in the studies that were conducted. The third section delves into the relationship between writing and cognition, both in the first and second languages. Lastly, in the fourth section, the tool *SpeechGraphs* is presented as a means for analyzing thought organization in writing.

2.1 ON WRITING

Writing is an important part of language expression in different areas of our lives. It is an essential skill that involves conveying one's ideas in written form and communicating these ideas to a reader. We start learning to write when we are children and continue to develop this skill throughout our lives.

Writing differs from other linguistic skills - reading, listening, and speaking - in several aspects. For instance, writing is a productive skill, different from reading and listening, which are receptive skills. Writing and speaking are skills that demand production of language, that is, they externalize inner language by giving it linguistic form (VASYLETS; GILABERT, 2022) and are, therefore, considered more difficult to fully master than receptive skills.

As writing is a form of language production, parallels can be traced with oral production. According to Vasylets and Gilabert (2022), features that can differentiate writing from speaking include the nature of motor execution, the nature of the output, and the relationship with the audience. Because writing is self-paced, individuals have more time than in speaking to think about the message they wish to convey and to formulate and revise it. Moreover, in writing production the output is visible and more permanent than in oral production, which diminishes the pressure that can constrain the implementation of language production processes. However, given that in written production the relationship with the audience differs from the face-to-face nature of oral production, writers need to be precise in their lexical and grammatical choices, paying special attention to the explicitness and coherence of their discourse. In accordance, Schoonen and colleagues (2009) state that "the level of linguistic proficiency and metacognitive

knowledge needed (for writing) is higher than for speaking, and the lack of context and conversational feedback demands a higher level of explicitness" (p. 81).

In this section, writing both in a first language (L1) and in a second language (L2), along with the additional demands placed by each, will be contemplated. What is more, some important considerations for the study of writing will be discussed.

5 FINAL CONSIDERATIONS

The main objective of this exploratory and original research was to investigate thought organization patterns (long and short-range recurrence measures) in the L1 and L2 narrative and argumentative written production of high school students and the relationship between thought organization and cognitive functions (short-term memory, working memory, and attention). To that extent, two empirical studies were carried out and reported in this dissertation.

The first study investigated thought organization (long and short-range recurrence patterns) in the written production of high school students in Portuguese and English. For that purpose, we analyzed the narrative and argumentative texts of 71 participants using the *SpeechGraphs* tool. The findings reported in Study 1 show that participants wrote more connected and less repetitive narrative and argumentative texts in their L1, Portuguese. This was expected due to the fact that participants have a more consolidated L1, in comparison to their L2, and it is the language they use to perform the majority of their daily activities. Moreover, the connectedness in narrative texts was correlated in the two languages, suggesting that participants who wrote more connected and less repetitive narratives in Portuguese also did so in English. However, surprisingly, this correspondence was not found in argumentative texts.

Our results also indicate that there were no differences in terms of long and short-range recurrence measures regarding the type of text being written. We discuss this finding under two different perspectives: either thought organization is similar for narrative and argumentative texts or the way the writing tasks were conducted leveled the complexity of the tasks so no differences were found. Furthermore, the long-range recurrence measures correlated significantly in the two types of texts both in Portuguese and in English, meaning that participants who had more connected narrative texts also presented these characteristics in argumentative texts. Interestingly, short-range recurrences correlated in the two types of texts only in Portuguese, but not in English.

This study also demonstrated that L2 proficiency is a predictor of thought organization (long and short-range recurrence measures) in English narrative and argumentative texts. This finding is in accordance with previous studies which state that more proficient L2 writers have more linguistic knowledge and better accessibility to this knowledge, more effective writing skills, and more attentional capacity to focus on higher levels of processing (CUMMING, 2001; SCHOONEN *et al.*, 2003; TIRYAKIOGLU *et al*., 2019, MANCHÓN, 2013). Therefore, this

finding supports the idea that L2 proficiency is a fundamental aspect to be considered for L2 writing.

The second study explored the relationship between the long and short-range recurrence patterns associated with thought organization in the written production of narrative and argumentative texts in Portuguese and English and measures of cognitive performance of a group of 30 high school students. More specifically, we analyzed the long and short-range recurrence measures in the participants' texts in Portuguese and English in association with their performance in a short-term memory task, a working memory task, and an attention task.

Even though we expected to find correlations between the graph attributes and the cognitive performance measures, only STM correlated significantly with long and short-recurrence measures in Portuguese. These findings might be due to different reasons, such as the fact that the writing tasks might not have been sufficiently cognitively demanding to express the individual differences in the performance of the participants on the tasks of cognitive functions, for instance. We have discussed these findings and encourage future work on the matter.

Taking these results into consideration, we can identify some contributions of the present dissertation. First, it is only the second study comparing thought organization in L1 and L2 writing production. As in the first study looking at these variables with children (LEMKE *et al.*, 2021), we also found correlations between the languages in narrative texts. However, this association was not found with argumentative texts in the sample we tested, which could indicate that different text types develop differently in the two languages. Second, besides comparing L1 and L2 written performance, this is the first study comparing *SpeechGraphs* attributes in two types of texts.

The present dissertation also contributes to expanding the research on the tool *SpeechGraphs* as a writing assessment tool. The possibility of analyzing the written performance of high school students in their L1 and L2 in different types of text through a low-cost and practical tool, capable of providing relevant data on the thought organization of adolescents, is one of the main contributions of the study.

From a pedagogical perspective, this research can contribute to the discussion on the development of writing skills in two or more languages. It is known that the development of one language affects the other. Thus, it is important to better understand what is specific to writing in a given language and what is shared between the languages. As this becomes more clear, teachers can help students develop writing schemas that are common for both languages in any of the languages, knowing that this type of knowledge can be transferred from one

language to the other. On the other hand, characteristics regarding writing that are language-specific should be practiced in that language. With this knowledge, teachers can better design writing curricula and classes so the teaching of writing becomes more effective.

Lastly, our findings suggest that distinct cognitive functions may have specific relationships with writing depending on the language and the type of text. This adds to the literature on the role of cognitive resources in writing and poses more questions than answers.

It is important to note that the research reported in the present dissertation is just a slice of the work that could and should be done in order to explore the issues presented here. We were ambitious and chose to investigate matters that are current and have not been largely studied before. For instance, not many studies have used graph analysis to assess written performance, especially including the short-range recurrence attributes. Hence, our hypotheses were mainly exploratory, based on the use of graph analysis to assess oral reports and on research on writing performance that used different ways of measuring the construct. Furthermore, we examined participants' writing production in two languages and two different types of text, in addition to the association of these measures with cognitive functions. Therefore, we are aware of the fact that many more analyses should be conducted in order to shed light on the phenomena investigated and reported in the present dissertation.

All things considered, it is indisputable that much more work should be done in order to advance the discussion initiated with the present dissertation. Our intention is not to conclude the discussion on the topics developed in the present work but to open the floor for discussion. With this in mind, in the following subsections, we present the limitations of the current research in addition to recommendations for future work.

5.1 LIMITATIONS OF THE CURRENT RESEARCH

The first limitation of the present research is that we have not yet explored the participants' answers in the Language Experience and Proficiency Questionnaire and Socioeconomic Information (QuExPLi). Some factors can contribute to written and cognitive performance, such as socioeconomic status or whether participants play video games, that were not taken into consideration in the present dissertation. Additionally, the questionnaire supplies information about participants' use of the English language that can be employed to understand their linguistic experience more comprehensively.

This investigation was also limited by the absence of a proficiency measure in the L1. In order to be able to determine the role linguistic proficiency plays in both languages, this assessment would also need to be done in Portuguese to allow for better comparisons.

Another limitation was not having a linguistic measure, such as syntactic complexity, to compare with the graph attributes generated from the texts. Such comparisons could help identify which *SpeechGraphs* attributes are best suited for analyzing high school students' written productions in two languages and in different types of text and will be done in the future.

Lastly, Study 2 was conducted with a small sample size (n = 30) which might not have allowed significant relationships to emerge. Not all participants from Study 1 met the inclusion criteria for Study 2. Moreover, given that the data for Study 1 were collected at the end of the 2021 school year and the cognitive tasks were administered at the beginning of the 2022 school year, some participants had changed schools and could not participate. A larger sample size could have allowed for more confidence in the results of the correlations and for more sophisticated analyses.

Despite their limitations, we believe our studies provide important contributions to writing research, especially regarding the use of graph analysis to assess writing performance. The next subsection presents some recommendations for future work.

5.2 SUGGESTIONS FOR FURTHER RESEARCH

Following the limitations presented in the previous subsection, more information on participants' linguistic experience and other types of experience would help us to establish a greater degree of understanding of the matters discussed in this dissertation. Thus, the next step for the present work is to take participants' experiences into account when looking at the data.

A natural progression of this work will be to analyze the linguistic features of L1 and L2 narrative and argumentative texts collected for the present research. Analyses using computational tools such as Coh-Metrix and NILC-Metrix are planned as our next step and could greatly add to the discussion.

Further studies should also explore the connectedness attributes in L1 and L2 writing production in different types of texts, with different populations. A study has been conducted with children (LEMKE *et al.*, 2021) and there is a current study working on this relationship with English teachers (MURICY, to be published). These studies can help determine the trajectory of thought organization in typical development writing performance.

Finally, with respect to the investigation of the relationship between writing and cognitive measures, more studies should be conducted analyzing different types of text and different populations. Furthermore, more studies investigating the relationship between cognitive functions and writing process measures, such as the ones done with keylogger tools, should be carried out. A greater focus on the writing process could produce interesting findings that account more for individual differences in cognitive performance

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