Children at-risk of writing difficulties

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Doctoral thesis

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A mon pare i mumare

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Summary

Writing difficulties have been mainly studied from the viewpoint of a specific learning disability. They are therefore treated as a byproduct of a primary diagnosis. Interestingly, research on the writing difficulties of children with dyslexia, language disorders, and other learning disabilities, present similar profiles. The thesis proposes an alternative approach to identifying children with writing difficulties, whether or not they have been diagnosed with language or learning disorder. Such an approach should help clarify general trends in the typical and atypical development of writing, help orient educational practices, and tailor clinical support to the needs of struggling writers, independently of the aetiology of their difficulties.

The thesis is organized into three main studies. In the first study, a large sample of children (*N* = 919) in 2nd and 4th grade was examined to identify children who struggle with writing in a language, Catalan, that does not count with updated, standardized language development tests. This first exploration yielded a framework for identifying struggling writers in the absence of standardized test batteries, and found four profiles of at-risk students: (1) children who produce consistently short texts (LowTextGeneration group); (2) children who have handwriting fluency problems (LowHandwriting group); (3) children who have issues with basic spelling skills (LowSpelling group); and (4) a Multiple Writing Difficulties (MWD) group, who showed difficulties across two or more domains. In the second study, the cognitive and linguistic profile of the at-risk children, as well as the characteristics of text-embedded features (e.g., grammatical accuracy, vocabulary) were examined, comparing them to a group of age-matched peers. Text-embedded characteristics differed often between at-risk and

typically developing children; in particular, the MWD group performed significantly below their peers across all measures. However, no cognitive or linguistic impairments were evident. The third study addressed two issues: (1) a subgroup of the at-risk children was retested 18 months later, revealing that they had maintained their at-risk status and most had even worsened their writing profile in comparison with same-grade peers. (2) The online characteristics of the writing process of these children were assessed using SmartPens, revealing that only text-generation-related measures were sensitive to distinguish at-risk from typically developing children.

To conclude, the thesis presents compelling evidence for the existence of a writing disorder that may appear in the absence of other learning or language impairments, and which does not resolve itself without targeted instruction. No cognitive or linguistic markers were identified, while process measures were similar across the populations compared. However, the writing difficulties of these children are severe, persistent, and call for further research. Several theoretical and educational implications are discussed, including the need for early intervention to prevent writing difficulties from becoming more pervasive with time.

Resum

Les dificultats amb l'escriptura fonamentalment s'han estudiat en relació als trastorns de l'aprenentatge. Així doncs, són normalment relegades a una conseqüència d'un trastorn primari. No obstant, la recerca en dislèxia, trastorn del llenguatge i altres trastorns de l'aprenentatge presenten perfils similars en quant a escriptura. Aquesta tesi proposa un enfocament alternatiu per identificar alumnes amb dificultats amb l'escriptura (DE), els quals poden haver estat diagnosticats o no amb trastorns de l'aprenentatge o del llenguatge. Aquest enfocament pot ajudar a clarificar diferents corrents sobre l'aprenentatge típic i atípic del llenguatge, proveir orientacions per a la pràctica educativa i dissenyar suport clínic per a les necessitats dels estudiants amb dificultats d'escriptura, independentment de l'origen de la seva dificultat.

Aquesta tesi està organitzada en tres estudis principals. En el primer estudi, es van examinar una vasta mostra d'estudiants (N=919) de 2n i 4t curs d'educació primària per identificar alumnat amb dificultats amb l'escriptura en català, una llengua que no compta amb tests actualitzats i estandarditzats per avaluar el desenvolupament lingüístic. Aquesta primera exploració va proporcionar un marc de referència per identificar alumnes amb dificultats en l'escriptura en absència de tests estandarditzats, i es van trobar quatre perfils d'alumnes en risc d'aquestes dificultats: (1) alumnes que produïen textos curts consistentment (el grup de Baixa Generació de Text), (2)alumnes que tenien problemes amb la fluïdesa de l'escriptura a mà (el grup Baixa Escriptura a mà) , (3) alumnes amb problemes amb habilitats ortogràfiques bàsiques (el grup Baixa Ortografia) i (4) un grup amb múltiples dificultats amb l'escriptura (MDE), els quals mostraven dificultats dues o més dimensions de l'escriptura.

El segon estudi adreçava el perfil cognitiu, lingüístic i de les característiques de les produccions textuals (p.ex., precisió gramàtica, vocabulari), dels alumnes en risc en contrast amb un grup control d'alumnes de la mateixa edat. Les característiques textuals divergien entre el grup amb dificultats d'escriptura i el grup d'alumnes amb un desenvolupament típic, especialment amb el grup de MDE, els quals van tenir un rendiment significativament per sota dels seus companys en totes les mesures. No obstant, no es van trobar evidències d'impediments cognitius o lingüístics.

El tercer estudi adreçava dues qüestions: (1) un subgrup de l'alumnat en risc va tornar a ser avaluat 18 mesos després, demostrant que havien mantingut el seu perfil de risc, i la majoria havien empitjorat el seu perfil escriptor en comparació amb el grup de la seva mateixa edat. (2) D'aquest mateix subgrup es van avaluar les característiques del procés d'escriptura online amb Smartpens, mostrant que només les mesures de generació de text eren suficientment sensitives per distingir entre l'alumnat en risc i l'alumnat amb un desenvolupament típic.

En conclusió, aquesta tesi presenta evidències fonamentades per advocar per l'existència d'un trastorn de l'escriptura que pot aparèixer en absència d'altres trastorns de l'aprenentatge o del llenguatge, el qual no es resol per si mateix sense una intervenció específica. No s'han identificat marcadors lingüístics ni cognitius, i les mesures de procés han estat similars a través dels grups. No obstant, les dificultats en l'escriptura d'aquest alumnat són severes, persistents i és necessària més recerca. La discussió d'aquesta tesi considera les implicacions teòriques i educatives, així com la necessitat d'intervencions primerenques per prevenir que les dificultats en l'escriptura s'agreugin amb el temps.

Resumen

Las dificultades en la escritura se han estudiado fundamentalmente en relación a trastornos en el aprendizaje i por tanto, normalmente son consideradas como una consecuencia de un trastorno primario. No obstante, la investigación sobre dislexia, trastorno del lenguaje y otros trastornos del aprendizaje presentan perfiles similares en cuanto a la escritura. Esta tesis propone un enfoque alternativo para identificar el alumnado con dificultades en la escritura, hayan sido diagnosticados o no con trastornos del aprendizaje o del lenguaje. Este enfoque puede ayudar a clarificar diferentes enfoques sobre el aprendizaje del lenguaje, tanto típico como atípico, proveer orientaciones para la práctica educativa y diseñar soporte clínico para las necesidades de los estudiantes con dificultades en la escritura, independientemente del origen de su dificultad.

Esta tesis está organizada en tres estudios principales. En el primer estudio, se examinó una amplia muestra de estudiantes (*N*=919) de 2º 4to curso de educación primaria, para identificar alumnado con dificultades en la escritura en catalán, una lengua que no cuenta con test actualizados ni estandarizados para evaluar el desarrollo lingüístico. Esta primera exploración proporcionó un marco de referencia para identificar alumnos con dificultades en la escritura en ausencia de test estandarizados i se encontraron cuatro perfiles de alumnos en riesgo de padecer estas dificultades: (1) alumnos que producían consistentemente textos cortos (el grupo de Baja Generación de Texto), (2) alumnado que tenia problemas de fluidez escribiendo a mano (el grupo de Baja Escritura a mano), (3) alumnado con problemas con habilidades ortográficas básicas (el grupo de Baja Ortografía), i (4) un grupo con múltiples dificultades con la escritura (MDE) que mostraban dificultades en dos o más dimensiones de la escritura.

En el segundo estudio se analizaron los perfiles cognitivos y lingüísticos de los alumnos en riesgo, así como las características textuales de sus producciones (p.e., corrección gramatical, vocabulario), comparándolos con un grupo control de alumnos de la misma edad. Las características textuales divergieron entre el grupo con dificultades de escritura y el grupo de alumnos con un desarrollo típico, especialmente con el grupo de MDE, cuyo rendimiento estuvo significativamente por debajo de sus compañeros en todos los resultados. No obstante, no se encontraron evidencias de impedimentos cognitivos o lingüísticos.

En el tercer estudio se trataron dos cuestiones: (1) se revaluó un subgrupo de alumnado 18 meses después, demostrando que no solo habían mantenido su perfil de riesgo, sino que la mayoría tenia un perfil escritor empeorado. (2) De este mismo subgrupo se evaluaron las características del proceso de escritura online con Smartpens, demostrando que solo las medidas de generación de texto eran suficientemente sensitivas para distinguir entre el alumnado en riesgo y el alumnado con un desarrollo típico.

En conclusión, esta tesis presenta evidencias concluyentes para abogar por la existencia de un trastorno de la escritura que puede aparecer en ausencia de otros trastornos del aprendizaje o del lenguaje y que no se resuelve por si mismo sin una intervención específica. No se han identificado marcadores lingüísticos ni cognitivos, y las medidas de proceso han sido similares en todos los grupos. Sin embargo, las dificultades en la escritura son severas, persistentes y es necesario seguir investigando. La discusión de esta tesis considera las implicaciones teóricas y educativas, así como la necesidad de intervenciones tempranas para prevenir que las dificultades en la escritura se agraven con el tiempo.

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Chapter 1.General Introduction and Review of Literature

1.1. Introduction: Writing, the Complex Process

Most studies about writing and its development start usually with variations of the same sentence: *writing is a complex process, writing is a cognitively demanding activity, writing is a necessary ability and skill to succeed*. These are the most recurrent versions of the same concept: Writing does not come automatically as breathing, pumping blood, seeing, hearing or feeling. It is neither an instinct, nor an impulse, but a product of the peak of the cognitive revolution of the homo sapiens. Writing is how humans have taken language further, and used it not only to communicate that there is danger, food or a viable mate, but to transfer information, record history, make transactions, share knowledge, and even play or create art.

In literate societies, we learn from an early age that there is another form of communication that transcends time and our vocal system of speech. There is no part of the day that has no written language in it: from text messages, groceries lists, driving signs, publicity, name tags, brands, social media, exams, titles of movies, and many others. Written language is everywhere, and literate people spend a great part of their day reading and writing (Alves, 2019; Tolchinsky, 2013).

Nonetheless, we are not born with this ability. Rather, we are taught how to write throughout the school years, progressively perfecting this process. Teachers try to ensure that their students learn how to write and, with each grade, requirements and expectations increase, as students are expected to have the capacity to express their knowledge in organized, coherent, cohesive, genre-adequate texts (Perera et al., 2016; Salas & Tolchinsky, 2017; Tolchinsky, 2013).

Students' writing is assessed not only on how accurate their spelling is, but also on their ability to use correct grammar and vocabulary, and to produce well-formed texts that address interlocutor and genre demands (Berman, 2008; Berman & Verhoeven, 2002; Berninger et al., 2008). The instruction, assessment, and evaluation of these skills vary across countries, languages and even across schools and teachers. But, in the end, all aim to achieve the same goal: to be able to communicate effectively through writing (Arfé et al., 2014b).

Nevertheless, not every child develops writing at the same rate, nor do they always meet age- or grade-level standards (Arfé et al., 2014b; Baker et al., 2009; Dockrell et al., 2019; Graham et al., 2001; Graham & Harris, 2015). Not surprisingly, writing difficulties have been a concern for both researchers and practitioners for decades (Cohn, 1960; Frogner, 1933; Ingram & Mason, 1965; Moore, 1950; Schneider, 1938), and have been attested across languages and the life span, from the early steps of writing to college students (Graham & Hall, 2016; Lane et al., 2008; Richards, 2015). Writing difficulties have typically been considered as a secondary effect of a primary learning or language impairment; that is, they have usually been studied from the perspective of learning disabilities and not as a difficulty per se. There is some coverage in the literature on the writing struggles of children with Dyslexia, Developmental Language Disorder (DLD), or Autistic Spectrum Disorder (ASD) (Connelly et al., 2006; Dockrell et al., 2014; Mackie et al., 2013; Myles et al., 2003; Puranik et al., 2007; Re & Cornoldi, 2010). The writing process of these children has been explored to various degrees, because their struggles offer crucial information about the development of the writing process and because they help orient pedagogical and clinical intervention. In this thesis, I aim to provide an alternative approach to the study of writing difficulties, bringing writing to the forefront and not treating it as a by-product of another learning or linguistic impairment.

1.2. The Development of Writing Processes

Writing is essential to succeed professionally and academically, so difficulties with writing may turn into a major obstacle for self-realization (Clegg et al., 2005). The earliest teaching strategies to teach how to write were highly focused on the characteristics of writing products; as such, writing instruction entailed teaching certain rules regarding content, adequacy, grammar, and spelling, and other orthographic and rhetorical aspects of text construction (Berman & Verhoeven, 2002; Berninger et al., 2008; Dockrell et al., 2007; Olinghouse & Leaird, 2009; Tolchinsky, 2004). In the early 1980s, researchers started questioning this approach to start exploring writing as a process, and focus on the cognitive skill that took place in skilled and, later on, unskilled written composition (e.g., Hayes & Flower, 1980; Scardamalia & Bereiter, 1987).

1.2.1. Models of Writing

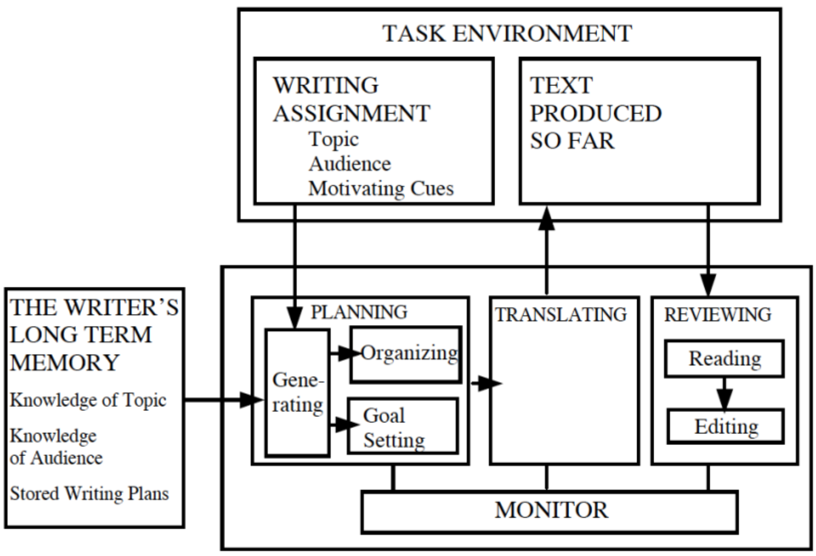
1.2.1.1. Hayes & Flower. The First 1980 Model of the Writing Process

In 1980 Hayes and Flower proposed a model on what writing entailed for expert adults, as can be seen in Figure 1.1. Writing was conceived, for the first time, as a response to an external problem or demand that the writer had to deal with (Hayes & Flower, 1980; Hayes & Flowers, 1986). The Task Environment entails the product, the written text, which is the result of the writing process. Writing involves planning, which entails setting goals and organizing the text that is to be written. During planning, there is a generation of ideas that later are translated into words. This generation of ideas draws from the writer's long-term memory (Hayes & Flower, 1980). Translation entails a transformation of this knowledge to linguistic written propositions. Hayes & Flower's

(1980) model proposes writing as a recursive process, an interactive process that draws on different cognitive processes as the task demands it, overseen by a monitoring device that allows one to go back and forth between processes, recursively. For example, a skilled undergraduate student that has to respond to an exam question, firstly draws all the specific knowledge of the topic, generates preverbal ideas, organizes the information and considers how to present it. At the same time, there is the need to set a specific goal attending to the topic and the audience (the professor in case), and then translates these ideas into adequate words for an academic task. While writing the text, this undergrad student needs to review, that is reread and edit all the information in the exam sheet. Nonetheless, when this student suddenly remember more details about the topic halfway through answering the question, the writing process may restart, and he/she goes back to the planning process to see where to fit the new ideas into the text written so far, reviewing again what has been written, and then translating the almost-forgotten ideas into words.

Figure 1.1

Hayes & Flower (1980) first model of writing



In sum, Hayes & Flower developed in 1980 the first model to explain how a skilled adult writer managed the cognitive processes to overcome a writing demand. The writing process is a response to an external demand and involves the activation of the long-term memory as well as a recursively activation of the planning, translation and revision domains.

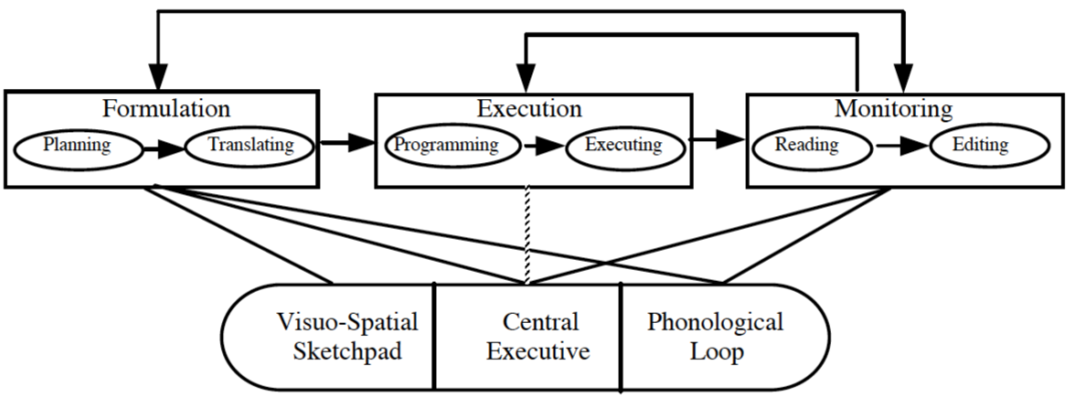
1.2.1.2. Kellogg (1996): Broadening the Role of Working Memory

Kellogg's (1996) proposal involved a more thorough account of the role of working memory in the writing process that integrated the relationship and recursivity between the three main components of writing with the components of working memory, presented in Baddeley (1986). Kellogg's model. Working memory had also been considered in Hayes's (1996) model as a general domain that would manage the resources considered in that model: long term memory, the cognitive process and the motivational components (Alamargot & Chanquoy, 2001; Hayes, 2012b). This model aimed to specify which component of working memory would be activated when each writing process occurred.

Baddeley (1986) proposed three main components: (1) the central executive, that acts as a manager of resources, bringing them forward or inhibiting them as to avoid a cognitive overload (McCutchen, 2000), (2) the phonological-articulatory loop, which retains the verbal and linguistic information, and (3) the visuo-spatial sketchpad that manages short-term spatial memory, processing visual information (Alamargot & Chanquoy, 2001). Each component plays a certain role in various writing process. Whilst the central executive is present during all writing process, functioning as a gatekeeper of working memory, each stage of the writing process demands certain resources. As can be seen in Figure 1.2, the initial stage of writing is formulation, where the planning and translation of ideas into text occurs, which requires support from all three components of working memory, given that both the visuo-spatial sketchpad and the phonological loop allow to transforming these ideas into text. Formulation is followed by execution, where the motor abilities come forward to be able to write down the text (programming and executing), supported by the central executive. Lastly, monitoring is the last step of the writing process where rereading and editing are fundamental to go back and forth to formulation and execution, controlled by the phonological loop and the central executive.

Figure 1.2

Kellogg's (1996) model links the writing process with each component of the working memory



In sum, this model accounted not only for the general role of working memory in the writing process, but it defined further how working memory interacts with each step of the writing process, and with other cognitive resources that take part in the process. Kellogg's model (1996) set the basis for future investigations, targeting working memory and its relationship to the different writing processes, with early predictions on how problems in working memory would result in writing difficulties, given the influence that it poses on all the writing process.

1.2.1.3. Bereiter & Scardamalia (1987). A Model that Differs Between Expert and Novice Writers

Bereiter and Scardamalia (1987) proposed that two different models were necessary to account for written composition by novice, the Knowledge Telling Model (Figure 1.3) and for expert writers, the Knowledge Transforming Model (Figure 1.4).

Figure 1.3

Knowledge telling model developed in Bereiter and Scardamalia (1996)

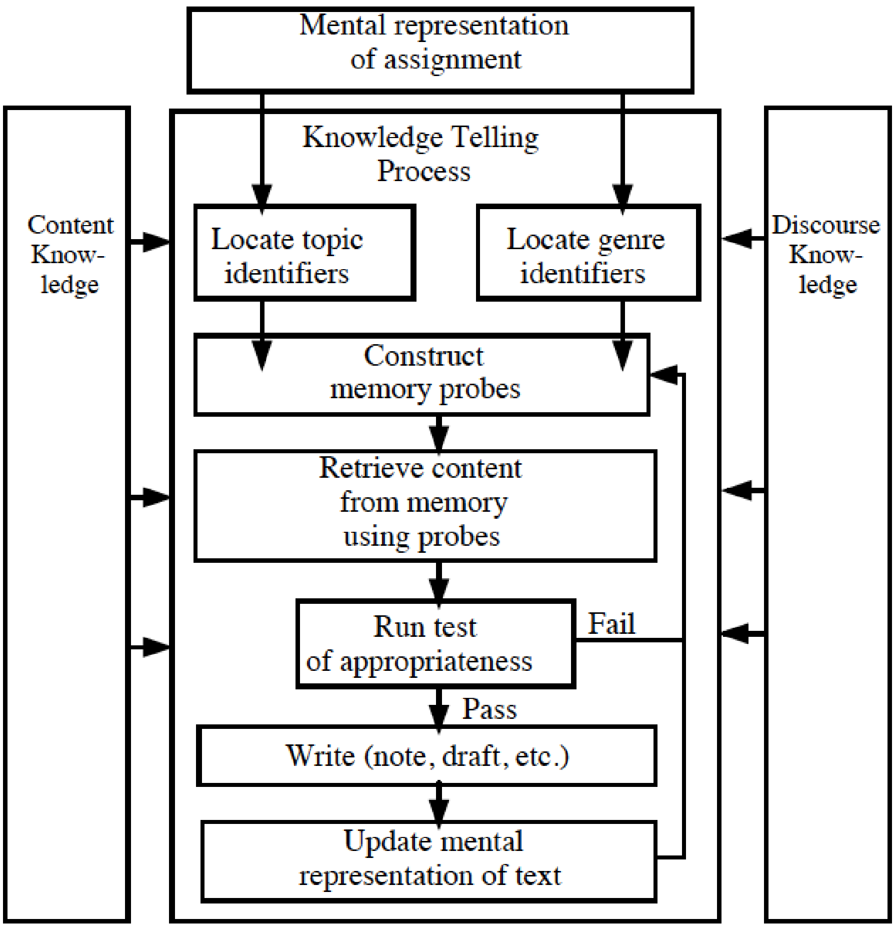
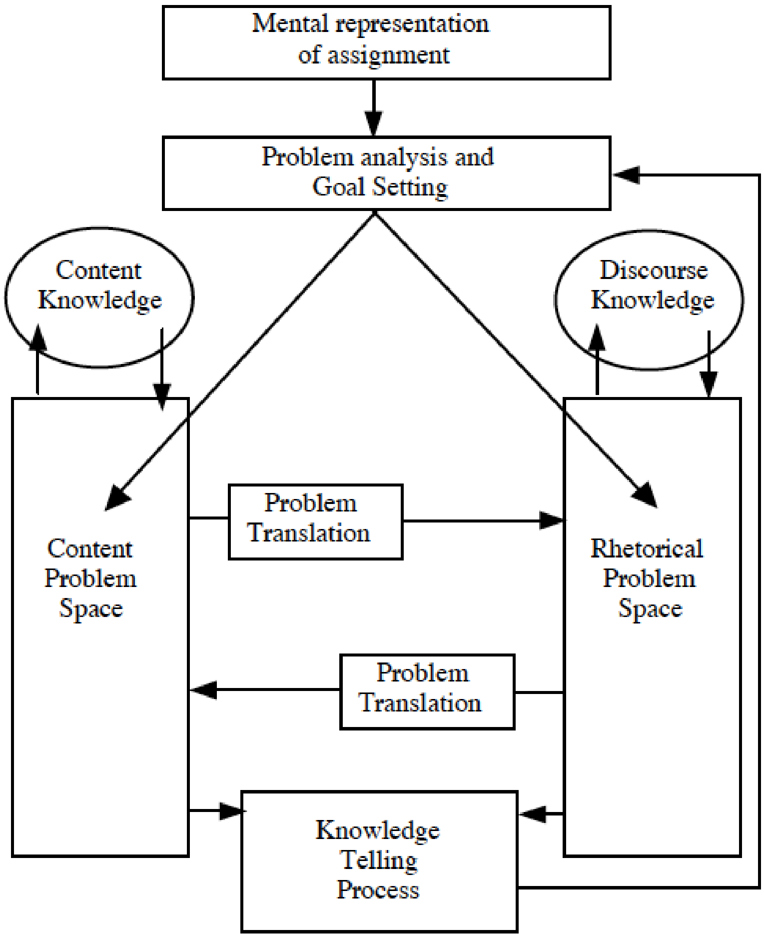


Figure 1.4

Knowledge transforming model developed in Bereiter and Scardamalia (1996)



On one hand, the Knowledge Telling model or strategy is an adaptation of oral language into written language, where novice writers would react to the task writing down the knowledge that they have on the topic. This strategy consists of trial and error runs, where the writer would screen long-term memory for information about the topic, and choose which information should be written down. Once the writer considers it appropriate for the communicative goal (either appropriate in form, content or discourse), this information is written down.

Writing, in this case, resembles a brainstorm of ideas on a topic. Novice writing often lacks coherence, cohesion, linearity and other rhetorical aspects, which are due to this transformation from an oral language response to a written one (Berninger et al., 1996; Fuller, 1995; Hayes, 2012b, 2012a; Tolchinsky, 2013). Children write in image of the oral language productions, how they talk, and trying to provide all the information of the topic without control over the overall discourse. This strategy entails not regarding neither rhetorical nor discursive aspects (Berninger et al., 1996; Hayes, 2012b).

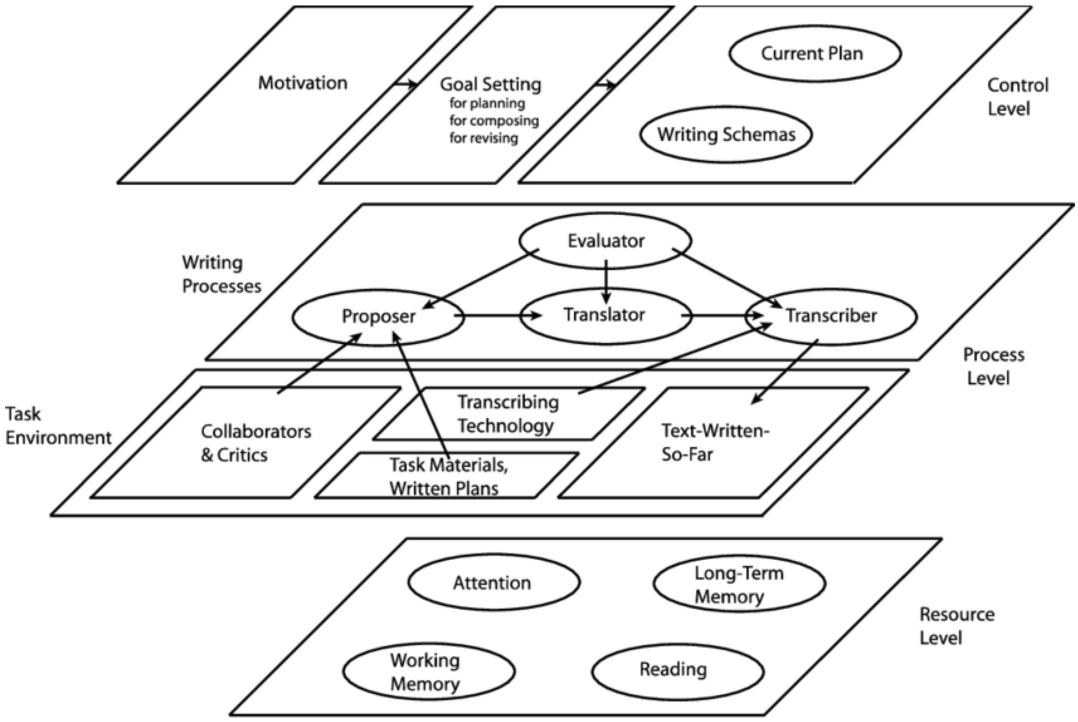
On the other hand, the Knowledge Transforming Strategy is no longer a trial and error but a goal-directed sophisticated problem-solving strategy, that is addressed considering two main areas: content-related problems and rhetorical problems. The text departs from analyzing the writing goal that it has to be achieved, keeping in mind not only accessing the Content Knowledge, and processing it in the Content Problem Space, to adapt and organize all the knowledge; but also that is a text that will be read, as well as the discursive knowledge, managed in the Rhetorical Problem Space to provide the text with genre, topic and discourse adequacy. These two spaces interact with each other to transform all the knowledge and adapt the text to the required needs, either if they are of content, or rhetorical. The sophistication of the writing process in this model is much more elaborated and reserved for expert writers, given that it entails considering and integrating knowledge and strategies that have to be developed across practice and expertise (Alamargot & Chanquoy, 2001; Scardamalia & Bereiter, 1987).

1.2.1.4. Hayes & Flower (2012b) Reformulation

Over time, Hayes and collaborators included many modifications and revisions (Chenoweth & Hayes, 2001; Flower & Hayes, 1981; Hayes & Flowers, 1986; Hayes, 2012b; Hayes & Chenoweth, 2006), whose latest version was Hayes model of 2012b(Hayes, 2012b, 2012a) that led to a more complete, detailed schema on the components that interacted during writing (Figure 1.5).

Figure 1.5

Hayes (2012b) latest model of writing process



Writing processes were organized into 3 levels: a controlling level where the demand of the text would start with motivation to write and setting goals. The motivation component was the newest incorporation to this model, as the first step in the control level, given that ample evidence showing that it would constrain or facilitate the writing process (Hayes et al., 1990; Hayes, 2012b; Troia et al., 2012). The processing level entails the interaction of the task environment with the writing processes to respond to a prompt, translate the prelinguistic ideas into words and revise what has been written. In this level Hayes (2012b) remarked the suppression of the planning and reviewing as entities at this stage, given that the author has considered them as specific writing activities, and therefore not a writing process (Hayes & Berninger, 2014). Moreover, it has to be noted that Hayes (2012b) places special attention to the transcription processes which occur during the translation of ideas into text (Hayes & Berninger, 2014). Transcription had not been considered until the reformulation of Chenoweth and Hayes (2001) model. This dimension was omitted, due to the exploration of adults skilled writers which had already automatized transcription abilities, that led to overseeing that they pose a constraint on the writing process. This dimension was found by exploring novice writers in developing stages (Berninger et al., 1992, 1994), which evidenced the role that transcription abilities have on the writing execution, when transcription is still in development and has not been entirely automatized as in skilled adult writers. Later it was explored on adult skilled writers (Hayes & Chenoweth, 2006). Lastly, this model presents a third level, the resources level, where the available cognitive resources for the writer lie, which condition the execution of writing processes such as the attention capacity, reading abilities, and working memory (Hayes & Chenoweth, 2006) and long-term memory.

In sum, Hayes's models offer an insight into how the writing process is managed. Nonetheless, other researchers focused on how novice writers manage these resources (Hayes, 2012b; Hayes & Berninger, 2014; Juel et al., 1986; Scardamalia & Bereiter, 1987), that lead to explore what would enable students to be more effective when writing (Berninger et al., 1992; Hayes & Berninger, 2014).

1.2.1.5. The Simple and the Not-So-Simple View of Writing

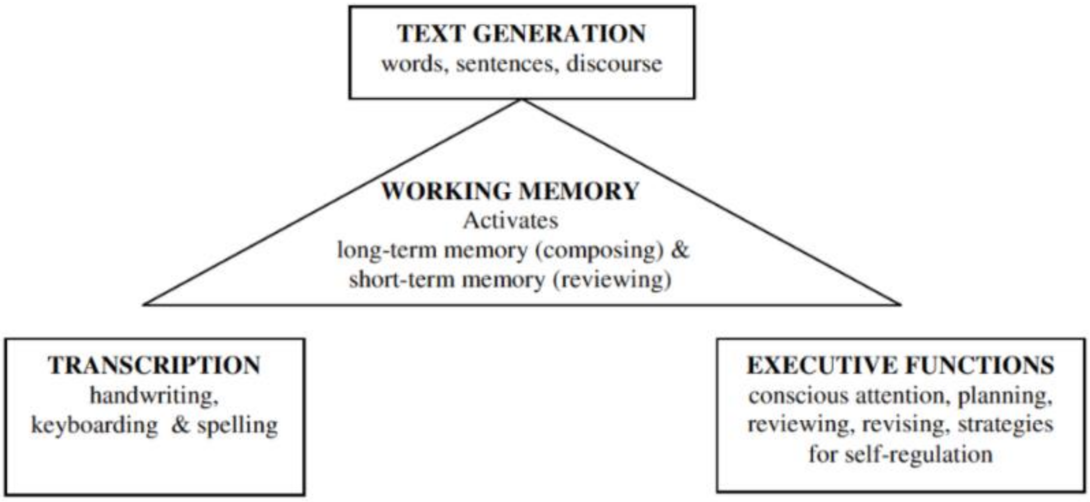
The Simple View model (Juel et al., 1986) departed from a more synthetic exploration of writing as the sum of two basic skills: ideation and spelling (Berninger, 1999; Graham et al., 1997; Juel et al., 1986). These two concepts embody how there are high-level skills, summarized as ideation (generating, organizing ideas, structuring them) and low-level skills, under the spelling category (the ability to transform the ideas into written words) in written composition (Juel et al., 1986). The Simple View model predicts, in developing writers, that the writing ability in the early years of the acquisition of these skills, low-level skills are determinant to be able to write effectively, and once it is automatized in time, higher-level skills take a more dominant role (Alamargot & Chanquoy, 2001; Juel et al., 1986; Tolchinsky, 2013).

Berninger and collaborators started working in the early 90's on models of writing for novice writers, or those in earlier stages of developing writing, given that previous Hayes and Flower's (1980) model had not accounted for novice writers. Novices were found not to plan neither revise, as well as have constricted text generations due to the role of transcription abilities (Abbott et al., 2010; Berninger et al., 1992, 1994). With a first modification of the simple view, Berninger & Amtmann (2003) developed a schema that incorporated handwriting to the transcription abilities, the motor execution ability to put the ideas into paper, as well as a triangular relationship between text generation, transcription and executive functions, indicating the close relationship and influence of the key skills of the writing process (Berninger & Amtmann, 2003; Berninger & Winn, 2006; Graham et al., 1997; Juel et al., 1986).

The not-so-simple view of writing (Berninger & Winn, 2006) took the simple view further, emphasizing text generation, transcription skills and executive functions as key elements of the writing process, with the working memory as the core of the process (Figure 1.6).

Figure 1.6

The Not-So Simple View model of writing (Berninger & Winn, 2006)



In the center of the pyramid there is working memory, as the vessel that contains storages and manages the cognitive processes and information (Berninger et al., 2009; Daucourt et al., 2018). The working memory acts as an enabler, managing the cognitive load for each individual (Berninger et al., 1994; McCutchen, 2000; Olive, 2011; Swanson & Berninger, 1996). All writers are equally limited by the management of these resources as seen in the capacity theory (Just & Carpenter, 1992), when some resources overload the attention (i.e. accessing the lexicon, spelling, handwriting, retrieving ideas). With this saturation of the cognitive capacity, the writer can have setbacks on their text generation having to focus the attention into details that when automatized allow a better text generation (Berninger et al., 1992; Berninger, 1999; Hayes & Chenoweth, 2006; Limpo et al., 2017; Olive & Kellogg, 2002; Swanson & Berninger, 1996).

Text generation is the higher axis, that represents the written final product of the transformation of ideas, pre-linguistic ideas that will be processed by transcription and executive functions into written text. This transformation has to be carried out accessing the linguistic knowledge (e.g., morphosyntactic skills, grammar) either at word, sentence or text levels (Berninger, V. W., & Amtmann, 2003; Berninger & Winn, 2006).

Low-level transcription skills represent one of the two axis on the base, supporting and regulating text generation, as had been seen that the automatization of both transcription skills play a major role in the writing process, as they can pose a constrictive role on the writing execution (Berninger & Amtmann, 2003; Berninger & Winn, 2006; Graham et al., 1997; Juel et al., 1986). Transcription skills are abilities that do not develop equally and simultaneously for all children, and the lack of automatization of these skills can pose severe problems on the writing process, given that focusing on low-level skills impairs the access to high-level writing skills (Berninger, 1999; Berninger et al., 1992; Bourke et al., 2014; Limpo et al., 2017; Limpo & Alves, 2013). Whilst skilled writers have automatized low-cognitive demands, both handwriting and spelling, and are able to focus their attention on high-level processes (e.g. planning, revising), novice writers have to shift focus between their cognitive demands to patch their lacks in either of them until they can automatize the low-level resources (i.e. spelling and handwriting; Olive & Kellogg, 2002).

On the other axis of the pyramid, at the same level as transcription skills, there is the executive functions axis, where the high-level skills of planning, revising and monitoring are represented as the other base to be able produce this text. To be able to write, high and low cognitive resources have to be activated and interact with each other to be able to respond to the demands of the writing process: planning, translating the ideas into words, transcribing them into paper and revising (Berninger et al., 1992; Hayes & Flower, 1980).

In sum, both transcription skills, spelling and handwriting, are the key specific elements of the writing process, as transcription skills have a constrictive effect on text generation when not automatized. The writing process relies on the cognitive capacity of the writer, as well as the low-level skills and the high-level skills, that set the basis to be able to generate text.

1.2.2. Writing Difficulties

Researchers have not only explored the writing of typically developing (TD) children but also examined the writing of children with learning disabilities (LDs). As we have reviewed above, writing may be constrained by several factors of the writing process, such as spelling (Bourke et al., 2014; Kim et al., 2014; Kim & Schatschneider, 2017; Olinghouse & Leaird, 2009), handwriting (Alves, 2019; Alves et al., 2012; Alves & Limpo, 2015; Connelly et al., 2006; Kim & Schatschneider, 2017; Limpo et al., 2017), as well as by working memory, short-term memory or executive functions (Berninger et al., 1994; Bourke & Adams, 2010; Cowan, 2010; Daucourt et al., 2018; McCutchen, 2000; Olive, 2004; Swanson & Berninger, 1996).

Writing difficulties have usually been considered as a secondary outcome of other, more general or primary impairments. Several studies have pointed out that people with a history of learning disabilities (LD), such as dyslexia, autistic spectrum disorder (ASD), developmental language disorder (DLD), or attention-deficit/hyperactivity disorder (ADHD), experience sustained difficulties with writing even until adulthood (DeBono et al., 2012; Hatcher et al., 2002; Hellendoorn &

Ruijssenaars, 2000; Tops et al., 2012). More recently, a new line of research has emerged that intends to raise the status of writing difficulties and start considering them as a potential primary impairment (Coker et al., 2018; Connelly, 2014; Dockrell et al., 2019; Graham et al., 2017; Graham & Harris, 2005; Ritchey & Coker, 2014). There are three main advantages to bringing writing difficulties to the forefront: First, it facilitates an in-depth understanding of writing and writing processes by focusing on examples where writing develops atypically; second, it allows for specific remediation strategies that target writing behavior that needs improvement; third, it might uncover children who do not suffer from any learning disabilities but who, nevertheless, experience serious difficulties with writing.

1.2.2.1. Affected Cognitive Processes

Writing is a cognitively demanding task and, as such, it involves the recruitment of several cognitive processes and resources (e.g., Hayes & Flower, 1980; McCutchen, 2000), such as working memory (Berninger & Winn, 2006; Bourke & Adams, 2003, 2010; Kellogg, 1996), short-term memory (e.g., Bourke et al., 2014; Bourke & Adams, 2010; Swanson & Berninger, 1996), as well as of low- and high-level executive functions (e.g., Altemeier et al., 2008; Berninger & Winn, 2006; Drijbooms et al., 2015, 2017). Given that most learning disabilities involve a processing or cognitive impairment, it is not surprising that several cognitive skills linked to writing have been found to be affected in LD populations. Table 1.1 offers a summary of the main findings of the affected cognitive processes that were identified in the scanned studies.

Table 1.1

Main findings of assessed cognitive processes across studies, by learning disabilities

		WM	EF	STM	IQ
ADHD	Capodieci et al., 2018	A[b]	-	-	-
ADHD	Geurts et al., 2004	-	A	-	-
ADHD	Nyeden et al., 1999	-	A	-	NA
ADHD	Rodríguez et al., 2017	A	-	-	-
ASD	Nyeden et al., 1999	-	A	-	NA
ASD	Geurts et al., 2004	NA	A	-	-
Dyslexia	Altemeier et al., 2008	-	A	-	-
Dyslexia	Cruz-Rodrígues et al., 2014	A	A	A	-
Dyslexia	Connelly et al., 2006	A	-	-	-
Dyslexia	Pagliarini et al., 2015	-	-	-	-
DLD	Conti-Ramsden 2015	-	-	A	-
DLD	Conti-Ramsden et al., 2001	-	-	A	NA
DLD	Dockrell et al., 2007	NA	-	-	-
DLD	Mackie et al., 2004	-	-	-	NA
DLD	Mackie et al., 2013	-	-	A	-
DLD	Vugs et al., 2014	A	A	-	-
DLD	Im-Bolter et al., 2006	A	A	-	-
DLD	Williams et al., 2013	A	-	-	NA

Note. Studies are organized by aetiologies. All studies contrasted with groups matched by chronological age. WM= Working Memory; EF= Executive Functions; STM= Short-Term Memory; IQ= Intelligence Quotient; ADHD= attention-deficit/hyperactivity disorder; ASD= autistic spectrum disorder; Dyslexia; DLD= developmental language disorder; A= Affected, NA= Not affected.

Working memory --that is, the ability to withhold information, while performing some kind of manipulation or operation (Baddeley, 1986)-- has been found to be impaired and to affect the writing skills of people who suffer from ADHD (Capodieci et al., 2018; Rodríguez et al., 2017), ASD (Nydén et al., 1999), DLD (Cuperus et al., 2014; Vugs et al., 2014; Williams et al., 2013), or dyslexia (Connelly et al., 2006; Cruz-Rodrigues et al., 2014; Varvara et al., 2014).

There is also evidence that LD children show affected low-level executive functions, which are fundamental for written composition (e.g., Altemeier et al., 2008; Salas & Silvente, 2019). Low-level executive functions, such as inhibition or updating of working memory (Diamond, 2013; Miyake et al., 2000), have been found to be affected in children with ADHD (Craig et al., 2016; Happé et al., 2006), ASD (Robinson et al., 2009), DLD (Cuperus et al., 2014; Im-Bolter et al., 2006; Vugs et al., 2014), and dyslexia (Helland & Asbjornsen, 2000), although conflicting results have been reported for ADHD, ASD (Sergeant et al., 2002), and dyslexia (Reiter et al., 2005).

Writing is a task that requires short-term memory to recall what has been written so far and to process and maintain information of the letters, words, and text that one intends to write down, among other uses during composing (Bourke & Adams, 2003, 2010; Cowan, 2010; Swanson & Berninger, 1996). DLD children, for example, have been found to have shorter verbal spans (Conti-Ramsden et al., 2001, 2015; Mackie et al., 2013), as well as dyslexic children (Varvara et al., 2014).

Finally, it has to be noted that IQ was not affected across neither of the scanned studies that assessed it, independently of the aetiology (Conti-Ramsden et al., 2001; Mackie & Dockrell, 2004; Nydén et al., 1999; Williams et al., 2013), and therefore, there are no differences between children with LD.

In sum, it appears that across learning disabilities, there are underlying affected cognitive processes that constrain the writing process. Processes such as working memory or core components of the executive functions, which have been shown to be essential in the mediation of the writing process are impaired across LD populations, constraining their writing ability.

1.2.2.2. Affected Text Features

A review of studies about the text generation difficulties of different learning-disabled (LD) populations also points to similar struggles across LDs with the expression of specific linguistic features embedded in their texts (Table 1.2).

Table 1.2

Main findings of the affected text features across studies, by learning disabilities

		Spell	Hw	Voc	Gram	TQ
ADHD	Re et al., 2007	-	-	-	A	A
ADHD	Re et al., 2010	A		A	A	A
ADHD	Capodieci et al., 2018	-	NA	-	-	-
ADHD	Geurts et al., 2004	-	-	-	-	-
ADHD	Myles et al., 2003	-	NA	-	A	-
ADHD	Tucha and Lange, 2001	-	A	-	-	-
ADHD	Tucha and Lange, 2005	-	A	-	-	-
ASD	Dockrell et al., 2014	-	A	A	A	A
ASD	Geurts et al., 2004	-	-	-	-	-
ASD	Kushki et al., 2011	-	A	-	-	-
ASD	Myles et al., 2003	-	-	-	A/NA*	NA

Table 1.2

Main findings of the affected text features across studies, by learning disabilities

		Spell	Hw	Voc	Gram	TQ
Dyslexia	Arfé et al., 2014	A	-	-	-	-
Dyslexia	Berninger et al., 2008	A	A	-	-	A
Dyslexia	Connelly et al., 2006	A	A	A	NA	A
Dyslexia	Pagliarini et al., 2015	-	A	-	-	-
Dyslexia	Puranik et al., 2007	A	-	-	A	-
Dyslexia	Rice 2004	A	-	-	-	-
Dyslexia	Sumner et al., 2013	A	NA	-	-	A
DLD	Conti-Ramsden 2003	-	-	-	NA	-
DLD	Dockrell et al., 2007	-	-	A	A	A
DLD	Dockrell et al., 2014	A	A	-	A	A
DLD	Mackie et al., 2004	NA	-	-	A	-
DLD	Mackie et al., 2013	A	-	-	A	-
DLD	Puranik et al., 2007	A	-	-	A	-
DLD	Williams et al., 2013	A	-	NA	NA	A

Note. Studies are organized for aetiologies. All studies contrasted with groups matched by chronological age. Spell= Spelling; Hw= Handwriting; Voc= Vocabulary; Gram= Grammar; TQ= Text Quality; ADHD= attention-deficit/hyperactivity disorder; ASD= autistic spectrum disorder; Dyslexia; DLD= developmental language disorder; A= Affected, NA= Not affected

* Myles et al., 2003 found affected morphology, whilst overall grammar was not.

LD children have also been found to struggle with transcription skills to a larger extent than their TD peers. Transcription skills, that is, spelling and handwriting, are considered foundational skills of writing (e.g., Berninger et al., 1992). Spelling has been found to be affected in children with DLD (Dockrell et al., 2014; Mackie et al., 2013; Mackie & Dockrell, 2004; Williams et al., 2013), ADHD (Re & Cornoldi, 2010), and dyslexia (Arfé et al., 2014b; Berninger et al., 2008; Cruz-Rodrigues et al., 2014; Puranik et al., 2007). Handwriting, on the other hand, also presents a challenge for DLD (Berninger et al., 2008), ASD (Dockrell et al., 2014; Kushki et al., 2011), and dyslexic children (Berninger et al., 2008; Pagliarini et al., 2015). There is some controversy about handwriting in ADHD children, as some studies have found it to be unaffected in comparison to controls (Capodieci et al., 2018; Myles et al., 2003), whilst others did find handwriting to be impaired for these children (Lange et al., 2007; Reiter et al., 2005). Finally, a study on dyslexic children concluded that they do not experience handwriting difficulties, but they do pause more when writing (Sumner et al., 2013).

Text generation, often measured in the number of words produced, is a privileged indicator of writing development, one of the best proxies for text quality, and one of the first dimensions of writing to emerge cross-linguistically (Berman & Verhoeven, 2002; Salas et al., 2016; Salas & Caravolas, 2019). When text generation is measured in the number of sentences, there are small or no differences between LD children and controls (Connelly et al., 2006; Myles et al., 2003). When measured in T-Units, text generation has been found to be affected in children with ADHD, ASD (Myles et al., 2003) and DLD (Puranik et al., 2007), but not in dyslexic children (Puranik et al., 2007). Text generation as the number of ideas is a less explored measure, but has been found to be affected in DLD children (Dockrell et al., 2007, 2014; Mackie et al., 2013; Mackie & Dockrell, 2004; Puranik et al., 2007), but not in children with dyslexia (Connelly et al., 2006; Pagliarini et al., 2015; Puranik et al., 2007) or ADHD (Re & Cornoldi, 2010; Rodríguez et al., 2015). In short, text generation has been assessed using a variety of measures, where the number of words has been argued to be the most sensitive to capture difficulties with writing (Connelly, Dockrell, Walter & Critten, 2012).

Besides difficulties with text generation, some studies have found specific text features to be affected in the writing of LD children. For example, lexical diversity is poor in ADHD children (Re et al., 2007), ASD children (Myles et al., 2003), and DLD children (Dockrell et al., 2007; Mackie et al., 2013; Mackie & Dockrell, 2004; Williams et al., 2013); however, one study found that children with dyslexia would be unimpaired in this respect (Puranik et al., 2007). LD children also struggle with other aspects of linguistic expression. LD populations have difficulties with grammar in their written texts. Children with ADHD and dyslexia present difficulties with grammar such as verbal, nominal, and adjectival agreement (Puranik et al., 2007; Re & Cornoldi, 2010), whilst children with ASD and DLD make more grammatical mistakes than age-matched peers (Dockrell et al., 2014).

All these difficulties also lead to impoverished text quality assessments regarding their peers. Children with LD are consistently found to have an affected text quality, either assessed in text structure, coherence, adequacy, cohesion or overall holistic measures. Text quality has been found affected in children with ADHD (Re et al., 2007; Re & Cornoldi, 2010), children with ASD (Dockrell et al., 2014), although for contrasting results see Myles et al. (2003); children with dyslexia (Berninger et al., 2008; Connelly et al., 2006; Sumner et al., 2013), and children with DLD (Dockrell et al., 2007, 2014; Williams et al., 2013)

In sum, most children with developmental disabilities of various aetiologies appear to have similar difficulties with the main components of writing; that is, with text generation and transcription. Most of them also experience problems with vocabulary and syntax (e.g., Puranik et al., 2007). Transcription abilities are one of the main constraints in students with learning disabilities such as dyslexia, autistic spectrum disorder (ASD), attention-deficit/hyperactivity disorder (ADHD) or developmental language disorder (DLD), who have been found to struggle with spelling (Berninger et al., 2008; Dockrell et al., 2014; Re & Cornoldi, 2010), or handwriting skills (Connelly et al., 2006; Dockrell et al., 2014; Graham et al., 2016; Kushki et al., 2011; Lange et al., 2007). Transcription directly impacts on text generation (e.g., Berninger & Winn, 2006); accordingly, the texts produced by LD children are typically of less quality than those by their age-matched peers (Arfé et al., 2014b; Dockrell et al., 2014; Sumner et al., 2013; Williams et al., 2013), creating a gap that not only affects across the schooling years but that can be attested up until adulthood (Connelly, Dockrell, Walter & Critten, 2012; Hatcher et al., 2002; Tops et al., 2012). The texts produced by children with different LDs often converge in showing similar issues, when compared to TD children. There is abundant evidence that LD children produce texts that are shorter (Mackie & Dockrell, 2004; Myles et al., 2003; Sumner et al., 2013), with poor lexical diversity (Re et al., 2007; Williams et al., 2013), and that contain more spelling mistakes (Berninger et al., 2008; Dockrell et al., 2014; Re & Cornoldi, 2010). Given these striking similarities across LDs, it seems necessary to explore the writing skills of children that fall behind their peers, whether or not presenting a diagnosis for a learning or language disorder (Coker et al., 2018; Ritchey & Coker, 2014). Crucially, these students have not only been found to struggle at a product level but also when writing is assessed on-line (Beers et al., 2017; Connelly, Dockrell, Walter & Critten, 2012; Sumner et al., 2013)

1.3. Examining the Online Writing Processes

The assessment of writing skills has mainly involved a posteriori analyses of the written products. Even as the focus in writing research shifted from product to process (Berninger et al., 1996), most writing research instruments usually consisted in analyzing the text once it was completed; for example by calculating the time invested in it or, for example, stopping the participants to retrieve verbally what had been thinking at that moment (Levy & Ransdell, 1994). However, interest in writing as it was happening increased the use of different techniques that have been refined and perfectioned over the years.

1.3.1. Think-Aloud Protocols

In order to identify and investigate writing processes, early on, researchers resorted to think-aloud protocols. Think-aloud protocols were incorporated to know what was crossing the writer's mind when writing. This verbalization of thoughts allowed in the early 80' to build the Hayes and Flower's (1980) model, which marked the starting point for understanding the writing process. This protocol was further developed later on with the dual-task and triple task technique, firstly proposed by (Kellogg, 1996), and developed later by Olive and his collaborators (Olive et al., 2001, 2002; Olive, 2004).

1.3.2. Dual and Triple Task

The dual -or triple-task technique (Kellogg, 1996; Olive et al., 2001) were an alternative to think-aloud protocols. The dual-task demands participants to write a text (first task), while they are interrupted by auditory stimuli to which they have to respond to as quickly as possible (second task). The reasoning was that a more belated response indicated engagement in more cognitively demanding tasks (Olive, 2004). As such, they were useful to know the specific writing process in which the writer was engaged at the time of the interruption (Olive et al., 2001; Olive, 2004, 2010). The triple task was identical to the dual task, except that, in addition, participants were asked to identify the specific writing process (e.g. planning, revising or transcribing) they were engaged in when the interruption occurred (third task; Olive et al., 2001).

These data offered insight on the extent of the effort that each cognitive process demands, as well as the time invested in the different processes of writing. This method was questioned due to the constant disruptions to the writer, who arguably could not properly concentrate on the main task. Nonetheless, several studies have shown that results that emerged from this type of research were solid and reliable (Levy & Ransdell, 1994; Olive et al., 2001, 2002; Olive, 2010).

1.3.3. Process Measures: Bursts and Pauses

More recently, research has been able to incorporate other, more sophisticated techniques, including keystroke logging, digitizing tablets paired with pens, and smart pens. These tools involved a radical change in data collection methods, given that writing was assessed more fluently, naturally and without disruptions. Most importantly, tablets and smart pens allowed access to new writing data, such as writing bursts and pauses. A writing burst is the string of words that a writer produces before needing to pause, and the pauses consist on the time where the writer does not write any text between strings of words. Bursts are thus conceptualized as a writing unit, given that writers do not necessarily produce full sentences; rather, they generate text of various sizes, which have been found to vary as a function of age and educational level (Alves et al., 2007; Berman, 2014; Chenoweth & Hayes, 2001; Limpo & Alves, 2013). A pause, on the other hand, is defined as a period of no writing activity of at least 2 seconds duration (Alamargot et al., 2007; Alves et al., 2007, 2008; Olive, Alves, et al., 2009; S. Strömqvist et al., 2006).

While expert writers are able to write on average around nine words per burst, children at grade 2 write around two words per burst, while 6th graders are able to write on average about 6 words (Alves et al., 2016; Alves & Limpo, 2015). During execution or burst production, the writer focuses on the graphomotor needs and translating ideas into text (Olive, Alves, et al., 2009). Automatization of specific transcription skills (i.e., handwriting and spelling) have been found to be predictors of burst length, given that a more fluent transcription processes should lessen cognitive demands and allow the writer to keep more words in working memory (Alves et al., 2016; Connelly, Dockrell, Walter & Critten, 2012; Limpo et al., 2017; Limpo & Alves, 2017). In turn, longer bursts are associated with a more efficient writing process that translates into higher-quality texts, and its growth is related to an age-related developmental factor (Alves & Limpo, 2015; Connelly, Dockrell, Walter & Critten, 2012; Olive & Kellogg, 2002). High-level skills can co-occur also during burst production, which was mainly associated with transcribing processes such as text generation and transcription (Olive, Alves, et al., 2009).

Writers combine time of writing activity with time where there is no written activity registered, known as pauses, that provide the boundaries to bursts. Pauses have been considered as the time in which writers stop their transcription to be able to recharge or manage the cognitive overload (Just & Carpenter, 1992; McCutchen, 2000) before being able to keep on writing (Alves et al., 2007; Olive, Alves, et al., 2009; Olive & Kellogg, 2002). Pauses provide an opportunity to update working memory, access high-level skills (planning, reviewing, updating), and generate more ideas (Alves et al., 2007; Olive, Alves, et al., 2009; Olive & Kellogg, 2002).

Pauses are also affected by the genre of the text being produced, where more pauses made in argumentative texts than in narratives, supporting the idea that the former demand are more cognitively demanding to writers (Beauvais et al., 2011; Medimorec & Risko, 2017; Olive et al., 2001). Novice writers tend to pause more, which affects their transcription fluency or their burst production, given that they seem to experience a cognitive overload during transcription. This limited cognitive capacity does not allow them to write fluently and forces them to pause more and for longer, to be able to manage all the writing dimensions (Alves et al., 2007; Olive, Alves, et al., 2009).

1.3.4. Keystroke Logging

Keyboard strokes were one of the first means of exploring writing processes, obtaining detailed, precise information of a writer's actions during text composing. The array of keystrokes and pauses is analyzed through web-based programs such as InputLog (Leijten & Waes, 2006) or ScriptLog (Strömqvist & Malmsten, 1998; Strömqvist & Karlsson, 2002), which are linked to text processors who collect the keystroke data (Leijten & Van Waes, 2012, 2013; Van Waes et al., 2006, 2012).

Keystroke logging records the bursts and pauses that are produced during a writing task (Alves et al., 2007; Leijten & Van Waes, 2012, 2013; Medimorec & Risko, 2017; Van Waes et al., 2006; Wengelin et al., 2009). Several studies explored the different patterns of pauses and bursts and the typing speed data, which offered a complete overview on how the text was constructed (Wengelin et al., 2009). This approach offers methodological advantages due to the already digitalized and processed data.

Keystrokes have also been a useful tool when working with children with language difficulties such as the studies with dyslexic populations, given that studies have found motivational issues regarding these children, who are more engaged and motivated by the use of this tool that eases the transcription (Beers et al., 2017; Strömqvist et al., 2006). Typing has been shown to improve transcription skills for students with difficulties, but there is controversy on which method produces better texts: typing or handwriting (Beers et al., 2018; Goldberg et al., 2003; Morphy & Graham, 2012), whilst it has to be considered the increase of use of keyboarding toward adolescence (Connelly et al., 2007). Several studies found that keyboarding eased writing fluency in the intermediate and higher grades (Berger & Lewandowski, 2012; Goldberg et al., 2003; Weigelt-Marom & Weintraub, 2018). Moreover, studies showed that students with writing difficulties were more fluent with keyboards, rather than writing by hand on paper (Morphy & Graham, 2012; for an extensive review, see Beers et al., 2017).

In sum, keystroke logging records typing skills, which are also measured in array of words and pauses. This tool offers accurate typing speed and pausing data, although methodological issues have to be considered between the difference of handwriting and typing on keyboards.

1.3.5. Eye and Pen

Eye-and-Pen records handwriting movements and pauses by measuring the pressure of a pen on a digital tablet, while it also records the eye's movements to track orbital focus during writing. Eye and pen methods allow identifying the movements of the writer's eyes, providing information on what is on focus during pauses: revising, planning, reading or searching for information (Alamargot et al., 2012; Wengelin et al., 2009). Furthermore, Ductus, a software developed to focus on the handwriting traces that were done on digital tablets. This system does not include eye-tracking but offers more detailed information on the handwriting process per se, with more detailed recognition of pen trajectories, for example, that records the centimeters that the pen covers in the stroke (Kandel et al., 2009; Kandel & Perret, 2015).

Eye-and-pen methodologies have not been exempt from criticism, especially because of the unnatural writing situation (Alamargot et al., 2006, 2007). Participants must remain still, with forced head positions and at a fixed distance from the tablet. Furthermore, writing must be done on tablets in tilted angles and pen positions that are not the usual handwriting position with a pen and paper (Figure 1.7), a situation that poses additional constraints, particularly when working with children or learning-disabled populations (Alamargot et al., 2006; Yamamoto et al., 2010).

Figure 1.7

Example of writing with Eye-and-pen digitizing pen, tablet and the head apparatus to register eye movement, extracted from Alamargot et al. (2012)

To sum up, Eye-and-pen was the turning point to be able to explore the writing process without disrupting the writing process, registering with the tablet the traces and movements of the pen, paired with orbital eye tracking. This method is one of the most widely used in studies, despite the unnatural writing situation.

1.3.6. Smartpens and HandSpy

Smartpens (Alves et al., 2019; Monteiro & Leal, 2012) paired with micro dotted paper, provide an ecologically valid writing situation, while also allowing a thorough data collection of details in the writing process. Smartpens have an infrared camera that registers every stroke made by the writer, which is stored in its internal memory and transferred via Bluetooth (Figure 1.8) to a digital tablet or computer.

Figure 1.8

Connectivity interface of the NeoNote app. Once the Smartpen's Bluetooth is activated, to link the Smartpen to the app these three steps are followed.

Earlier models of LiveScribe Pens transferred the data to web-based applications, whilst the latest Neo Smartpen transfers the raw data to tablet or phone-based applications, which may later be transferred to hybrid apps such as Drive or Evernote, among others. This transfer then allows a transformation of the data to adapt it for interpretation in the HandSpy web (https://handspy.up.pt/), a software developed at the University of Porto (Alves et al., 2019; De Sousa & Leal, 2013; Monteiro & Leal, 2012; Monteiro & Leal, 2013). HandSpy is necessary to analyze and to extract measures of pauses, speed, time and distance. Micro-dotted paper combines small symbols in the background of the paper allow the software to ubicate the specific location where the pen meets the paper (and to identify each different sheet).Further details on the Smartpens and HandSpy usage and methodological issues are discussed in depth in Chapter 4.

In sum, Smartpens register the handwritten traces on paper, and HandSpy (De Sousa & Leal, 2013; Monteiro & Leal, 2012; Monteiro & Leal, 2013) allows to analyze the burst and pauses data. Smartpens allow registering handwriting in a natural writing environment, and paired with HandSpy offers objective empirical evidence of the writing process.

1.4. Objectives and Hypotheses of the Thesis

The thesis is part of two research projects: 'Enseñar a escribir: Reflexión metalingüística y estrategias de autorregulación', funded by MINECO (ref.EDU2015-64798-R, PI: Teresa Ribas); and 'Ara l'escriptura! Millorar l'expressió escrita per garantir l'equitat de l'alumnat', funded by RecerCaixa-ACUP (ref.015ACUP 00175, PI: Naymé Salas). These projects granted access to schools and data for the analysis of written products.

The thesis proposes an alternative perspective to the study of writing difficulties since LD children from various aetiologies appear to experience similar issues with writing (as reviewed in section 1.2.2 above). It seems then sensible to approach writing difficulties from a more general viewpoint, rather than from the narrow perspective of a specific learning disability. Most importantly, such an approach would also allow us to identify children who struggle with writing in the absence of other learning or language disabilities, who may go unnoticed and not receive the type of remediation strategies or support needed. In this way, the thesis builds on the recent, pioneering work along similar lines by Coker et al. (2018; Ritchey & Coker, 2014) and Dockrell et al. (2019), by providing both cross-sectional and longitudinal data on poor writers in Catalan, a language whose writing has received little attention in the past. Therefore, in this thesis, we focus on exploring the writing process of children potentially at risk of writing difficulties to build a general writing difficulty profile that should be useful to identify children who struggle in writing regardless of whether they also present another learning language disorder.

This general goal will be realized by three specific objectives:

(1) provide an assessment framework to identify children who struggle writing, independently of a preexisting, diagnosed condition in Catalan, a language where there are no standardized writing tests;

(2) examine the text-based traits, as well as the cognitive and linguistic profile of children at risk of writing impairment;

(3) determine the main characteristics of the writing process of children at risk of writing impairment.

With regards to specific objective (1), we expected to find a group of children whose writing performance lagged significantly behind age-matched peers. This group would be formed by children with and without LDs, provided that most students with learning disabilities have shown writing difficulties, but that previous studies have also identified children whose struggle with writing cannot be attributed to a primary disorder (e.g., Coker et al., 2018; Dockrell et al., 2019). Specifically, we expected that the struggling group would show lower levels of achievement in one or more key writing component: spelling, handwriting and text generation (Berninger & Amtmann, 2003; Berninger & Winn, 2006). To test these hypotheses, we applied two different identification methods, and reported on the advantages and disadvantages of each, while presenting the rationale and criteria for identifying children at-risk of writing impairments.

With regards to specific objective (2), we expected that at-risk children would show difficulties in a series of text measures obtained (e.g., vocabulary diversity, grammatical errors, spelling) in comparison to age-matched peers. Moreover, in line with the cognitive deficits found across various populations experiencing writing difficulties (Cruz-Rodrigues et al., 2014; Cuperus et al., 2014), we expected that at-risk children would show lower levels of working and short-term memory, among other cognitive, linguistic (e.g., vocabulary knowledge, receptive morpho-syntax) and literacy-related (e.g., reading) skills. To achieve goal (2) and test our hypotheses, we administered a number of writing tasks and tests, obtaining measures of non-verbal IQ, short-term memory, and low-level executive functions (inhibition and updating). We also collected measures of children's vocabulary and morphosyntax levels, as well as word reading and reading comprehension, in order to examine whether to provide a fuller picture of the skills underlying the writing of at-risk children, as well as the specificity of their difficulties, in contrast to TD controls (Dockrell et al., 2019; Kim & Schatschneider, 2017).

Lastly, regarding the specific objective (3), we expected that at-risk children would show difficulties in the writing process, this being bursts and pauses. These measures are expected to be impaired in the at-risk groups, with a more hindered execution of text, shorter bursts with more and longer pauses than the TD peers, as had been previously found in studies on the writing process of children with LDs (Connelly, Dockrell, Walter & Critten, 2012; Sumner et al., 2013). To test this hypothesis we administered writing, spelling and handwriting tasks with Smartpens and afterwards analyzed with HandSpy software to examine burst length and number, as well as pause length and number.

1.5. Organization of the Thesis

This thesis is structured in 5 chapters that intend to provide an in-depth exploration of aspects of the writing process of Catalan-speaking children at-risk of writing difficulties. Each chapter addresses one of the specific goals mentioned above.

Chapter 2 addressed specific goal (1) focusing on the assessment of writing to be able to identify "struggling writers" (Dockrell et al., 2019). Taking into account that there are no standardized tests in Catalan, it was paramount to establish clear, objective criteria. Chapter 3 addressed specific goal (2). It aimed to define the cognitive profile and the text-based traits of struggling writers. With the previously identified groups of children who presented difficulties. This chapter aimed to investigate the writing and cognitive profile of children at-risk of writing difficulties, regardless of whether they have concomitant diagnoses. Chapter 4 addressed specific goal (3). Therefore, it focused on the online measures of the writing process, obtained with Smartpens and analyzed via HandSpy software (Alves et al., 2019; Monteiro & Leal, 2012). Because data for the study was collected 18 months after the data for Chapter 3, we also examined the longitudinal stability of the identification of the at-risk children. Chapters 2 through to 4 each include a brief introduction, with a review of relevant literature on the specific topic, a Method and Results section, as well as a Discussion section. Chapter 5 includes a general discussion to reflect on all three studies, in the light of previous research. In addition, theoretical and educational implications are discussed.

Chapter 2. Identification of Children At-Risk of Writing Difficulties

Detecting possible struggles with writing at early ages is crucial to be able to develop remedial intervention and school resources to reinforce writing abilities at school (e.g., Arfé et al., 2014a; Graham et al., 2011; Graham & Perin, 2007; Morphy & Graham, 2012), given that writing difficulties can persist until adulthood (Connelly, Dockrell, Walter & Critten, 2012; DeBono et al., 2012; Tops et al., 2012). Most studies that explore writing difficulties in early ages remark how an early intervention is crucial to bridge the gap between these students and their peers (Graham et al., 1997, 2000, 2001; Jones & Christensen, 1999; Puranik & Lonigan, 2012; Ritchey & Coker, 2014). Therefore, our aim in this chapter was to design an identification protocol of writing difficulties in Catalan for children in the early and intermediate stages of primary education, to be able to detect difficulties with writing, independently of the existence of other learning disabilities.

2.1.1. How is Written Language Assessed?

Tests of written language assessment are usually part of larger batteries for cognitive assessment including mathematical thinking, receptive grammar, or oral comprehension, such as the Test of Written Language (TOWL-IV; Hammill & Larsen, 2009), the Wechsler Individual Achievement Test-III (WIAT-II; Wechsler, 2009), or independent tests batteries targeting only written-related skills such as the *Batería de evaluación de los Procesos de escritura* 'Battery of evaluation of the writing processes' (PROESC; Cuetos et al., 2004) or the Detailed Assessment of Speed of Handwriting (DASH; Barnett et al., 2010). Tests require frequent revision and updating to be able to adapt to changes in norms (e.g., linguistic expression, grammar, bias-free language), as well as to theoretical and practical scientific findings.

Standardization allows to determine whether a student's performance matches the expected results for her age or educational level. Tests are assessed for validity ("how much does this test assess what was intended to observe?") and reliability ("how consistent is this test?"), ideally with a large sample of participants, representative of the target population (Betz et al., 2013; Trevethan, 2017). Furthermore, standardized tests have been used by researchers working on learning disabilities to be able to ascertain a cohort's impairment and the difference between them and their typically developing peers (TD). They are standardized for specific populations (e.g. UK, USA) and age ranges.

Batteries consist of an array of subtests that assess the target skills; tests of written expression typically include subtests that asses the low level (e.g., spelling) and high level (e.g., organization, coherence) writing skills. That is, most test batteries are informed by current findings and theories on how writing develops (Berninger, 2006). Table ***2.1*** shows a detailed relation of the main tests used to assess writing development across English-speaking populations, as well as one test in Spanish (PROESC; Cuetos et al., 2004) and another in Catalan (Cervera et al., 1991).

Transcription skills are usually assessed throughout spelling tasks. A Spelling subtest is included in most of test batteries (e.g., PROESC, TALEC; WRAT-V, WJ-III, TOWL, WOLS), and these tests usually include more than one assessment for spelling. The most frequently used measure across tests to assess spelling is the dictation of words, where students hear a word or a sentence and they have to write it down correctly. Sometimes, spelling is also assessed in a dictation of pseudowords (e.g., PROESC, TOWL, WJ-III) or also a task that entails correcting orthographic and grammatical conventions (WJ-III, TOWL), where students have to, for example, edit illogical sentences or apply the rules for punctuation and capitalization correctly.

When assessing transcription skills, it has to be noted how writing scores are usually conditioned by handwriting ability (e.g. the PROLEC writing task includes a “mechanics” assessment, as well as the TALEC, which also considers calligraphy as relevant for the overall score), although handwriting is not considered across most of the tests. Of the most frequently used tests that can be seen in Table ***2.1***, handwriting assessment is included only in the WIAT-III and the DASH tests (Barnett et al., 2010; Wechsler, 2009). The DASH test is a full battery to assess only handwriting proficiency and includes two copying tasks of the pangram ‘The quick brown fox jumps over the lazy dog’ to assess speed and legibility independently, and graphic speed tasks where handwriting is not assessed writing words but drawing ‘X’ shapes inside printed circles on a paper within 1 minute following specific instructions of size and orientation (Barnett et al., 2010), and an alphabet writing task, measuring how many words in correct alphabet order can a child write before a specific time limit (15 or 30 seconds, depending on the test). It has to be noted that there is also a writing task in the DASH test, but the text generation measure is used to assess handwriting. Students are presented with the prompt “my life” and write about this topic for 10 minutes to therefore be able to count the total amount of letters written.

Almost all tests include a text generation task, except the WRAT-V test. These writing tasks usually include one or more of three types of prompts: (1) writing an essay, (2) a picture stimulated narrative task, or a (3) free writing task.

Essay composition is usually assessed under specific conditions stipulated for each test, depending on the main target of the assessment: whilst some tests analyze the overall quality of the text, there can be written productions specifically designed to analyze the argumentation ability, grammatical knowledge or handwriting (as has been seen in the DASH writing subtest). For example, the GRE tests, which are designed for adults, assesses the ability to analyze an issue and take different perspectives as well as analyze a topic and be able to argue in favor of a specific logic (GRE; Educational Testing Service, 2004). In the GRE tests, the texts are assessed analytically with specific punctuation and criteria to score different domains (e.g. topic development, text structure, vocabulary, adequacy, coherence, cohesion, proper use of grammar and orthography).

Another system to assess text generation is with tasks introduced by stimuli pictures or a writing prompt that entail the generation, such is the case for the OWLS, TEWL, TOWL and DASH tests. On one hand, tests such as the OWLS, TEWL or TOWL use picture stimuli to assess children on text generation. The text is scored analytically with specific punctuation for each of the different domains (e.g. format, cohesion, ideation, spelling, organization). In contrast, tests designed to be assessed with CBM measures, differ from this overall scoring given that the scoring is provided by quantifiable measures such as the number of words written, or correct writing sequences that the student has been able to write. In this case, the stimulus is a narrative prompt, a story starter, that will elicit the generation of text. The student has 4 minutes to write a short story that afterwards will be assessed on total of words written, correctly spelled words and correct word sequences (Wright, 1992). The test provides a standardization for grades for each evaluation time of the year (fall or spring).

The third type of writing tasks in the standardized tests are those with a free writing task where children are only instructed to write a story freely for a limited amount of time such as in the PROESC, TALEC or WJ-III tests. The tests propose measures of holistic scoring considering the different proficiency in domains such as vocabulary, plot and character development, interest to the reader, compositional skills, grammar, punctuation or capitalization.

In standardized test written text assessment can be analytical or holistic. Analytical scoring entails detailed instructions on what are the criteria to receive a specific scoring are, and fixing norms for what a good or bad text is (such as in the WIAT-II UK test with a 0-6 detailed norms for the holistic scoring). For example, the writing assessment of the Graduate Record Examination (GRE; Educational Testing Service, 2004) has a detailed explanation on how the texts should be to achieve a score of (6) *outstanding*, (5) *strong*, (4) *adequate,* (3*) limited*, (2) *seriously flawed* or (1) *fundamentally deficient.*

Holistic evaluations are frequently included to provide a single quality score for writing (Dockrell et al., 2014). Holistic measures reflect the overall impression and judgement that an evaluator gets from the whole text. With one mark, this score can include a vast array of dimensions such as content development and fitness to the topic, structure, vocabulary, coherence or grammatical and spelling accuracy. Although holistic quality scoring has been widely used and it is often required as the primary marker for the assessment of writing (Berman & Nir-Sagiv, 2008; Dockrell et al., 2014; Salas & Tolchinsky, 2017), it has received substantial criticism, among other reasons, because of the susceptibility of evaluators to be biased (Blanche-Benveniste, 1982; Charney, 1984; Lee et al., 2010).

Table 2.1

Summary of scanned standardized tests

Test	Subtests	Age Range of application	Written Assessment		
			Hw	Spell	Text Gen
CBM (Marston & Magnusson, 1985)	Mathematics Reading Written expression	5 to 12 years	-	-	-
GRE (Educational Testing Service, 2004) [Analytical Writing section]	Analytical Writing Quantitative reasoning Verbal Reasoning	Adults	-	-	✓
DASH (Barnett et al., 2010))	Alphabet Writing Copy Best Copy Fast Free Writing Graphic Speed	9 to 16 years, 11 months	✓	-	✓
OWLS-II (Carrow-Woolfolk, 2011))	Comprehension Listening Oral Expression Reading comprehension Written Expression	5 to 21 years, 11 months	-	-	✓
PROESC (Cuetos et al., 2004)	Essay Writing Narrative Writing Pseudowords Spelling Sentence Spelling Word Spelling	8 to 15 years	-	✓	✓

Table 2.1

Summary of scanned standardized tests

Test	Subtests	Age Range of application	Written Assessment		
			Hw	Spell	Text Gen
TALEC (Cervera et al., 1991)	Copying task Reading letters Reading syllables Reading words Reading comprehension Spelling Writing Sample	n/a	✓	✓	✓
TEWL-III (Hresko et al., 2012)	Basic Writing Contextual Writing Overall Writing	4º to 11 years, 11 months	-	-	✓
TOWL-IV (Hammill & Larsen, 2009)	Combining Sentences Contextual Conventions Logical Sentences Punctuation Story Composition Spelling Vocabulary	9 to 17 years, 11 months	-	✓	✓
WIAT-III (Wechsler, 2009)	Reading Comprehension Pseudoword Decoding Numerical operations Mathematical Reasoning Spelling Writing Fluency Sentence Composition Essay composition Listening comprehension Oral expression	4 to 16 years, 11 months	✓	✓	✓

Table 2.1

Summary of scanned standardized tests

Test	Subtests	Age Range of application	Written Assessment		
			Hw	Spell	Text Gen
WJ-III (McGrew & Woodcock, 2001; WJ-III; Vaughn-Blount et al., 2011)	Alphabet Calculations accuracy Humanities Math fluency Reading comprehension Reading fluency Science Social Studies Writing fluency Writing accuracy	5 to 95 years	-	-	✓
WRAT-V (Robertson & Wilkinson, 2017)	Math Computation Sentence Comprehension Spelling Word Reading	5 to 14 years 18 to 85+ years	-	✓	-

2.1.1.1. Criteria to Identify At-risk Students

The tests referred to in Table ***2.1*** have been used in numerous studies, setting -2 SDs from the mean as a threshold indicative of writing struggles (e.g., Dockrell et al., 2005, 2019; Mackie & Dockrell, 2004). For example, the Wechsler Individual Achievement Test-II (WIAT-II; Wechsler, 2001) has been widely used in studies with students from different etiologies (e.g., Abbott et al., 2010; Altemeier et al., 2008; Connelly, Dockrell, & Barnett, 2012; Zajic et al., 2018), as well as the Wechsler Objective Language Dimensions , WOLD (Wechsler, 1996), which has also been applied in different studies (e.g., Connelly et al., 2006; Dockrell et al., 2019; Sumner et al., 2013), but nowadays has been superseded by WIAT-II. Moreover, studies do not only resort to complete batteries, but often use a subtest that measures a precise skill, as can be seen, for example, in Dockrell et al. (2019): they use WOLD measures to distinguish between typical and struggling writers, CBM measures to assess writing productivity, accuracy and quality, the BAS-II (Elliott, Smith & McCulloch, 1997) measures to assess spelling ability and DASH (Barnett et al., 2010) measures to assess handwriting fluency.

In sum, there is a vast array of standardized tests to assess written language and each one counts with specific subtests that provide performance scores for the key writing components (e.g., handwriting, spelling or text generation). Students who struggle or fall behind their peers are easily identified by nation-wide, empirically-based criteria. Students are typically considered to have difficulties when their scores are 2 SD below the average for their age (Del Barrio, 2016; Trevethan, 2017). The identification of learning disabilities is crucial to ensure that the students have access to school and financial support or certain adaptations in the curriculum and assessment tests (Del Barrio, 2016).

2.1.1.2. Assessment of Written Language in Catalan

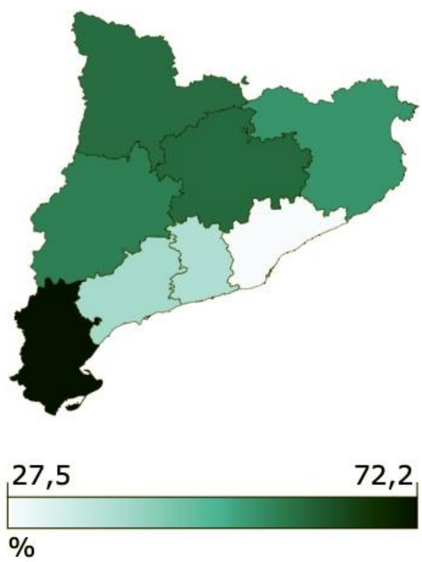
Most of the literature on writing development comes from languages with standardized tests, which account with nation-wide reference norms such as the National Reading Panel report (Shanahan, 2005) from the US Department of Health and Human Services (NICHD), or the guides for standardized testing across schools that can be seen in the UK's Standards and Testing Agency. In contrast, Catalan has very few, suboptimal options for assessing written language, as we review below.

Catalan is a minority language that coexists with Spanish (Idescat, 2015), and is the main language of schools in Catalonia. Catalan was banned from public life between 1939-1975 (Benet, 1978) and only since 1983 the law for the Linguistic Normalization was passed by the Parliament of Catalonia in order to reestablish Catalan as the co-official language in Catalonia, which allowed to reintroduce it as the main language in schools (Pons, 2004).

Nowadays, the use of Catalan as the main language in adults is associated to higher levels of achievement at school and university, to skilled occupation, and to place of birth (Idescat, 2015). Children attending schools in districts with a lower socioeconomic status and high affluence of immigration, who use mainly Spanish or other languages, have low to no exposure to Catalan in their immediate environment (Idescat, 2015). As can be seen in Figure 2.1, updated demographic data of language use from the Statistics Institute of Catalonia reported that, in 2018, Catalan was more present in the rural regions of Catalonia, while only 29,3% of the population in Barcelona has Catalan as their main language (Idescat, 2019).

Figure 2.1

Map of distribution of population that uses Catalan as a main language, from Idescat (2019)



Districts of Barcelona, where there is a higher percentage of national and international immigration, Spanish is usually the main language children are exposed to. Their exposure to Catalan mainly occurs in the school environment (Idescat, 2015). At schools, all subjects, except Spanish and English, are taught in Catalan. While it is safe to assume that the children in our sample are speakers of both Spanish and Catalan, the language of interest for this thesis, they vary in the extent to which they master the language and in the amount of exposure to it.

As mentioned above, there are few standardized tests to assess writing and reading proficiency in Catalan and, to the best of our knowledge, there have not been any large-scale empirical studies concerning the writing difficulties of Catalan-speaking students. Teachers who detect any kind of language problem in their students, refer them to public medical centers or specific centers such as the CDIAP 'Child Development and Early Care Centers' when the difficulty is detected between 0 and 5 years old children, or mental health primary attention centers such as the CSMIJ 'Child and Youth Mental Health Center' for children between 5 years old and 18 years old.

Children are evaluated with bespoke cognitive tests and administered questionnaires to identify learning or language disabilities. It is customary to use the Autism Diagnostic Interview Revised (ADI-R; Rutter et al., 2011) for identifying possible cases of ASD, or the Dyslexia Screening Test- Junior (DST-J; Fawcett et al., 2010) to identify dyslexia at an early age. Nonetheless, these tests are standardized for Spanish-speaking populations and not for Catalan-speaking ones. To assess reading, in contrast, there are adaptations of Spanish tests such as the *Prova d'Avaluació dels Components Bàsics de l'Aprenentatge de la Lectura* 'Evaluation tests of basic components of learing of reading' (PACBAL; Castells, M., Font, J. & Ramon, 2016) or the PROLEC-R (Cuetos et al., 2009). Besides these tests, the *Avaluació de la Comprensió Lectora*, 'Evaluation of Reading Comprehension' (ACL; Català i Agràs et al., 2001) has been used since the early 80'. Its standardization and language use have not been updated since.

The only test for writing assessment in Catalan is an adaptation of a Spanish test, the TALE, which was adapted to Catalan in the TALEC version (Cervera et al., 1991) and has not been updated since the early 90'. The TALEC test battery presents several shortcomings to be used as a valid assessment measure nowadays. Firstly, it was standardized in the early 90' with only 300 children from Barcelona, and it does not account for the linguistic diversity in the territory. Secondly, writing is assessed with an open text generation task, where children can write about any topic they may choose. Instructions do not provide an accurate scoring procedure, as authors propose a holistic scoring for the texts in terms of suggestive overall text quality, as well as three main measurements to take into account: (1) legibility of words (i.e. irregularities in size and tracing of words, oscillations of graphisms), (2) accuracy of orthographic conventions and (3) syntactic and expressive content (Cervera et al., 1991). In consequence, we considered this test to be outdated and not in line with current theories of writing, as for example, the role of handwriting calligraphy and legibility in writing development is not certain, as it has considered to be a subjective factor for rater's judgements (Santangelo & Graham, 2016), and thus, we opted to rule it out as a viable assessment option. An important goal of this thesis was thus to explore assessment protocols, inspired by empirical findings and some of the current used test batteries, fit for the target population that would enable both practitioners and researchers to identify children with writing difficulties.

2.1.2. This Study

Our aim for this chapter was to identify students who presented writing difficulties in Catalan, whether or not they also presented other learning disabilities. Given that we lack adequate standardized measures to assess writing competence, we set out to produce a protocol for writing assessment in the absence of standardized tests. The design for this chapter follows, to a degree, the proposal by Coker et al. (2018), who classified struggling writers into a profile of children who have difficulties with handwriting ("writing fluency" group), another group characterized by difficulties with text generation (the "low writing samples" group), and a group that presented multiple writing difficulties (the "at-risk" group). Coker et al.'s categories are well in line with current models of writing development (Berninger & Winn, 2006) and targeting most of the essential struggles identified in the standardized test batteries. In order to provide a closer match to such models and tests, we also added a group of children who showed difficulties with spelling. Therefore, we aimed to tap into the three major components of writing: (1) text generation, (2) handwriting and (3) spelling. To achieve this goal, we administered several tests that targeted each of these skills. In addition, demographic information obtained from the children in the sample, such as familiar SES or language use outside school, was also used to complement identification.

We expected to identify struggling writers along in each dimension (spelling, handwriting, and text generation), as well as children who struggled with more than one dimension. Three different screening approaches were examined. First, we proceeded to identify children using the most common cut-off point of most standardized test batteries; that is, children who performed at least 2 SD below the average for each skill (i.e., spelling, handwriting, text generation) or a combination of them. Second, we screened for children performing at or below the 25th percentile, in line with recent research suggesting that this is an acceptable measurement that has been shown to be sufficiently sensitive and specific (Davidi & Berman, 2014; Hooper et al., 2013; Serrano & Defior, 2014). Finally, we considered students who fall only 1 SD from the mean, a more lenient approach that has nevertheless been used in several studies (Altemeier et al., 2008; Conti-Ramsden et al., 2001; Snowling et al., 2016; Williams et al., 2013). A crucial criterion used across all three approaches was that the target low scores, as defined by each approach (i.e., -2 SDs, at or below the 15th percentile, or –1 SD), had to be consistent across more than one task. Alternatively, the severity of the difficulty had to be of importance. For these reasons, we included two writing tasks (a narrative text and an opinion essay) in order to assess text generation skills; two handwriting fluency tasks; and a single spelling task where we looked for low scores on phonological accuracy, rather than conventional accuracy. Arguably, even our youngest participants (2nd graders) should have mastered the phonological representation of phonemes in writing (Caravolas et al., 2001). In other words, our approach to the identification of writing difficulties capitalized on consistency across testing or the severity of the difficulty.

2.2. Method

2.2.1. Participants

Participants were 919 students (465 2nd Graders and 454 4th Graders) from the larger project. All children attended public schools (N=12) in different Barcelona districts. Their school teachers and parents consented to participate in the study, which was approved by the Ethics Committee of the University.

It was important to ensure that there were no easily identifiable factors that conflicted with the identification of writing difficulties. Since the main goal of the chapter, and the thesis, was to test whether there are struggling writers with and without comorbid disabilities, we did not use information about other learning or developmental disabilities as a criterion for exclusion or inclusion of participants. However, children's exposure to Catalan, the language of instruction and the target language of the thesis, varies considerably across the school children in Barcelona (Idescat, 2015), to avoid a confound between poor knowledge of or exposure to Catalan and poor writing competence. In consequence, we administered a sociolinguistic questionnaire that inquired about children's language use outside of school. Table ***2.2*** shows that only in five schools Catalan use outside school was about 50% or higher.

Table 2.2

Selected schools based upon number of children with frequent Catalan exposure

School	Catalan exposure
01	**49%**
02	**48.1%**
03	**60.4%**
04	13.7%
05	11.5%
06	0%
07	15.8%

Table 2.2

Selected schools based upon number of children with frequent Catalan exposure

School	Catalan exposure
08	**75.7%**
09	30.1%
10	**71.2%**
11	31.6%
12	12%

Note. Schools that met the criteria to be eligible are in bold.

In addition, our own observation of the language dynamics at these five schools indicated that they use Catalan in virtually all interactions, inside and outside the classrooms. In contrast, the remaining schools showed only incidental use of Spanish, while children communicated with each other mainly in Spanish. These observations were further confirmed by the teachers at all these centers. Our final sample, eligible for exploration, consisted of 357 children from 2nd and 4th Grade (188 male, 169 female) from 5 schools.

2.2.2. Tasks and Measures

Writing sample 1. Narrative Text. Children replied to one of two prompts “A boy/girl loses his/her pet” and “A boy/girl gets angry with his/her best friend” depending on the school they attended. Prompts were counterbalanced across classrooms; this means that each classroom was administered a single prompt, but that different classrooms were randomly assigned prompts. Students were given 10 minutes to prepare a draft and 20 minutes to write their story. Afterward, the candidate and a research assistant transcribed the texts in CLAN-compatible format (MacWhinney, 2000).

Writing sample 2. Opinion essay. Children answered the prompt “Do you think that every boy and girl your age should go to school?” or “Do you think that children at school need recess?” depending on the school they attended. Prompts were counterbalanced across classrooms and administration of the two writing tasks was randomized to avoid any conditioning. Following the same procedure as in Writing sample 1, students were given 10 minutes to prepare a draft and 20 minutes to write their essays. Texts were transcribed in CLAN-compatible format (MacWhinney, 2000) by the candidate and a research assistant.

Handwriting 1. Alphabet task. Handwriting skills were assessed with the alphabet task, after Berninger et al. (1994). Children had to write down the alphabet as fast as possible from memory. If they finished, they had to start again until one minute had passed. The score was the number of correctly traced letters within the first 15 seconds. However, given that not all schools in Barcelona taught the alphabet to children, we applied two scorings: one that penalized alphabetical order (strict) and one that did not (lenient). The strict scoring involved a substantial loss of information, given that a non-trivial number of students got scores of 0. Because the correlation between the two scorings was extremely high, $r = .996$, we opted to use the lenient score in all subsequent analyses. A research assistant also scored a random 20% of the sample obtaining a reliability (ICC) of = .984.

Handwriting 2. Days task. To obtain a second measure of handwriting fluency, we asked students to write the days of the week as fast as possible within a minute, and they had to restart if they finished before the time had elapsed. Scoring was the number of correctly written letters within the first 15 seconds, ad misspellings were not penalized. Reliability between the candidate and a research assistant on a random 20% of the sample was .995 (ICC).

Spelling. Children were tested on spelling ability with a bespoke dictation task of 34 words, counterbalanced for frequency, length in syllables, and syllabic complexity, and administered in two fixed, randomized orders to avoid conditioning between them. The examiner first read the word out loud, then said the word in a sentence and lastly repeated it isolated one last time: *vent. Si fa vent, podrem anar a navegar. Escriviu vent*, 'wind. If there is wind, we can go sailing. Write wind'. All words were awarded 1 point when they were written in a phonologically plausible form, that is, when the word was written in a way that was consistent with the phonological structure of the word, even if it not according to convention. For example, for *vent*, 'wind' above, the <t> at the end is silent, and the <v> is one of two possible representations, along with <b>, of the phoneme /b/, as in *balena*, 'whale'. Therefore, *<ben>, *<bent>, or *<ven> were all phonologically plausible answers. This task's internal consistency was good, with Cronbach's alpha = .919. Inter-rater reliability (ICC) for the scoring was also assessed on a random 20% of the sample between a trained research assistant and the candidate and it was .989.

2.2.3. Procedure

Children were assessed on transcription measures in their schools during the first semester (October-December). The handwriting measures were administered along with other cognitive and linguistic tasks from the larger project in an individual session in quiet rooms. The spelling task was administered in the usual classroom simultaneously for all the children of that class. During the second semester (February-March), the written expression tasks were administered in two different sessions, one for the opinion essay and the other for the narrative task.

2.3. Results

For all three approaches to identify struggling writers, scores were standardized for each age group, so that deviations from the mean were based on each child's grade level. Means and standard deviations for the 357 participants in each grade task can be found in Table 2.3.

Table 2.3

Means and SD for all the participants in the tasks*

	2nd Grade	4th Grade
N	181	176
Spelling	21.86 (8.22)	23.77 (8.41)
Handwriting ABC	5.33 (1.92)	8.66 (2.95)
Handwriting Days	9.40 (3.11)	16.32 (4.25)
No. Words OP	22.35 (16.61)	49.90 (26.13)
No. Words NA	65.22 (36.44)	124.48 (54.73)

Note. ABC = Alphabet task; No. = number; NA = narrative text; OP = opinion essay. *Standard Deviation in parentheses.

2.3.1. Writing Difficulties as -2 SDs

We first explored the resulting categorization when struggling writers were defined as those performing -2 SDs from the mean. This categorization yielded very low counts of children with writing difficulties (23), with only 6 of whom had been previously diagnosed with a main learning disability. Table 2.4 displays the total count of children in each writing difficulty (WD) group: low handwriting, low spelling, low text generation, and multiple writing difficulties.

Table 2.4

Distribution of children who scored below 2 SD

	LowSpell	LowHw	LowTG	MWD
N	4	7	9	3
2nd Grade	3	2	6	1
4th Grade	1	5	3	2

Note. LowSpell= Low Spelling; LowHw = Low Handwriting; LowTG = Low Text Generation; MWD = Multiple Writing Difficulties

2.3.2. Writing Difficulties as 25th Percentile

We divided our sample in percentiles and identified children who fell at or below the 25th percentile, given that this threshold has been previously used to identify at-risk students on writing performance (Davidi & Berman, 2014; Hooper et al., 2013; Serrano & Defior, 2014). As can be seen in Table 2.5, we found 34 students who showed difficulties with text generation, 90 who performed poorly in the spelling task and 62 students who showed low handwriting proficiency. One last group showed overlapping difficulties across two or more domains, which consisted of 29 students. Of all the identified students (N =215), 27 had previous diagnoses of various learning disabilities.

Table 2.5

Distribution of children who scored below the 25th percentile

	LowSpell	LowHw	LowTG	MWD
N	90	62	34	29
2nd Grade	47	32	20	14
4th Grade	43	30	14	15

Note. LowSpell= Low Spelling; LowHw = Low Handwriting; LowTG = Low Text Generation; MWD = Multiple Writing Difficulties

2.3.3. Writing Difficulties as -1 SD

Finally, we examined the categorization of children into the different at-risk groups when following the -1SD criterion. Distribution of children in each group can be seen in Table 2.6.

For text generation, we found 17 students who met the criteria for the Low Text Generation group, given their poor performance in both the narrative text and the opinion essay. There were 15 students who performed below -1 SD in both the Alphabet and the Days task: they were considered, thus, to be in the Low Handwriting group. Thirty-nine children performed below -1 SD in the spelling task when the phonological accuracy of their productions was assessed. Lastly, we found one last group of 11 children with Multiple Writing Difficulties, whose results were not only below -1 SD across both tasks of a skill but affected more than one skill. Only 24 students from the total (N=82) had been previously diagnosed with a learning disability.

Table 2.6

Distribution of the children at-risk of writing difficulties using -1SD as criterion.

	LowSpell	LowHw	LowTG	MWD
N	39	15	17	11
2nd Grade	10	20	4	7
4th Grade	5	19	13	4

Note. LowSpell= Low Spelling; LowHw = Low Handwriting; LowTG = Low Text Generation; MWD = Multiple Writing Difficulties

2.4. Discussion

This chapter intended to provide a protocol for identifying children at-risk of writing difficulties, with or without comorbidities. The greatest challenge of such a goal was to examine writing competence in children who speak a minority language that does not count with viable, updated, and standardized tests for assessing written language. For this reason, three approaches to identification were used: (1) a strict -2SD from the mean approach, in line with most standardized tests; (2) a method that included children at or below the 25th percentile; and (3) a more lenient approach that selected children who performed -1 SD from the mean for their age group. All three approaches included a requirement that the criterion needed to be met across two tasks of the same skill or, alternatively, in a single spelling task that assessed the basic ability to represent the phonological structure of words.

The selection of an at-risk cohort is a complex issue in languages where no standardized measures can facilitate the identification of students that do not meet the typical development standards for their age. Most studies of writing difficulties (Dockrell et al., 2014, 2019; Myles et al., 2003; Re et al., 2007) count with measures that were obtained from tests standardized with representative samples of the target populations, which are frequently updated and improved. Constant update allows using reliable and relatively objective criteria for the identification of children with writing difficulties. However, in Catalan, a minority language in a bilingual territory, researchers and practitioners do not have access to such instruments.

One of the main outcomes of the chapter is the finding that a -2 SD criterion is much too restrictive a requisite for detecting writing difficulties in a consistent way. A -2 SD criterion is used across standardized tests that count with high internally and externally valid results (Barnett et al., 2010; Wechsler, 2009). In minority languages without any previous valid standardized test for writing assessment, we do not count with reference data for the writing proficiency of children in primary school. Therefore, exploring such a limited sample entails the loss of statistical power in further analyses and may not account for all the children that are potentially affected. Our initial interest was to account for a broad detection of writing difficulties, given that struggle with one domain (e.g., handwriting) is likely to have repercussions in other domains (e.g., text generation), and they tend to persist until adulthood (Clegg et al., 2005; DeBono et al., 2012; Tops et al., 2012). Early identification of children that struggle with writing is key to ensure an effective intervention. For this reason, it is vital to be able to identify struggling writers as early as possible, even at kindergarten or fist grades (Coker et al., 2018; Kim et al., 2011, 2014; Puranik & Lonigan, 2012). Restrictive inclusion criteria is fundamental to not misidentify students, but this is an available resource where the mean is optimal in several indicators, or, as standardized tests have, to have an internal and external validity from a large representative sample, and therefore we opted for a more inclusive criteria, to meet other incidence rates more similar to other studies, which was more suitable for a first large scale study of writing in Catalan.

On the other hand, the approach that looked for children at or below the 25th percentile identified a large percentage of children as at-risk. The initial distribution detected a very high incidence of writing difficulties, however, it constituted 60% of the sample. Such a prevalence rate indicated that this identification could be too broad, as was too different from previous studies, and over identify TD children who simply are slightly behind other classmates.

Finally, we looked for students who fell behind their peers using a less strict criterion than -2 SD. Although -1 SD is considered a lenient score in standardized tests, other studies also embraced -1 SD as a fit criterion to identify at-risk children (e.g., Altemeier et al., 2008; Conti-Ramsden et al., 2001; Graham et al., 2005; Williams et al., 2013). It could be argued, thus, that a criterion of -1 SD, paired with a consistency requirement (as in the case of text generation and handwriting) or the severe nature of impairment (as in spelling) is a sound, viable protocol for an early and objective identification of children with writing difficulties. Eighty-two students, out of a sample of 357 (i.e., about 23% of the sample) matched the writing difficulties profiles, this incidence being more similar to Dockrell et al. (2019), who identified a 37.5% of their sample as struggling writers, and Coker et al. (2018), who found an incidence of affection of the 31.2% of the sample. Our findings moreover provide support to the categorization of writing difficulties profiles proposed by Coker et al. (2018), who attempted to match difficulties to the main components of writing. In our adaptation, which chiefly consisted of adding a Low Spelling group, we found support for the existence of groups of at-risk children that fit a (1) a Low Text Generation, (2) a Low Handwriting, and (3) a Low Spelling profile. In addition, we also found a smaller group of children with more pervasive difficulties, which we labelled the Multiple Writing Difficulties Group (MWD).

In short, Chapter 2 aimed to provide testing framework that served to identify students with writing difficulties without being able to rely on standardized tests. This first identification of writing difficulties should not be taken as a diagnosis of a learning disability but as an indication to explore further the nature and extent of these consistent struggles across writing dimensions. The cognitive abilities of these at-risk students and their writing profiles are explored further in Chapter 3. Furthermore, a longitudinal confirmation of these writing profiles is reported in Chapter 4.

Chapter 3. The Cognitive Profile and Text-based Traits of Struggling Writers[1]

3.1. Introduction

This chapter aims to examine the text-based features and cognitive profile of at-risk children, and whether they differ from their typically-developing (TD) peers. We will briefly review previous research on the characteristics of the written productions by struggling writers. Moreover, we will explore differences in potential skills that could be at the root of their cognitive and linguistic struggles.

3.1.1. Affected Text Features

Several studies have found that there are specific text features affected in the writing of learning-disabled (LD) children. These include measures of lexical diversity and grammar (e.g., verb or noun agreement), which have been reported as affected in children with ADHD (Re, Pedron, & Cornoldi, 2007), ASD (Myles, et al., 2003), dyslexia (Puranik, Lombardino & Altmann, 2007), and SLI (e.g., Dockrell, Lindsay, Connelly, & Mackie, 2007; Dockrell, Ricketts, Charman, & Lindsay, 2014).

Most importantly, several studies have converged in pointing out that LD children often show impaired text generation skills, across various LDs including dyslexia, SLI, ASD, or ADHD (e.g., Connelly, Campbell, MacLean & Barnes, 2006; Connelly, Dockrell, Barnett & Lane, 2012; Dockrell et al., 2007, 2014; Mackie & Dockrell, 2004; Myles et al., 2003; Sumner, Connelly & Barnett, 2013; Zajic et al., 2016). Text

[1] The findings reported in this chapter have been accepted in Infancia y Aprendizaje on the 28th of December of 2019. For the sake of continuity, minor adaptations to the accepted version were carried out. The exact accepted version is reproduced in Appendix 1.

generation is a writing-specific process (Berninger & Winn, 2006) responsible for the production of written text (measured in words, sentences, or ideas), and it is considered to be one of the best proxies for the overall quality of a text and one of the first dimensions of writing to emerge (Berman & Verhoeven, 2002; Salas & Caravolas, 2019; Salas, Llauradó, Castillo, Casas, & Martí, 2016).

Most models of writing consider that text generation is affected by a writer's transcription skills (i.e., spelling and handwriting), such that low levels of transcription are assumed to be at the root of poor text generation skills (e.g., Berninger & Winn, 2006; Juel, Griffith, & Gough, 1986). Accordingly, both spelling and handwriting have been reported to be affected in the writing of SLI (e.g., Dockrell et al., 2014), ADHD (e.g., Graham, Fishman, Reid & Hebert, 2016), dyslexic children (e.g., Arfé, Dockrell, & Berninger, 2014), and ASD (Dockrell et al., 2014; Kushki, Chau & Anagnostou, 2011).

3.1.2. Affected Cognitive Processes

Writing is a cognitively demanding task and, as such, it involves the recruitment of several cognitive processes and resources (e.g., Hayes & Flower, 1980). Given that most learning disabilities involve some kind of processing or cognitive impairment, it is not surprising that a number of cognitive skills linked to writing have been found to be affected in LD populations. For example, working memory, that is, the ability to withhold information, while performing some kind of manipulation or operation (Baddeley, 1992) has been found to be impaired and to affect the writing skills of people who suffer from ADHD, ASD, SLI, and dyslexia (e.g., Capodieci et al., 2018, Nyeden, Gillberg, Hjelmquist, & Heiman, 1999; Vugs, Hendriks, Cuperus, & Verhoeven, 2014; Connelly et al., 2006). Moreover, inhibition, a core, low-level executive function (Diamond, 2013), which is instrumental to writing (e.g., Salas & Silvente, 2019), has also been found to be affected in ADHD (Craig et al., 2016), ASD (Robinson, Goddard, Dritschel, Wisley, & Howlin, 2009), SLI (Cuperus et al., 2014), and dyslexia (Helland, & Asbjørnsen, 2000). In addition, short-term memory is also affected in SLI (Conti-Ramsden, Ullman, & Lum, 2015; Conti-Ramsden, Botting & Faragher, 2001; Mackie, Dockrell, & Lindsay, 2013) and dyslexic children (Varvara, Varuzza, Padovano-Sorrentino, Vicari, & Menghini, 2014).

3.1.3. This Study

we have established that a few developmental disabilities, despite having different aetiologies, result in children experiencing some common writing difficulties and similar cognitive impairments. We argue that there may be a developmental disorder that affects writing, which affects LD populations as well as children without other developmental or learning disabilities. In line with previous studies (e.g., Coker et al., 2017; Dockrell et al., 2019), we aim to investigate the writing features and cognitive profile of children at risk of writing difficulties, whether they belong to an LD population or not.

In Chapter 2 we identified children with marked difficulties on one or more aspects of written composition. In this chapter, we compared them to a group of age-matched controls on a number of text-based features and cognitive skills. Following Coker et al. (2017), we identified children based on their performance on three domains: handwriting, spelling, and text generation (number of words).

Our study had three main goals. First, we aimed to examine the text-based features of the at-risk groups. We expected that the MWD group would show lower levels of achievement across all text-based measures, in comparison with the TD group. We also expected the single-deficit groups (i.e., LowTG, LowSpell, LowHw) to be impaired for specific text features, although their problems would not be as pervasive as the MWD group's. However, given the codependency of the various writing skills and processes (Connelly et al., 2006; Cruz-Rodrígues et al., 2014; Mackie et al., 2013), their lower achievement might not be confined to the feature that led to their identification, but could affect other, related features as well. For example, the Low TG group could also show lower levels of handwriting fluency (Jones & Christensen, 1999). Second, we aimed to examine the cognitive profile of all at-risk groups, in comparison to the TD group. We expected that the children in the MWD group would be impaired in most cognitive measures, when compared to the TD group. For this reason, we administered a number of tasks and obtained measures of non-verbal IQ, short-term memory, and low-level executive functions (inhibition and updating). We also collected measures of children's levels of vocabulary and morphosyntax, in order to examine whether there were any language issues, a likely cause of writing difficulties (Dockrell & Connelly, 2009). A third goal was to determine the specificity of the writing difficulties observed. To pursue this goal, we obtained measures of word reading and reading comprehension, to determine whether children's struggles with writing were specific to the writing domain or if they were literacy-general.

3.2. Method

3.2.1. Participants

Our sample consisted of 132 children (77 boys; 55 girls) from 2nd and 4th grade, with a mean age of 101.11 months (SD = 12.73, Table 3.1). Of the 132 students, only 24 had been previously diagnosed with ADHD (5 children), ASD (1 child), dyslexia (2 children), DLD (5 children), and 2 children had curricular adaptations at school. In addition, 8 children in the sample had been identified as requiring special needs. In this final sample, the percentage of children with no Catalan support outside of school was

35%, but a comparison of the rate of Catalan support outside of school indicated that it was similar across at-risk and reference groups, X^2 (5, 132) = 3.90, p = .420.

Table 3.1

Number of participants, distribution by grades and percentage of Catalan at home by group

	LowSpell	LowHw	LowTG	MWD	TD
N	15	39	17	11	50
2nd Grade	20	10	4	7	20
4th Grade	19	5	13	4	30
Catalan at Home	53%	56%	64%	63%	74%

Note. LowSpell= Low Spelling, LowHw = Low Handwriting, LowTG = Low Text Generation, MWD = Multiple Writing Difficulties, TD= Typical development

3.2.2. Tasks and Measures

Written expression. Students elaborated two texts: a narrative and an opinion essay. In the narrative, children from three schools replied to one of two prompts "A boy/girl loses his/her pet" or "A boy/girl gets angry with his/her best friend". In the opinion essay, they answered to the prompt "Do you think that every boy and girl your age should go to school?" or "Do you think that children at school need recess?". Prompts counterbalanced across classrooms. Children were given 10 minutes to produce a draft and 20 minutes to complete their opinion essay or their story. The first author and a trained research assistant transcribed all texts. We obtained the following measures from each text:

Number of words. This measured assessed text generation at the word level and was the feature that served as the basis of identification of the LowTG group. The number of words in both texts was automatically counted in CLAN (MacWhinney, 2000). Reliability (ICC) between the first author and a research assistant on 100 randomly chosen texts was .996.

Spelling mistakes. This measure assessed accuracy at the word level. Spelling mistakes were identified and then counted automatically in CLAN. Morphosyntactic errors, invented words, typical colloquialisms, and interferences from Spanish were not penalized. Reliability (ICC) between the first author and a research assistant on 100 randomly chosen texts was .856.

Lexical diversity. To assess this word-level text feature, we calculated the Mass Ratio, which provides a measure of different word use that is not sensitive to text length. The formula for this measure is $M = (\log n - \log t) / \log^2 n$ (Torruella & Capsada, 2013).

Number of clauses. This measure assessed text generation at the sentence level by segmenting texts into clauses, following Berman and Slobin's (1994) criteria. Clauses were counted automatically using the FREQ command in CLAN. Reliability (ICC) between the first author and a research assistant on 100 randomly chosen texts was .958.

Word per Clause. This measure assessed syntactic complexity at the sentence level. It involved a calculation of the ratio of words per clause.

Grammatical mistakes. Accuracy at sentence level was assessed by identifying grammatical mistakes, such as morphosyntactic errors, inadequate use or absence of pronouns, incorrect noun or verb agreement, or grammatical replicas of Spanish constructions. The number of grammatical mistakes was counted automatically in CLAN and then divided by the total number of clauses in the text.

Alphabet task (Berninger et al., 1994). To assess handwriting skills, students were asked to write the alphabet from memory as fast and as many times as they could for one minute. Given that some schools in Spain do not teach the alphabet, the task was evaluated in two ways: one which penalized alphabetical order errors (strict) and one that did not (lenient). Correlation between the strict and lenient scoring was very high, r = .996. We proceeded to use the lenient score, as it allowed us to include all the participants in the sample. The score was the number of legible letters, regardless of the order, written within the first 15 seconds. Reliability with a second scorer on 20% of the sample was ICC = .984. A result below -1SD in this task, as well on the Days task (below) was used to identify children form the LowHw group.

Days task. This task aimed to measure handwriting fluency when writing highly known words. Students were asked to write the days of the week from memory, as fast and as many times as they could for one minute. The score was the number of legible letters written within the first 15 seconds. Spelling mistakes were not penalized. Reliability with a second scorer on 20% of the sample was .995. A result below -1SD in this task, as well on the Alphabet task (above) was used to identify children form the LowHw group.

Spelling. Children were administered a bespoke dictation task. Children were dictated 34 words, which were counterbalanced for frequency, length in syllables, and syllabic complexity. The administrator said each word out loud in isolation, then contextualized it with a sentence, and repeated it one last time, again in isolation. Words were presented in pseudo-randomized order and administered in two different sequences which were counterbalanced. All words in the task were scored for phonological plausibility. Words were counted as correct if the phonographic structure of the word was represented with a letter that has the intended phonological value, even if conventionally inaccurate. For example, for *hivern,* 'winter', the <h> is silent, and the <v> stands for phoneme /b/, which can be represented also by letter <b>. Therefore, *<ivern>, *<ibern>, or *<hibern>, although conventionally incorrect, were scored as phonologically plausible representations of the target word and afforded 1 point. The final score was the sum of all phonologically plausible representations. A trained RA scored a random 20% of the cases, and inter-rater reliability (ICC) was .989. Internal consistency of the task was also assessed; Cronbach's alpha = .919. Scores - 1SD in this task were used to identify children to form the LowSpell group.

IQ Raven Matrices (BAS II; Raven, 1999). Non-verbal intelligence was assessed with the Spanish adaptation of Raven's Progressive Matrices test. Reliability for this task is reported in the manual to have a Cronbach's α of .86.

Rapid Automatized Naming (RAN; Lervåg & Hulme, 2009). To assess rapid retrieval of well-known letters and produce a verbal output, children were asked to name a set of 5 letters out loud (a, s, d, p, o) from a stimulus sheet as fast as they could. The letters were displayed on an A4 sheet in 5 rows of 8 letters randomly distributed. There were two trials with a different ordering of the letters. The administrator noted the time that it took to complete each trial. The final score was the mean time in seconds between both trials. Reliability was the correlation between the trials, *r* = .834.

Word Span*.* This task assessed verbal short-term memory (after Caravolas et al. 2012). Students were asked to recall lists of short, high-frequency words. The length of the lists increased progressively, starting with two-word lists and up to eight-word lists. There were four lists per length. The test was discontinued when children failed to recall correctly three consecutive lists of the same length. Each correct list was scored with

0.25, so that a completely correct length scored 1 point. The total score was the sum correct (range: 0-8). Split-half reliability for this task was .739.

Digit Span (WISC-IV; Wechsler, 2004). To assess updating of working memory we administered the *Digits* subtest of the Spanish adaptation of the WISC-IV test battery (Wechsler, 2007). This test involves a baseline digit recall subtask in which children have to repeat lists of digits that increase in length, starting with 2 and of up to 8 digits. There are two lists (i.e., items) per list length. The test includes a second subtask, in which children need to repeat lists of numbers but in reverse order. Each correct item was scored with 1 point and the overall score was the sum of both subtasks. The manual reports a reliability of .74, but because the test is standardized to be administered in Spanish, not Catalan, we calculated reliability for our sample; Cronbach's α was .74.

Opposite Worlds (TEA-Ch; Manly et al., 2001). To assess verbal inhibition, children were shown a path made of blocks with the numbers "1" or "2". In the baseline, "same world" trial, they were asked to say the numbers '1' or '2' printed on the path, as fast as they could. Two other trials ensued, in which children were asked to say the opposite of the number they saw ("opposite world" trials). The administrator wrote down the time (in seconds) to complete each trial. The final score was the mean time of the two "opposite world" trials. Test reliability was the correlation between the opposite-world trials, $r = .823$.

Morphosyntax. Because there are no standardized measures of morphological or syntactic development of Catalan, we adapted a sentence reading test (PROLEC-R, Grammatical Structure test; Cuetos, Rodríguez, Ruano & Arribas, 2007) and used it to estimate a receptive morphosyntax measure. The administrator read a sentence to the children and asked them to point to one of four pictures, choosing the one that best matches the sentence. A virtually identical procedure can be found in the TROG-II test (Bishop, 2003). The task was discontinued if the children failed five consecutive answers. There were 16 items in total and one point was given for each correct answer. The final score was the sum correct (range: 0-16). Cronbach's α was .83.

Vocabulary (WISC-IV; Wechsler, 2004). Because there are no standardized tests of Catalan vocabulary, we adapted the Vocabulary subtest of the WISC-IV Spanish test battery. A group of expert researchers in the field of language teaching in Catalan, as well as primary teachers were consulted to find words that were similar to the Spanish items in terms of frequency of use, register/tone, age of acquisition, and overall difficulty. The final instrument consisted of 26 items of increasing order. Children were asked to provide a definition for each word. For example, the administrator asked, “What is a *clock*?” or “What does *emigrate* mean?”). The first 6 items were awarded 1 or 2 points depending on depth and specificity of the definition, whilst the next 20 items were awarded a maximum of 1 point. Answers defining the term in Spanish were accepted, given that we evaluated the knowledge of the Catalan term, yet only the translation of the word was not awarded any points. The final score was the sum of all points obtained across items. Six well-trained research assistants collected and scored 16% of the sample each, and a seventh research assistant scored the entire sample. The average *r* for each 16th percent of the sample was .958 (range .940 - .984). In addition, we estimated the internal consistency of the task; Cronbach's α = .887.

Word Reading. This subtest of the PROLEC-R reading test battery (Cuetos et al., 2007) was used to assess children’s word reading ability. Students were asked to read aloud 40 words. One point was given for each correctly read word and the total score was the sum of all correct answers. The manual reports a Cronbach’s α of .79.

ACL (Català, Català, Molina & Monclús, 2004; 2008). To assess reading comprehension, we adapted the standardized test *Avaluació de la Comprensió Lectora* (ACL, Català et al. 2004; 2008). The test requires children to read brief texts of various genres and then answer multiple-choice questions. There are different versions of the test according to the school year the children have last completed. Therefore, the 2nd and 4th grade children completed the Grade 1 and Grade 3 version (as per the test instructions), respectively, and we added the first two texts of the Grade 2 and Grade 4 instrument, respectively. This procedure was followed to ensure that the test would be able to capture children whose skill level is above grade level. The final instrument administered to 2nd graders included 9 texts with 31 questions, while the 4th graders answered 33 questions from 9 texts. Children had 45 minutes to complete the test. One point was awarded to each correct answer and the final score was the proportion of correct responses. The manual reports a reliability (KR-20) of 0.80 for the Grade 1 subtest and 0.72 for the Grade 3 subscale.

3.2.3. Procedure

Children were assessed on all measures in individual sessions in quiet rooms, with the exception of the Raven, Spelling, ACL, and Written Expression tasks, which were administered to the entire class in their classroom. All tests instructions, items, and administration were in Catalan. Testing took place during the first trimester (October-December) of the school year, except for the Written Expression task which took place in the second trimester (February-March). The order of administration of the tests was counterbalanced to avoid conditioning between tests.

3.3. Results

Descriptive statistics can be found in Table 3.2. Children were off-ceiling in all measures, but differences between groups were apparent. Data were generally normally distributed, with skewness values within -1.27 and 1.61, and kurtosis values ranging between -2.26 and 2.16.

Table 3.2

*Means and SDs of all identification tasks per group**

Writing measures	Groups				
	LowHw	LowSpell	LowTG	MWD	TD
Mean Age	96.20 (12.23)	100.00 (11.78)	107.29 (12.76)	95.90 (11.83)	102.40 (13.11)
Mean SES	52.00 (14.87)	52.42 (12.18)	58.48 (10.46)	59.63 (15.36)	59.21 (12.57)
Spelling Phon.	23.67 (5.09)	5.59 (5.94)	26.12 (3.95)	12.27 (12.22)	25.28 (5.53)
Hw ABC	2.93 (1.49)	7.03 (3.05)	6.88 (2.55)	3.45 (0.82)	8.06 (2.50)
Hw Days	5.67 (1.92)	12.83 (4.45)	13.73 (5.51)	5.56 (2.24)	15.18 (4.30)
Words OP	31.87 (22.54)	33.03 (19.09)	16.00 (7.98)	10.64 (6.68)	44.17 (31.31)
Words NA	86.60 (37.72)	104.25 (67.91)	42.94 (24.05)	38.70 (45.52)	101.43 (50.57)

Note. LowSpell= Low Spelling; LowHw = Low Handwriting; LowTG = Low Text Generation; MWD = Multiple Writing Difficulties; TD= Typical development; Spelling Phon = spelling task with phonographic accuracy scoring Hw ABC = handwriting fluency Alphabet task; Hw Days = handwriting fluency Days task; OP = opinion essay; NA = narrative text.
*Standard deviation in parentheses.

To address our goals, namely, which text-based measures and cognitive skills distinguish typical from at-risk writers, we ran a series of one-way ANCOVAs[2] , controlling for the effect of age, on each text-based measure and cognitive skill. We included planned comparisons (Simple method), where the four at-risk groups (LowHw, LowSpell, LowTG, and MWD) were compared against our reference group of TD children. We used the Benjamini-Hochberg (BH) correction for false discovery rate (FDR), in which p-values are adjusted to the number of repeats and weighted by their order (Benjamini & Hochberg, 1995). This correction method reduces the probability of type I errors that may occur due to multiple comparisons. Unlike other known methods, the BH correction integrates the number of repeats and amount of significant results.

3.3.1. Identification Tests

We first tested whether groups were statistically significantly different from the reference group in the key aspects of writing that led to their classification into each of the at-risk groups. There was a significant main effect of Group in both measures of handwriting fluency, the alphabet task, $F(4, 119) = 16.51$, $p < .001$, $\eta_p^2 = .04$, and the days task, $F(4,82) = 12.25$, $p < .001$, ηp2 = .037. Planned comparisons revealed that the LowHw group scored significantly below the reference group in both tasks ($p < .001$ in both the alphabet and days tasks). The MWD group also obtained lower scores in both tasks ($p < .001$), while the LowTG group obtained significantly lower scores in the alphabet task ($p = .008$). For phonological spelling accuracy, there was a significant effect of Group, $F(4, 125) = 67.04$, $p < .001$, $\eta_p^2 = .68$. Planned comparisons reflected a significantly poorer performance of the LowSpell ($p < .001$) and MWD groups ($p < .001$).

[2] Note that, in addition to controlling for age in all ANOVAs, they were carried out with values that had been standardized to the mean for either 2nd or 4th grade.

With regards to number of words, there was a significant Group effect in the narrative texts, $F(4, 117) = 14.75$, $p < .001$, $\eta_p^2 = .33$, and in the opinion essays, $F(4, 116) = 11.10$, $p < .001$, $\eta_p^2 = .28$. Planned comparisons revealed that the reference group wrote significantly more words than the LowTG group ($p < .001$). In addition, the MWD group performed significantly below the reference group in both text types ($p < .001$ for both texts). Finally, the LowSpell group produced significantly less words than the reference group in the opinion essay ($p = .004$).

These results confirmed the selection criteria for all at-risk groups. In addition, some groups showed difficulty with traits for which they had not been identified, while the MWD group scored significantly poorer than the reference group across all traits.

3.3.2. Writing Profile of Each At-risk Group

Word-level writing features were assessed in terms of text spelling accuracy and lexical diversity (Mass Ratio). Results (Table 3.3) showed a significant main effect of Group for the proportion of spelling errors, but only in the opinion essays, $F(4, 116) = 3.74$, $p = .007$, $\eta_p^2 = .114$. Planned comparisons showed significant results for the LowTG group (p = .009) and for the MWD group (p = .007) but not for the LowSpell group ($p > .05$). For lexical diversity, no significant main effect of Group was found in the narratives, $F(4,112) = 1.83$, $p = .128$, $\eta_p^2 = .06$, or in the opinion essays, $F(4,89) = 0.60$, $p = .660$, $\eta_p^2 = .03$.

Sentence-level writing features were assessed by the total number of clauses, the average number of words per clause, and the proportion of grammatical mistakes. For the number of clauses, there was a main effect of Group in the narrative texts, $F(4,115) = 10.74$, $p < .001$, $\eta_p^2 = .27$, as well as in the opinion essays, $F(4,116) = 7.77$, $p < .001$, $\eta_p^2 = .21$. Planned comparisons indicated that the LowTG group scored significantly below the reference group in both text types (*ps* <.001). The MWD group also produced significantly fewer clauses on average in the narrative texts (p = .002) and in the opinion essays (p = .022). A measure of words per clause showed no significant main effect of Group in the narrative texts, $F(4, 115) = 0.49$, $p = .740$, $\eta_p^2 = .17$. Words per clause in the opinion essays did show a main effect of Group, $F(4, 116) = 5.03$, $p = .001$, $\eta_p^2 = .15$. Planned comparisons revealed that the MWD group scored significantly below the reference group ($p < .001$). Finally, for grammatical accuracy, there was a significant effect of Group in the average proportion of grammatical errors in the narrative text, $F(4, 116) = 3.60$, $p = .008$, $\eta_p^2 = .110$. The reference group significantly outscored the LowHw (p = .001). This means that children with low handwriting fluency had difficulty with text generation at the sentence level.

Table 3.3

Mean and Standard Deviations of text-based measures by group.*

Writing measures	Groups				
	LowHw	LowSpell	LowTG	MWD	TD
No. Words NA	86.60 (37.92)	104.25 (67.91)	42.94 (24.05)	27.11 (28.64)	101.43 (50.57)
No. Words OP	31.87 (22.54)	33.03 (19.09)	16.00 (7.98)	9.30 (5.27)	44.17 (31.31)
Spelling errors NA	24.68% (12.44)	18.92% (11.17)	15.73% (8.72)	21.83% (10.79)	15.95% (12.58)
Spelling errors OP	37.52% (20.33)	28.20% (16.99)	35.56% (18.98)	45.72% (13.56)	27.01% (16.02)
Mass NA	0.05 (0.02)	0.05 (0.02)	0.04 (0.01)	0.05 (0.02)	0.05 (0.01)

Table 3.3

Mean and Standard Deviations of text-based measures by group.*

Writing measures	Groups				
	LowHw	LowSpell	LowTG	MWD	TD
Mass OP	0.05 (0.03)	0.04 (0.02)	0.04 (0.03)	0.07 (0.06)	0.05 (0.03)
No. Clauses NA	16.07 (8.62)	20.03 (13.43)	9.00 (4.90)	5.25 (4.65)	19.49 (9.22)
No. Clauses OP	8.27 (5.40)	8.42 (5.41)	4.41 (2.06)	5.10 (4.23)	10.62 (6.96)
Word per Clause NA	5.69 (0.93)	5.49 (1.30)	5.57 (2.42)	5.51 (1.84)	5.28 (0.90)
Word per Clause OP	3.76 (1.11)	4.14 (1.30)	3.60 (0.89)	2.34 (1.03)	4.10 (1.24)
Grammatical Errors NA	2.27 (1.75)	1.18 (1.17)	1.41 (1.46)	1.80 (1.48)	0.93 (1.14)
Grammatical Errors OP	0.87 (1.41)	0.57 (0.88)	0.69 (1.14)	1.11 (0.93)	0.61 (0.94)

Note. LowSpell= Low Spelling; LowHw = Low Handwriting; LowTG = Low Text Generation; MWD = Multiple Writing Difficulties; TD= Typical development; No.= number; OP= opinion essay; NA= narrative text

*Standard deviation in parentheses

3.3.3. Underlying Cognitive-linguistic Profile

In order to compare groups on a number of key cognitive and linguistic skills, as well as in their reading skills, we ran another series of one-way ANCOVAs, controlling for age (Table 3.4). Children in all at-risk groups did not differ from the reference group on a measure of non-verbal intelligence (Raven test), $F(4,118) = 1.83$, $p = .128$, $\eta_p^2 = .06$.

No significant Group effect was found either for verbal short-term memory (word-span task), $F(4,119) = 1.15$, $p = .335$, $\eta_p^2 = .04$. The core executive functions of inhibition (Opposite-worlds task) and updating of WM (Digit-span task) did not show a significant Group effect, $F(4,118) = 2.10$, $p = .085$, $\eta_p^2 = .07$, and $F(4,119) = 2.27$, $p = .065$, $\eta_p^2 = .07$, for inhibition and WM, respectively. Finally, there was no significant effect of Group in the RAN task, $F(4,118) = 2.08$, $p = .088$, $\eta_p^2 = .07$. These results indicate that at-risk children had similar levels in key cognitive skills in comparison with the reference group.

To obtain the linguistic profile of the at-risk children, we compared them with the reference group in terms of their morphosyntactic skills and vocabulary knowledge. Results showed that there was no significant effect of Group in morphosyntax, $F(4, 119) = 0.30$, $p = .878$, $\eta_p^2 = .01$, or in vocabulary, $F(4, 118) = 1.48$, $p = .214$, $\eta_p^2 = .05$.

We finally compared children's reading skills, in order to ascertain whether their writing difficulties were specific or literacy general. There was a significant main effect of Group in word reading, $F(4, 112) = 3.15$, $p = .017$, $\eta_p^2 = .10$. Planned comparisons showed that the MWD group performed significantly below the reference group ($p = .006$). In contrast, we found that the main effect of Group was non-significant for reading comprehension, $F(4, 115) = 1.77$, $p = .139$, $\eta_p^2 = .06$.

Table 3.4

Mean and standard deviations of text-based measures by group.*

Cognitive measures	Groups				
	LowHw	LowSpell	LowTG	MWD	TD
Hw ABC	2.93 (1.49)	7.03 (3.05)	6.88 (2.54)	3.40 (0.84)	8.06 (2.50)

Table 3.4

Mean and standard deviations of text-based measures by group.*

Cognitive measures	Groups				
	LowHw	LowSpell	LowTG	MWD	TD
Hw Days	5.67 (1.92)	12.83 (4.45)	13.73 (5.51)	5.56 (2.24)	15.18 (4.30)
Spelling	23.67 (5.09)	5.59 (5.94)	26.12 (3.95)	13.50 (12.15)	25.28 (5.53)
Raven	27.27 (9.71)	34.33 (10.86)	32.94 (10.61)	29.70 (11.93)	35.00 (10.41)
RAN	29.40 (9.36)	27.73 (10.40)	24.64 (7.10)	35.29 (11.03)	24.83 (8.16)
Word Span	2.57 (0.50)	2.79 (0.53)	2.72 (0.49)	2.67 (0.58)	2.91 (0.65)
Digit Span	11.53 (1.96)	11.77 (2.04)	12.82 (2.38)	10.50 (1.90)	12.69 (2.14)
Opposite Worlds	48.87 (12.10)	45.62 (11.74)	46.18 (12.66)	56.40 (9.65)	44.20 (11.62)
Morphosyntax	11.27 (2.46)	11.26 (2.39)	12.12 (2.15)	11.10 (2.92)	11.85 (2.59)
Vocabulary	15.64 (5.27)	17.37 (5.28)	18.59 (4.66)	14.10 (6.76)	18.69 (4.42)
Reading Comprehension	19.39 (8.49)	22.67 (5.55)	21.33 (6.43)	23.56 (4.93)	27.67 (2.08)
Single Word Reading	32.20 (5.12)	36.00 (4.43)	36.06 (9.15)	29.00 (8.20)	36.06 (5.50)

Note. LowSpell= Low Spelling; LowHw = Low Handwriting; LowTG = Low Text Generation; MWD = Multiple Writing Difficulties; TD= Typical development; OP= opinion essay; NA= narrative text; Hw ABC = handwriting fluency Alphabet task; Hw Days = handwriting fluency Days task.

*Standard Deviation in parentheses.

3.4. Discussion

This study aimed to build a profile of the struggling writer, independently of whether there were comorbidities with other learning disorders. We started by following the composition of at-risk groups proposed by Coker et al. (2017) and found 71 children who showed consistent or severe struggles with handwriting (n = 15), spelling (n = 39), or text generation (n = 17). Moreover, in line with Dockrell et al. (2019) and Connelly, Dockrell and Barnett (2005), we were able to identify a group of children who presented difficulties with several aspects of writing (n = 11). Notably, only a few (3) of these children had been diagnosed or identified with a learning disability. A first outcome of this study is, thus, that there are children who struggle with writing despite not having been diagnosed. In our data, the prevalence of struggling writers was around 3%, but epidemiological studies are needed to add precision to our findings. Nevertheless, this figure is comparable to other learning disabilities like dyslexia, whose prevalence has been reported to be around 5% (e.g., Lagae, 2008), ADHD with 4.3% of prevalence in populations under 15 years old (Coll & Pons, 2017) or ASD, whose prevalence in Catalonia is around 1.23% (Pérez-Crespo et al., 2019).

Our first goal was to examine the nature of the texts of the at-risk groups and to determine the extent to which they differed from their TD peers. For this reason, we compared them on a series of text-based measures. Children in the LowHw group had difficulties with the mechanics of letter-writing fluency. However, this defining trait did not limit most aspects of their writing performance: these children showed no marked difficulties with spelling, lexical diversity, syntactic complexity or, crucially, the amount of text generated (measured either in words or clauses). Nevertheless, they made more grammatical mistakes in the narratives, indicating that the extra effort of handwriting could be limiting their ability to keep track of grammatical agreement. The LowSpell group was unable to comply in an age-appropriate manner with the basic phonographic requirements of writing. Nonetheless, these children seemed to have found a way around this difficulty that prevented them from affecting other features of their texts. The exception was the amount of text produced in an opinion essay. This is well aligned with the abundant evidence of the constraining role of spelling in text generation (e.g., Abbott, Berninger, & Fayol, 2010; Juel et al. 1986). In addition, it has been suggested that children may develop an early awareness of their difficulties with spelling, which could also be motivating them to write less (Hayes, 2012). The LowTG group was identified because they produced substantially fewer words across two texts. Their difficulties were confirmed when measured in number of clauses, meaning that children in the LowTG group struggled to generate text at the word and sentence levels. They also scored significantly below their TD peers on handwriting fluency. This seems to indicate that, while not severely impaired on handwriting as the LowHw group, at least part of the difficulties to generate text of the LowTG group may stem from disfluent handwriting skills, again in accordance with a robust line of research pointing to the key role of handwriting in writing development (Limpo & Alves, 2013; Jones & Christensen, 1999; Salas & Silvente, 2019). To sum up, it appears that struggling even with one process of writing composition is likely to have repercussions on other processes. Over time, children with problems on a single aspect of written composition could suffer from a more pervasive problem with written expression. We would like to suggest that these children should receive tailored treatment for their writing difficulties, in order to guarantee that they will be able to cope with the ever-increasing demands of writing tasks.

Finally, the MWD group provided the profile of the struggling writer. Of the 11 children identified in this group, only 2 had been previously diagnosed with SLI, and 1 student was receiving a curricular adaptation. Their texts, as we expected originally, were shorter, contained a larger proportion of spelling mistakes, and less syntactic complexity. Notably, the affected writing features were strikingly similar to reports of the writing difficulties experienced by children with learning disabilities (e.g., Connelly et al., 2006; Dockrell et al., 2014; Re et al., 2010).

Our second goal was to investigate the cognitive profile of all groups of writers. A critical finding of this study is that all groups of children at-risk of writing difficulties showed a similar cognitive profile to the reference group, at least in terms of non-verbal intelligence, short-term and working memory, inhibition, and RAN. This means that children's struggles with writing cannot be explained on the basis of cognitive impairments.

Our third goal was to determine whether the writing difficulties we observed were due to poor language skills, and whether children's difficulties were writing-specific or if they affected literacy in general. Our data revealed that our struggling writers showed similar levels of vocabulary and of receptive morphosyntactic skills, as well as normal levels of reading comprehension. However, the MWD group had difficulties with word reading. Therefore, we claim that there is a profile of student who struggles with writing quite specifically, and in the absence of language issues, although issues with reading deserve further exploration.

To conclude, we found that around 3% of children attending early and middle elementary school may suffer from a developmental disorder that targets writing specifically, without the necessary existence of comorbid developmental disorders, abnormal IQ, or poor language skills. In line with previous findings by Dockrell et al. (2019) and Connelly, Dockrell, Walter & Critten (2012), these children produce short texts, make more spelling mistakes, and have disfluent handwriting. We found compelling evidence that, at the root of their writing profile, there are no affected cognitive processes; critically, executive functions, RAN, and short-term or working memory were unaffected across the board. These children arguably require a timely identification, so that an intervention program can be put in place early on. Future studies should strive to explore further its causes and its relationship with other learning disorders, as well as to determine effective remediation strategies.

Chapter 4. Longitudinal Validation and a Process–centered Approach to Investigating Writing Difficulties

4.1. Introduction

Most studies on writing difficulties have focused on the specific constraints that are present across aetiologies of Learning Disabilities (LDs), such as dyslexia, ADHD, ASD, or SLI (see review on section 1.2.2 above). However, a more recent approach contends that difficulties in writing can be detected without any specific LD diagnosis (Coker et al., 2018; Dockrell et al., 2019). In this sense, Chapter 3 found support to the claim that there are children who experience writing difficulties with and without a concomitant LD diagnosis. Children were found to fall into two main groups depending on the extent to which they differ from their typically developing peers (TD). Most children have rather focused difficulties with a single component of writing (Single Writing Difficulty group; SWD), such as handwriting, spelling, or text generation, although they are likely to also lag behind TD peers in other, related components. A more reduced group of children was found to struggle with most writing components simultaneously (Multiple Writing Difficulty group, MWD). Most importantly, our findings showed how writing difficulties could not be explained because of deficits in cognitive or linguistic skills.

This chapter aimed to address two key limitations that can be observed across several studies on writing difficulties, as well as in the previous chapters in this thesis: (1) writing difficulties have been chiefly identified cross-sectionally, but we lack evidence about their long-term prevalence; and (2) identification of WDs is carried out using only product measures, as opposed to online process measures of composing. Therefore, the chapter was structured as two separate, but related, studies: Study 1, where we aimed to determine whether the difficulties found in Chapter 3 persist longitudinally, by exploring new writing products obtained 18 months later for a subgroup of participants; and Study 2, where we aimed to examine the online writing process of these students in comparison to TD peers.

4.1.1. Longitudinal Identification of Writing Difficulties.

There is scant longitudinal reference works on writing difficulties. While cross-sectional measures offer a window into the development of writing and writing difficulties in LD populations (Berninger & Chanquoy, 2012), measurement are specific to a single moment of data gathering. The few longitudinal studies have helped understand writing development and writing difficulties across multiple years and grades (Abbott et al., 2010; Dockrell & Connelly, 2009; Juel, 1988). Most studies have pointed out the critical role of transcription in determining later writing skills. Transcription has been found to be predictive of later text generation abilities. Struggling writers would typically show slow handwriting and make more spelling mistakes, which would arguably constrain text generation (Abbott et al., 2010; Juel, 1988).

Writing difficulties in LD populations have been explored longitudinally in children with DLD (Dockrell et al., 2007; Dockrell et al., 2010). Dockrell et al. (2007) found that DLD children have consistent struggles with writing across the school years. This study was later expanded following these children's performance at 16 years old (Dockrell et al., 2010), whose writing was still constrained by spelling and vocabulary skills. In short, the relatively scarce longitudinal evidence on writing difficulties supports the claim that issues with writing are long-standing and they may even persist until adulthood. Most remarkably, transcription skills are not mastered even towards the end of high-school for these children, with the resulting constraints on text generation. In Study 1 we conducted a longitudinal (18 months) follow-up of a sub-cohort of our WD children and compared their transcription and text generation performance to a group of TD reference peers.

4.1.2. Writing Research Using Online Measures

The second key limitation that most writing research deals with, is that writing is only assessed on the basis of children's written productions. It could be argued, however, that that their difficulties should be evident when observing online measures that record the writing process. Given that most models of writing predict problems in the product (e.g. poor spelling, limited text generation) are the result of difficulties with the writing process (Berninger & Winn, 2006; Hayes, 2012b), an examination of online writing features should inform current models of writing development and help to deepen our knowledge of the specific nature of writing difficulties (Alves, 2019). Therefore, Study 2 in this chapter aimed to explore the process of writing, obtaining detailed measurements of children's bursts and pauses during text composing.

Words, clauses or phrases are the units to analyze written productions. Berman (2014) defines them as the "quantifiable methods for evaluating written language expression". However, these syntactic units do not represent how writers put words onto paper, given that they do not produce writing in perfectly structured sentences or in full clauses. In 1986, Kaufer, Hayes, and Flower noticed that the composing unit is not necessarily equivalent to a linguistic or syntactic unit, but to arrays of written words, which were termed "bursts". The writing process consists of bursts, that is, arrays of consecutive words that the writer puts down onto paper before needing to pause (Kaufer et al., 1986). Studies on writing bursts started with the comparison of levels of proficiency in adults (Alves et al., 2007; Kaufer et al., 1986; Limpo & Alves, 2013), and with the comparison of written productions in bilingual people, where they demonstrated that the average burst length is longer when producing a text in a writer's first language than in her second language (Chenoweth & Hayes, 2001). This means that, at least, bursts are sensitive to linguistic knowledge or the speed of processing of the writer. When studied developmentally with novice writers, Alves and Limpo (2015) found that children in Grade 2 are able to produce a mean of 2 words per burst, whilst children in Grade 7 are able to produce a mean of 6 words per burst before having to pause. In contrast, expert writers compose texts in bursts of 9 words on average. This means that burst production becomes more efficient with age and is also mediated by transcription skills (Alves et al., 2012; 2016; Beers et al., 2017; Connelly, et al., 2012; Limpo et al., 2017).

Both expert and novice writers require pausing several times during text composition. Pauses, the counterpart of writing bursts, are time when no graphomotor activity can be registered. Pauses allow writers to focus on higher-level writing processes, such as planning and revising, given that there is no burst activity that may compete with on the demands of transcription skills (Alamargot et al., 2007; Alves et al., 2007; Olive, Alves, et al., 2009; Strömqvist et al., 2006). Other uses of pauses? Children pause and they don't often plan nor revise. Most pauses are found at the end of paragraphs, sentences, and words (Medimorec & Risko, 2017); nonetheless, especially in novice writers, they can happen at any time during composition.

For a period of no graphomotor activity to be regarded as a pause, the most frequently used threshold is 2 seconds (Alves et al., 2008; Schilperoord, 2002; Strömqvist et al., 2006). The literature in writing converges in that a shorter pause threshold (e.g., of 1 or 1.5 seconds) is often indicative of tracing and transcription activity, such as deciding on punctuation marks or accessing lexical information, as well as consciously resolving a spelling ambiguity (Brizan et al., 2015; Medimorec & Risko, 2017; Wengelin, 2006). Overall, pauses amount to about half the time taken to compose a text (Alamargot et al., 2007; Strömqvist & Ahlsén, 1999; Strömqvist & Wengelin, 1999), and allow writers to recharge high-level skills and access their cognitive resources, supporting the capacity theory of working memory (McCutchen, 2000).

Several studies have also found that pausing rate and burst length can be affected by genre, such as the difference between composing a narrative and an argumentative text (Alves & Limpo, 2015; Medimorec & Risko, 2017). Argumentative texts, involve extra cognitive effort on the part of the writer (Beauvais et al., 2011; Medimorec & Risko, 2017) and, hence, are produced with shorter bursts than a narrative text and require the writer to pause more (Alves & Limpo, 2015; Medimorec & Risko, 2017; Olive, Favart, et al., 2009; Van Hell et al., 2008).

4.1.2.1. Gaining Insight on the Online Processes: *Smartpen* And *HandSpy*

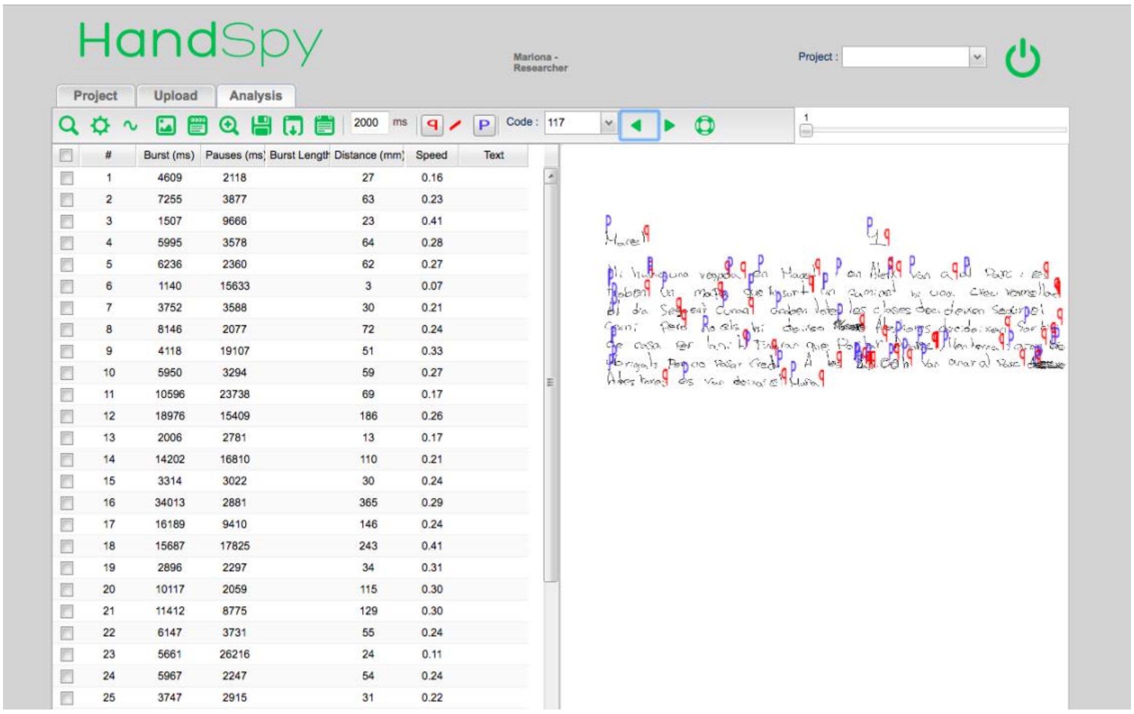
Online techniques offered a window into the mind of the writer and allowed researchers to test the fitness of writing models. The early instruments to assess online writing processes (e.g., think-aloud protocols, triple-task) were designed to tap into cognitive skills, such as working memory or executive functions. In addition, they served to understand the organization and the activation of high and low cognitive processes, such as planning, revising or transcribing (Hayes & Flower, 1980; Olive et al., 2002; Olive, 2010). More recently-developed techniques allowed exploring pauses and bursts, which granted researchers access to more fine-grained approaches to examining the writing process (Alamargot et al., 2007; Alves et al., 2019; Brizan et al., 2015; Connelly et al., 2007; Feng et al., 2019; Hayes, 2012a, 2012b; Leijten & Van Waes, 2013; Levy & Ransdell, 1994; Limpo & Alves, 2017; Olive, 2010). This section describes the technique used in this thesis. A revision of other tools and instruments to capture the writing process can be found in section 1.3.

Smartpens are pens that include movement recording on the paper, without needing tablets or keystroking that may alter handwriting; thus, they allow to tap into the natural motor skills involved in writing. LiveScribe™ or Neo Smartpens™ are no different than ordinary pens (early models were heavier and bigger, a feature that has been addressed in the newest models), except for a switch button that turns an infrared camera on or off and records each stroke that is done on special micro-dotted paper, Ncode™. Smartpens store the collected data in their internal memory to be later transferred to an app. Alternatively, they can connect with a tablet via Bluetooth and the writing can be followed on the app in real-time.

HandSpy (Alves et al., 2019; De Sousa & Leal, 2013; Monteiro & Leal, 2012; Monteiro & Leal, 2013) is an interface that allows transforming the coordinates of the strokes collected by a Smartpen to InkML, the digitalized set of data recorded from the strokes, where information about trace, pressure, speed and hand gestures are encoded (Chee et al., 2011). It transforms registers into visible text or protocols with the exact recording of the written text, along with a detailed analysis of burst and pause times, as well as speed and distance data (Monteiro & Leal, 2012; Monteiro & Leal, 2013). The web is thus structured as a data repository (Monteiro & Leal, 2012), with different workspaces to manage data (Figure 4.1). For specific usage of HandSpy, a detailed explanation can be found in Appendix 2.

Figure 4.1

The HandSpy Interface to analyze the writing process.



4.1.2.2. Previous Research on Writing Difficulties Using Online Measures

A review of the literature has found few studies concerning the writing process of populations with writing difficulties (Beers et al., 2017; Connelly, Dockrell, Walter & Critten, 2012; Sumner et al., 2013). For example, Connelly et al. (2012) and Beers et al. (2017) explored the bursts of children with developmental language disorder (DLD) and dyslexia, respectively. Both studies found that either children with DLD or dyslexia produced the same amount of writing bursts as the control groups, although their bursts were shorter on average. This led them to conclude that, in children with DLD and with dyslexia, transcription skills constrain the writing process. Additionally, Sumner et al. (2013) found that the writing process of dyslexic children is constrained due the fact that they make more pauses during the text production than TD children. The authors argued that longer pauses are not due to handwriting impediments, but that they are related to children's poor spelling skills. Therefore, all three studies concurred that transcription skills were posing an increased cognitive overload on the writing process of children, adding a major difficulty for either children with DLD or dyslexia. This is in line with the overwhelming evidence that transcription is a major constraint of writing for novice writers (Berninger et al., 1992; Connelly, Dockrell, Walter, et al., 2012; Limpo et al., 2017). This cognitive overload was reflected both on burst length and on the need for pausing more (Beers et al., 2017; Connelly, Dockrell, Walter, et al., 2012; Sumner et al., 2013). Other studies also showed that students with dyslexia type on keyboards less fluently and produce shorter bursts (Beers et al., 2017). Notably, all of the above-mentioned studies were conducted with English-speaking children. To the best of our knowledge, there are no studies that explore the writing process in Catalan, neither for typically-developing children nor for children with learning disabilities.

4.1.3. This Study

This chapter is structured into two studies: Study 1 aimed to conduct a longitudinal examination of the persistence of writing difficulties of the children in Chapter 3, by following a subsample of them 18 months later. Study 2 aimed to provide a detailed account of the online writing process of children with writing difficulties.

For Study 1, we hypothesized that writing difficulties would have persisted at least in the domain in which they were identified (e.g. a child in the Low Text Generation group maintained her specific difficulties over time, and 18 months later produced shorter texts than her TD peers). Moreover, we expected that writing difficulties could become even more severe longitudinally and have affected other domains, similarly to what has been reported in previous studies on reading and writing difficulties (Caravolas et al., 2001, 2012; Juel, 1988; Juel et al., 1986).

The main goal of Study 2 was to explore the writing process of children with writing difficulties, examining the online measures (bursts and pauses) to look for differences between children with writing difficulties and their TD peers. We expected writing difficulties to affect the writing process, in line with previous studies (Connelly, Dockrell, Walter & Critten, 2012; Sumner et al., 2013). Therefore, we expected all writing difficulties groups would produce fewer and shorter bursts, as well as more and longer pauses.

All the participants had been drawn from a larger intervention study; therefore, we controlled for the effect that such intervention could have on our measures. Part of our students (48) had received an Self-Regulated Stratagy Development writing intervention (SRSD; Harris & Graham, 2009; Salas, Birello & Ribas, under review) between the tasks administered in Chapters 2 and 3 and the tasks administered for the current chapter, whilst the rest of the students (21) were part of a business-as-usual control group. The data used for this chapter was collected 12 months after the end of the intervention.

4.2. Study 1: Longitudinal verification of writing difficulties profiles

4.2.1. Method

4.2.1.1. Participants

A subsample of students from the previous chapter was followed up 18 months later. Students were drawn from the sample of 132 2nd and 4th graders (77 male, 55 female). This follow-up study was carried out with 12 children from the Low Handwriting group (LowHw), 11 children from the Low Spelling group (LowSpell), 10 children from the Low Text Generation group (LowTG) and 10 children from the Multiple Writing Difficulty group (MWD). The children not included in this study had either left the school or parents did not provide the additional informed consent to take part of this data collection in time. Moreover, some logistical difficulties to collect the data meant that we were not able to collect data from a few of the participants in our previous chapters.

The final sample consisted of 69 children attending 3rd (36 students) and 5th grade (33 students) with a mean age of 9;10 years (SD = 13 mo.). Of the 69 students that made the final sample, there were students with concomitant diagnoses of learning disabilities: 2 children with ADHD, 1 child in the Autism Spectrum Disorder, 3 children with recognized DLD and 4 children who had curricular adaptations at school. A detailed distribution of the children and their demographic information can be found in Table 4.1

Table 4.1

Total number, distribution by grades and demographic data of participants

	TD	LowSpell	LowHw	LowTG	MWD
N	26	11	12	10	10
Mean age	9;11 (1 yo.)	9;10 (1;1 yo; mo.)	8;8 (1;1 yo; mo.)	10;8 (1 yo.)	9;5 (11 mo.)
3rd Grade	12	6	9	2	7
5th Grade	14	5	3	8	3
Left-handed	5	1	0	0	1
Male	8	6	7	8	9
Female	18	5	5	2	1
Intervention Group	19	5	9	7	8
Control Group	7	6	3	3	2

Note. Age in years; months (SD in months). TD= Typical-development; LowSpell= Low Spelling; LowHw = Low Handwriting; LowTG = Low Text Generation; MWD = Multiple Writing Difficulties

4.2.1.2. Procedure

Participants were administered the tasks at the end of the school year (May-June) of 3rd and 5th grade. Tasks were part of a larger test battery, administered in two different sessions in groups of 5 children: session one consisted of (1) writing an opinion essay, (2) a spelling task and (3) a handwriting task; session two consisted in (1) writing narrative text, (2) a pseudo-word spelling task. The order of sessions was counterbalanced between schools to prevent conditioning between administration orders.

4.2.1.3. Tasks and Measures

Writing samples. Students were asked to write two texts: an opinion essay and a narrative text. For each text, they were presented with three possible prompts, so that they could choose the topic that appealed more to them, to be able to exclude motivation factors (Bruning & Kauffman, 2016; Hayes, 2012b; Hayes & Berninger, 2014). In the opinion essay the children were asked to choose one of the following prompts: (1) “Do you think that there should be secrets between parents and their children?”, (2) “Do you think that all children should have a pet?” or (3) “Do you think there should be free things in life?”. For the narrative texts, children could choose one of the following prompts: (1) “A boy/girl and his/her friend find a treasure map”, (2)“A couple of twins wake up with superpowers” or (3)“A boy/girl and his/her friend travel to another country.'' Note that all opinion essay prompts had a similar structure and that all narrative prompts included two animated characters (after Alves & Limpo, 2015). Both text generation tasks were transcribed. We obtained automatic counts of the number of words, calculated with CLAN (MacWhinney, 2000).

Alphabet task (Berninger et al., 1992). Students were asked to write in one minute all the letters of the alphabet as fast and as many times as they could. Because children are not always taught the alphabet at school, a lenient scoring system was applied by which all legible letters, regardless of whether they were written in alphabetical order, were counted- The final score was the total number of letters written in 15s.

Days task. Students were asked to write in one minute the days of the week from memory. They were instructed to write as fast as they could. This task aimed to acquire a second measure of handwriting fluency when writing highly known words, given the potential limitations of the previous task. Spelling mistakes were not penalized. The final score was the number of legible letters written in 15s.

Spelling. Students were asked to write 45 words that were dictated out loud in isolation and repeated a second time. Words from the task were extracted from the reading subtest of the PROLEC-R reading test battery (Cuetos et al., 2009). Of the 45 words of the test, 5 were changed due to its similarity to others and to add more morphological complexity to the test. One point was given for each conventionally written word. The final score was the total number of words with conventional spelling.

Pseudo-words spelling task. Students were asked to write 45 pseudowords that were dictated out loud in isolation and repeated a second time. Words from the task were adapted from the reading subtest of the PROLEC-R reading test battery (Cuetos et al., 2009). Pseudo-words were created from the test battery that contains words ranging from high-frequency words to low-frequency words, as well as words with different syllabic structure to account for the most diverse plausible syllabic structures in Catalan, such as *gueixo*, *crispall*, or *pocle*. Catalan has a syllabic structure always organized around a vowel. This core vowel can be simple or complex, with up until three vowels. The syllabic core can be preceded with previous consonants (up to two), and followed for up to three consonants, as in ins.tru.ment (VCC-CCV-CVCCC).One point was given for each phonologically plausible written word, this meaning that different versions of the word could be possible, as long as it met the phonological subjacent structure. One point was given for each phonologically plausible written word, e.g., for the pseudoword *trencia,* children could write *trencia, trensia, trancia, transia.* The complete list of the pseudowords tasks with all the plausible words that were accepted can be found in Appendix 3.

4.2.2. Results

Means and standard deviations can be found in Table ***4.2***. Distribution of the data was assessed. Whilst skewness and kurtosis values were between normalcy ranges, three outliers were identified in the pseudo-word spelling task. The values were Winsorized (Dixon & Tukey, 1968; Wilcox, 1994) and ranked in order next to the lowest score in centesimal order (e.g., -2.51 < -2.52 < -2.53). Similar procedures were followed by Cirino et al. (2018) . No further modifications were carried out for the rest of the measures. These three modifications entailed the rescoring of < 1% of the total data points.

Table 4.2

Means and SD of each measure for groups

	TD	Low Spell	LowHw	LowTG	MWD
No. Words NA	89.31 (29.93)	68.00 (41.80)	59.25 (19.54)	70.30 (15.05)	63.00 (29.83)

Table 4.2

Means and SD of each measure for groups

	TD	Low Spell	LowHw	LowTG	MWD
No. Words OP	59.42	51.7	36.67	41.10	32.80
	(26.13)	(27.22)	(25.12)	(19.53)	(17.15)
Handwriting ABC	13.23	8.00	7.58	7.60	7.10
	(3.95)	(3.35)	(5.44)	(3.44)	(3.93)
Handwriting Days	20.38	15.55	13.50	17.20	12.80
	(6.66)	(3.42)	(8.97)	(3.97)	(4.57)
Spelling	29.69	24.82	16.58	24.60	17.70
	(6.83)	(8.32)	(7.32)	(10.42)	(11.64)
Pseudo-word	31.42	28.45	25.08	24.60	23.70
spelling	(4.38)	(4.32)	(5.09)	(8.45)	(8.68)

Note. TD= Typical-development, LowSpell= Low Spelling, LowHw = Low Handwriting, LowTG = Low Text Generation, MWD = Multiple Writing Difficulties
No= Number; NA = narrative text; OP = opinion essay; ABC = Alphabet task

Two-way ANOVAS to test the effect of Group (TD; LSpell; LHw; LProd; MWD) and Intervention (Intervention; Control) were conducted with the correspondent Bonferroni adjustments (p = .001). Interactions were explored, when applicable, with t-tests for the simple effect of intervention, and with one-way ANOVAS for the simple main effect of group. Bonferroni corrections were applied in multiple comparisons. We tested whether 18 months later groups maintained the statistically significant differences with the TD group in the tasks they were identified by in Chapters 2 and 3. Two-way ANOVA's results are displayed in Table 4.3.

Table 4.3

Two-way ANOVA results for each measure

	Group effect		Intervention effect		Group x Intervention interaction	
	F (4,59)	*p*	F (1,59)	*p*	F (4,59)	*p*
No. Words NA	1.93	.117	2.90	.094	0.93	.454
No. Words OP	3.65	.010*	13.84	<.001*	4.65	.002*
Hw ABC	6.84	<.001*	4.59	.036*	0.67	.061
Hw Days	2.78	.035*	2.75	.103	0.12	.976
Spelling	10.45	<.001*	14.65	<.001*	5.93	<.001*
Pseudo-word spelling	8.85	<.001*	10.77	.002*	1.92	.119

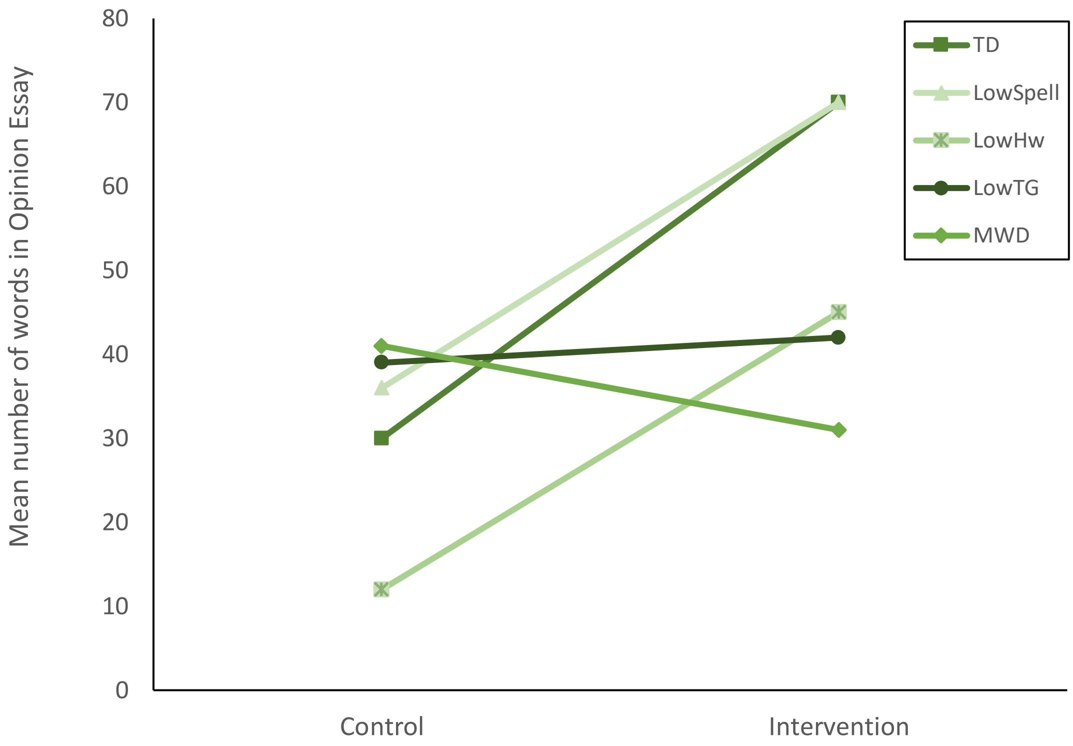
Note. No= number; NA = narrative text; OP = opinion essay; Hw = Handwriting; ABC = Alphabet task

Regarding the total number of words in the narrative text, we found no significant main effects of Group, $F(4, 59) = 1.93$, $p = .117$, $\eta_p^2 = .12$, nor Intervention, $F(1, 59) = 2.90$, $p = .094$, $\eta_p^2 = .05$. This indicated that students writing skills were similar across groups, and that having received an intervention on writing or not did not have a significant impact on the number of words produced. The Group x Intervention interaction was also not significant, $F(4, 59) = .27$, $p = .454$, $\eta_p^2 = .06$.

In contrast, there was a statistically significant main effect of both Group, $F(4, 59) = 3.65$, $p = .010$, $\eta_p^2 = .20$, and Intervention, $F(1, 59) = 13.84$, $p < .001$, $\eta_p^2 = .19$, in the number of words written in the opinion essay. Post-hoc comparisons revealed that, for the Group effect, there were only significant differences between the TD group and both the LowTG (p = .017) and the MWD group (p = .003). The rest of between-group comparisons were no significant. Main effects were modified by a significant interaction between Group and Intervention, $F(4, 59) = 4.65$, $p = .002$, $\eta_p^2 = .24$ (Figure 4.2).

Figure 4.2

Interaction between Intervention and Group effects in the Opinion Essay task



Note. TD= Typical-development; LowSpell= Low Spelling; LowHw = Low Handwriting; LowTG = Low Text Generation; MWD = Multiple Writing Difficulties.

A one-way ANOVA tested the simple effect of Group, indicating that there were no significant differences between groups on the total number of words written for students in the control group, $F(4, 16) = 3.39$, $p = .034$, whilst those students who were part of the intervention did show statistically significant differences between groups, $F(4, 43) = 8.35$, $p < .001$. Post-hoc comparisons, showed that the TD group differed significantly from the LowTG (p = .006) and the MWD (p = .001) evidencing that both at-risk groups wrote fewer words with regards to the TD group. The rest of between-group comparisons was no significant. The independent samples t-test for the Intervention effect in each group was only found to be significant for the TD (p < .001) and LowSpell (p = .002) group. Therefore, both the LowSpell and TD groups received the positive effects of the intervention, and performed better than the rest of groups, who did not show any significant improvement on the number of words in the opinion essay.

In the alphabet handwriting task, there was a statistically significant main effect of Group, $F(4, 59) = 6.84$, $p < .001$, $\eta_p^2 = .32$. Post-hoc comparisons showed that the TD group performed better than the rest of groups ($p_s < .001$), whereas there were no statistically significant differences between at-risk groups. Moreover, there was a significant effect of the intervention, $F(1, 59) = 4.59$, $p = .036$, $\eta_p^2 = .07$, whereby children who received the intervention performed better in this task than children in the control group. There were no significant differences in the interaction between Group and Intervention, $F(1, 59) = .67$, $p = .613$, $\eta_p^2 = .04$, and therefore the intervention affected all groups at the same extent.

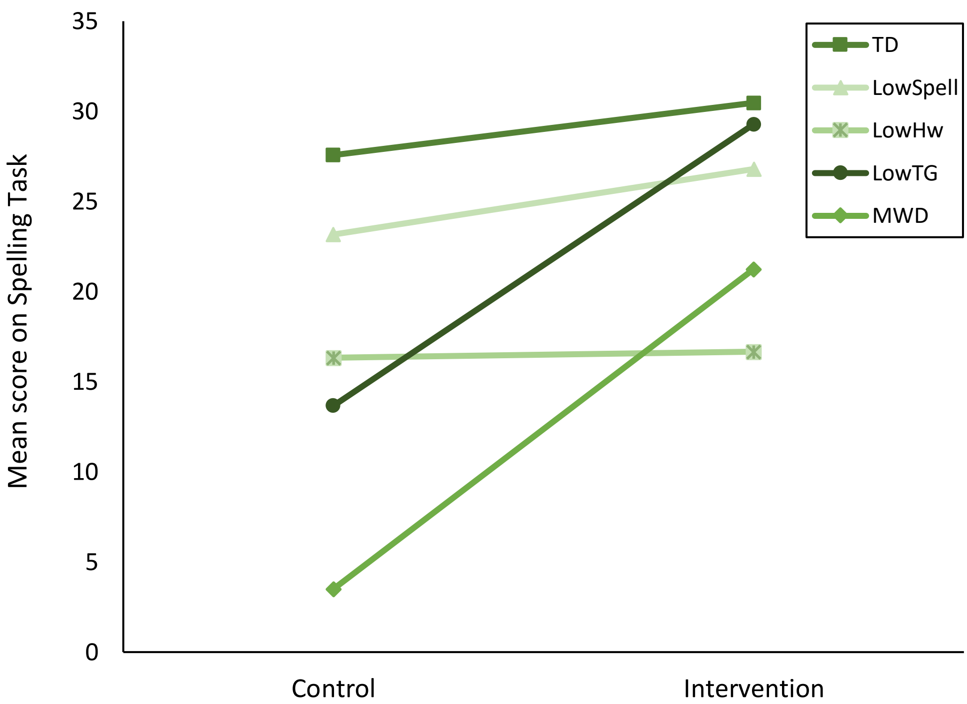
There was a statistically significant main effect of Group in the Days task, $F(4, 59) = 2.78$, $p = .045$, $\eta_p^2 = .16$. Post hoc comparisons revealed that only the MWD group showed a statistically significant poorer performance than the TD group ($p = .045$), while no other significant differences were noted. There was no significant effect of Intervention on this task, $F(1, 59) = 2.75$, $p = .103$, $\eta_p^2 = .05$, and the interaction was also not significant, $F(4, 59) = .12$, $p = .976$, $\eta_p^2 = .01$.

There was a statistically significant main effect of both Group, $F(4, 59) = 3.65$, $p = .010$, $\eta_p^2 = .20$, and Intervention, $F(1, 59) = 13.84$, $p < .001$, $\eta_p^2 = .19$, on the spelling task. Post hoc comparisons revealed that there were significant differences between the

LowHw ($p < .001$), LowTG ($p = .006$) and MWD ($p = .001$) groups against the TD group. Theses main effects were modified by a significant interaction, $F(4, 59) = 5.93$, $p < .001$, $\eta_p^2 = .29$. One-way ANOVAs tested the simple effect of Group. There were significant differences between groups both for those students who did receive the intervention $F(4, 16) = 7.46$, $p = .001$, as well as for students who were part of the control group, $F(4, 43) = 5.90$, $p = .001$, as can be seen in Figure 4.3. Post hoc comparisons between groups, showed that the TD group differed significantly from the LowTG ($p = .002$) an MWD ($p = .021$) groups. The independent samples t-test for the Intervention effect in each group was found to be significant for the LowTG group ($p = .005$), and marginally for the MWD group ($p = .045$) who were the only groups who experienced a positive effect from the intervention.

Figure 4.3

Interaction between Intervention and Group effects in the Spelling task



Note. TD= Typical-development, LowSpell= Low Spelling, LowHw = Low Handwriting, LowTG = Low Text Generation, MWD = Multiple Writing Difficulties

In the Pseudo-word spelling task, there was a statistically significant main effect of Group, $F(4, 59) = 8.84$, $p < .001$, $\eta_p^2 = 38$, where the TD group performed significantly better than the LowHw group ($p < .008$), the LowTG ($p < .001$) and the MWD ($p < .001$) groups, although the TD group did not show any significant differences with the LowSpell group. Moreover, there was a significant main effect of Intervention, $F(1, 59) = 10.77$, $p = .002$, $\eta_p^2 = .15$, where the children in the intervention performed better than the children in the control group. Post hoc comparisons revealed that, whilst there were no differences between the TD and LowSpell groups, the TD group obtained statistically significant higher scores than the LowHw ($p = .011$), the LowTG ($p < .001$) and the MWD ($p = .005$). The interaction was not significant, $F(4, 59) = 1.92$, $p = .119$, $\eta_p^2 = .12$.

As it fell out of the scope for this study, the intervention results were considered to control for the possible differences, but the results did not intervene in the differences between at-risk groups. For the intervention effect on all groups, the interactions have not been statistically significant, except for the spelling task. In the opinion writing task, post hoc comparisons, showed that the TD children that were part of the intervention wrote significantly more than both the TG and MWD children, and that the intervention had an effect on the number of words in opinion essays for children in the TD and LowSpelling groups. Nonetheless, both the TG and MWD groups did receive the positive effects of the intervention in regards of the handwriting task.

To recapitulate, as can be observed in Table 4.4, there has been a main effect of Group in all measures except for number of words in the narrative text. Firstly, it should be noted that among at-risk groups the differences are non-existent, and they can be considered as part of the same group, as will be further detailed in the discussion section. Secondly, the differences between the various at-risk groups and the TD group are now more extensive, involving not only in the initial domain of affection, but also additional domains. For example, the LowTG and LowHw groups results are significantly different in more dimensions of writing than initially (i.e., Chapter 3). In contrast, the LowSpell group has remained only statistically different from the TD group in both handwriting tasks.

Table 4.4

Summary of differences between groups in the different identification tasks

	At-risk groups vs. TD group				Differences between at-risk groups			
	Low Spell	Low Hw	Low Prod	MWD	Low Spell	Low Hw	Low Prod	MWD
No. Words NA	ns	ns	ns	ns	ns	ns	ns	ns
No. Words OP	ns	ns	*	*	ns	ns	ns	ns
Handwriting ABC	*	*	*	*	ns	ns	ns	ns
Handwriting Days	ns	ns	ns	*	ns	ns	ns	ns
Spelling	ns	ns	*	*	ns	ns	ns	ns
Pseudo-word spelling	ns	*	*	*	ns	ns	ns	ns

Note. TD= Typical-development, LowSpell= Low Spelling, LowHw = Low Handwriting, LowTG = Low Text Generation, MWD = Multiple Writing Difficulties; NA = narrative text; OP = opinion essay; ABC = Alphabet task

4.2.3. Discussion Study 1

Study 1 aimed to test the longitudinal stability of the initial identification of the children with poor performance in spelling (LowSpell), handwriting (LowHw) or in text generation (LowTG), as well as a group with multiple difficulties (MWD). Results showed, 18 months later, that the students on the TD group still significantly outscored their previously identified peers in most tasks, with the exception of the number of words in the narrative text, where all students showed a similar performance. These results support our previous finding that there is a group of children who struggle with writing in comparison regardless of whether they have concomitant learning disabilities (Chapter 3; Pascual & Salas, in press). In addition, the present study extends prior findings by showing that such difficulties are evident in the long term.

All groups differed from the TD group, but, most notably, the differences among them were never significant. Although certain groups did not differ significantly from the TD group in some measures, there were no significant differences with other at-risk groups. This means that roughly the same pattern of difficulties was observed across struggling groups. Therefore, we argue that they should be considered as one group of children with Writing Difficulties (WDs). Nonetheless, it has to be noted that the LowSpelling group was often undistinguishable from the TD group, and therefore their profile was less affected than the rest of the groups with single writing difficulties, who in time have titled to having problems in more than one aspect of writing. The LowSpelling group has not shown such a pervasive problem in every aspect of writing as their peers, but nonetheless they must be closely followed up, given that they have not abandoned completely the at-risk profile. Moreover, the initial LowSpelling group showed consistent struggled with handwriting, in line with recent evidence that spelling and handwriting are tightly linked across development (e.g., Abbott et al., 2010; Ding, Li, & Wu, 2020).

Hence, seeing the similar patterns of writing across all at-risk groups, and once confirmed the differences with the TD group, we opted to treat all the WD groups as one, ending up with two main groups for the subsequent study: (1) the reference group of TD children to whom the at-risk children results are compared, and (2) a Writing Difficulties group with all at-risk students. Such a procedure we would argue that it is founded in the evidence gathered so far, as well as it will result in a gain in statistical power, while minimizing statistical errors motivated by multiple comparisons.

4.3. Study 2: an analysis of the writing process

4.3.1. Method

4.3.1.1. Participants

Study 2 follows the same subsample of participants from Study 1. Departing from the results of Study 1, we compared the 26 students with TD to a now single group of children with writing difficulties (n = 43). Table ***4.5*** displays demographic information.

Table 4.5
Demographic data of participants in Study 2

	TD	WD
N	26	43
Mean age in years; months (SD in mo.)	9; 11 (11 mo.)	9;10 (13 mo.)
3rd Grade	12	24
5th Grade	14	19
Left-handed	5	2

Table 4.5
Demographic data of participants in Study 2

	TD	WD
Male	8	30
Female	18	13
Intervention Group	19	14
Control Group	7	29

Note. TD= Typical-development group; WD= Writing Difficulties group

4.3.1.2. Tasks and Procedure

In this study we analyzed traces of the composition process, that is, we identified all bursts and pauses in both the narrative text and the opinion essay also used in Study 1 (for a the detailed prompt for text generation refer to section 4.2.1.3 of this same chapter).

Children wrote each text in N idea pads® using NeoSmartpen® pens (M1 model). The Smartpens used weigh slightly more than a regular pen (17.4g) and are 149.6 mm long, giving them the appearance of a regular pen. The M1 model had a refilling pen tip with black ink and hosted an infrared camera which recorded the coordinates of the stroke of the pen on the paper, the spatial and temporal traces of the stroke. N idea pads® are A4 ruled line sheets with Ncode™ technology, that is micro-dotted lines and symbols (+ / \) that allowed pens to triangulate their position on the paper and to recognize the specific page of the pad in which the child was writing. The pen storage the information until connected to the NeoNotes app.

For logistical and ecological validity reasons, we assessed students in groups of 5. Nonetheless most studies with SmartPens have not dealt with simultaneous data gathering and this posed a constraint on the procedure. As can be seen in Figure 4.4, each child was given a Neo Smartpen matched with a micro-dotted paper by color coding. This color coding was used to address the difficulty of gathering simultaneous data from different children. The Neonotes app does not recognize each pen and pad individually and therefore the data could overlap when two pages with the same numeration were uploaded. To solve this issue, we matched each pen with a set of pads with a color system. At the end of the day, each pen's data was downloaded to the Neonotes app, named with the color and school code, and afterwards locked[3] to avoid overlapping pages.

Figure 4.4

Child writing with the lined paper and the Neo Smartpen.

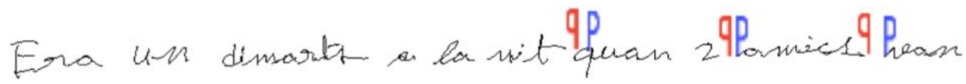
Once in the Neonotes app, and to extract the on-line measures, the data was converted to be compatible with the HandSpy software (for a detailed report of the data

[3] The written pages of the notebooks will download as pages of one same notebook. To avoid overlapping the data, there is an archive system that allows "closing" and storage the notebooks, which will remain as a closed set of pages and when uploading more data to the app, this will be part of a new notebook.

management see Appendix 2. This tool reconstructs the text from the spatial and temporal traces recorded and reports bursts and pausing data for each text. As can be seen in the example below (Figure 4.5), each pause is marked with a blue p (p) and the end of each burst with a red q (q).

Figure 4.5

Example of burst and pause markers in HandSpy



'It was a Tuesday night when 2 friends did…'

4.3.1.3. Measures

Bursts. To assess children's capacity to generate text before having to pause, two burst measures were considered**: (1) number of bursts**, and **(2) average burst size** (henceforth burst size). Following previous research (Alves et al., 2016; Alves & Limpo, 2015; Limpo & Alves, 2017) the minimum unit that was considered to constitute a burst was a word. Whilst the total number of bursts was calculated automatically with HandSpy software, burst length was calculated manually counting each word in the burst. To address the specificities of Catalan grammar, we established the word boundaries as the spaces between words. For example, Catalan has a pronominal system that can merge the pronoun or pronouns with the verb, and these pronouns can be placed after (e.g., *estimar-lo*, 'love him') or before the verb (e.g., *s'estimen* '[they] love [each other]'. On the other hand, the full-formed independent pronouns were counted as words: *diem-los-ho* 'we tell them that' was counted as 1 word, whilst *els ho diem* 'we tell them that' was counted as 3 words). In sum, clitic pronouns were counted as part of the word according to their spelling; if they are spelled connected to the word or separated by apostrophes (‘) or dashes (-), they were considered as a single word. Conversely, if they were written separately from the verb. Moreover, children tend to embed the pronoun into the verb until they have not learned in depth the Catalan pronoun system, which is taught in 5th and 6th Grade (Departament d’Educació, 2001). Reliability (ICC) was .907 between the author and a trained speech therapy student, alien to the purpose of the study, who rescored a random 30% of the texts.

Pauses. Pauses between bursts were interruptions of writing activity that lasted 2 seconds or longer, following the threshold established by previous research (Alves & Limpo, 2015; Connelly, Dockrell, Walter & Critten, 2012; Limpo & Alves, 2017; S. Strömqvist et al., 2006; Sumner et al., 2013). Pauses were reported automatically in the HandSpy software. All bursts of less than a word or strikethrough text were included as pauses or part of pauses and not counted as bursts (for a review of the procedure, see Alves et al., 2019). Moreover, the pre-writing pause and the post-writing pause were eliminated from the total count. The pre-writing pause is the pause between the moment in which the instructor starts the timer of the task and the starting point of writing of each child; a post-writing pause is the registries of waiting time between the end of writing for each child and the end of the global task as logged due to group dynamics (e.g., the peers have not ended their task and the child who has ended starts drawing or simply waits). Both these measures were suppressed to avoid registering exacerbated pausing time, which did not reflect the actual writing time. Therefore, two pause measures were considered: (**1) number of pauses** and **(2) mean pause duration** (henceforth pause duration). Reliability (ICC) was .935 between the author and a trained speech therapy student, alien to the purpose of the study, who rescored a random 30% of the texts.

4.3.2. Results

Distribution of the data was assessed. Whilst skewness and kurtosis values were between normalcy ranges, two outliers were identified for the burst size measure of the opinion essay. The values were Winsorized (Dixon & Tukey, 1968; Wilcox, 1994) and ranked in order next to the highest score in centesimal order. No further modifications were carried out for the rest of the measures. These three modifications entailed the rescoring of 0.36% of the total data points. Table 4.6 reports the descriptive statistics for all the dependent variables by group on the on-line measures obtained from the narrative text and the opinion essay.

Table 4.6

Means and standard deviations of tasks for each group

Measures	TD group		WD group	
	M	SD	M	SD
No. Bursts NA	24.67	4.99	19.90	6.46
No. Bursts OP	16.46	6.74	14.28	6.39
Bursts Size NA (w/b)	4.05	1.42	3.89	1.91
Burst Size OP (w/b)	4.72	3.08	3.20	1.61
No. Pauses NA	27.54	7.15	23.56	8.31
No. Pauses OP	19.19	8.46	17.06	6.97
Pause Duration NA (s)	6.20	2.27	7.73	3.84
Pause Duration OP (s)	8.31	3.58	9.79	5.16

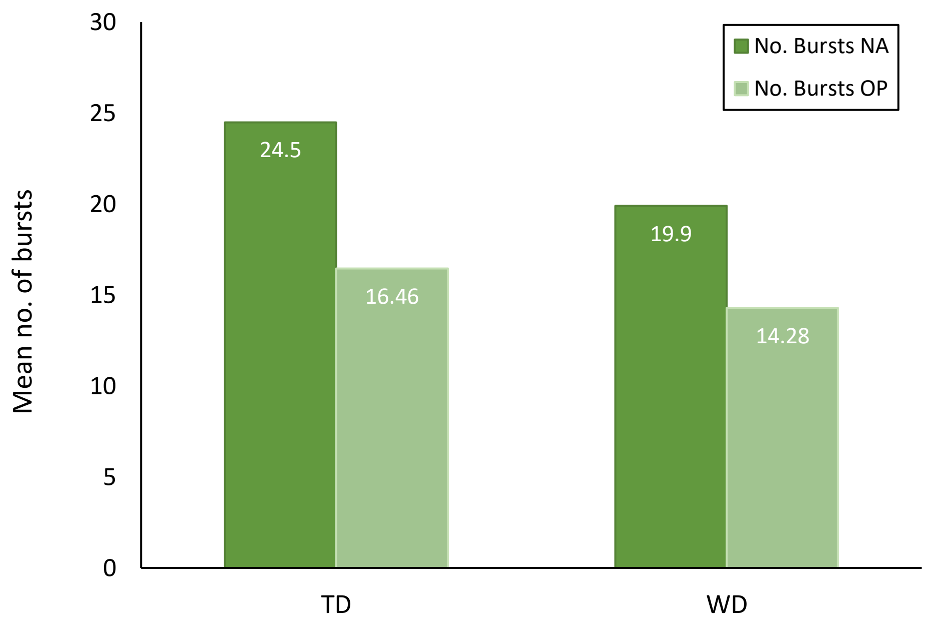
Note. TD= typical-development; WD = writing difficulties; w/b = words per burst; No.= number; NA = narrative text; OP = opinion essay; ABC = alphabet task; s= seconds

We ran a series of two-way mixed ANOVAS, controlling for age, for each writing process measure to determine the effects of Group (between-subjects factor) and Genre (within-subjects factor). The effect of Genre (opinion vs narrative) were assessed to examine differences in composing opinion essays in contrast to narrative texts. The effects of Group were assessed to control for the possible differences between children with WD and their TD peers in the writing process.

For number of bursts, the performance of groups was statistically significantly different, $F(1,55) = 4.16$, $p = .046$, $\eta_p^2 = .07$. The TD group wrote more bursts in both genres than the WD group (Figure 4.6). Moreover, there was no significant effect of Genres, $F(1,55) = .98$, $p = .328$, $\eta_p^2 = .02$. Additionally, there was no significant interaction effect between Group and Genre, $F(1,55) = 2.48$, $p = .121$, $\eta_p^2 = 43$.

Figure 4.6

Difference in number of bursts between the TD group and the WD group



Note. TD= typical development group; WD = writing difficulties group; No. Bursts NA= Number of bursts in the narrative text; No. Bursts OP= Number of bursts in the opinion essay.

For burst size, we found no statistically significant differences between the TD group and the WD group, $F(1,55) = 2.81$, $p = .100$, $\eta_p^2 = .05$. Moreover, there was no significant effect of Genre on the average burst size of WD children in contrast with TD children, $F(1,55) = .27$, $p = .608$, $\eta_p^2 = .01$. The interaction was also not significant, $F(1,55) = 4.03$, $p = .050$, $\eta_p^2 = 68$.

We found no statistically significant differences between the TD group and the WD group in the number of pauses, $F(1,55) = 1.64$, $p = .206$, $\eta_p^2 = .03$, indicating that both groups paused a similar number of times during composition. Moreover, there was no significant effect of Genre in the number of pauses, $F(1,55) = .69$, $p = .411$, $\eta_p^2 = .01$. The interaction between Group and Genre was also not statistically significant, $F(1,55) = 1.16$, $p = .286$, $\eta_p^2 = .21$.

We found no statistically significant differences on pause duration between the TD group and the WD group $F(1,55) = 2.94$, $p = .092$, $\eta_p^2 = .05$, showing that pauses lasted approximately the same amount of time across groups. Furthermore, we found no significant effect of Genre in pause duration, $F(1,55) = .80$, $p = .375$, $\eta_p^2 = .01$. Finally, the interaction between Group and Genre was also not significant, $F(1,55) = .01$, $p = .951$, $\eta_p^2 < .01$.

4.3.1. Discussion Study 2

This second study aimed to provide a profile of the writing process of students with writing difficulties in comparison to their TD peers. Our initial hypothesis argued that there would be significant differences both in burst and pause measures, expecting the WD groups to produce fewer and shorter bursts, as well as more and longer pauses. Our hypothesis was only partially met, given that we only found significant differences between the WD group and the TD group in the number of bursts, but not in burst size, number of pauses or pause duration.

Number of bursts, which is highly related to the total number of words written, was the only affected measure, in contrast with previous research (Connelly, Dockrell, Walter, et al., 2012). This finding is not entirely surprising, as in young ages bursts grow exponentially across schooling (Alves & Limpo, 2015), and number of bursts relates with number of words, given that longer texts will constitute more words and more bursts, whilst in older grades bursts can be longer and this relationship diminishes. Number of words had been found to be impaired in the previous chapters (Chapter 2, Chapter 3 and section 4.1.2.2, Study 1 of this same chapter), and was one of the main criteria to identify students with text generation difficulties, as well as children with multiple writing difficulties. Therefore, the WD children wrote less and this factor impacted on the total amount of bursts that they were able to produce.

Average burst size had been linked directly to writing fluency in expert writers (Chenoweth & Hayes, 2001). Moreover, burst size has been shown to be an indicator of the writing process development across childhood (Alves et al., 2019; Alves & Limpo, 2015) and writing quality (Connelly, Dockrell, Walter, et al., 2012). For these reasons, we expected to find shorter average burst sizes for children with writing difficulties, in line with previous studies (Connelly, Dockrell, Walter, et al., 2012; Dockrell et al., 2019), although Dockrell et al. (2019) showed how burst size is not a measure that has enough specificity and sensitivity to distinguish between children with and without writing difficulties. Therefore, we argue that our different results are due to the lack of a cohort with a more severe level of impairment. Certainly, both studies that did find significant differences for average burst size analyzed children with diagnosed LDs or with standardized-tested performances below 2 SD, while our study included children with various ranges of affection, given that accounted for children with and without concomitant disabilities. Nonetheless, despite the non-significant results, this study already shows a tendency, as TD children in this study have produced an average of 4.4 words per bursts, whilst children with WD have produced an average of 3.5 words per burst. Therefore, it is also possible that we did not find statistically significant differences due to our rather reduced sample size. Future research with larger WD cohorts should be carried out to explore further this contrast.

Regarding pause number and average pause duration, the lack of significant differences between groups suggests that the writing process is similarly effortful for both children in the WD and TD groups. Pausing has been explored as either a time to manage the cognitive overload, as well as a time in the writing process to be able to focus on high-level writing skills (Alves et al., 2008; Just & Carpenter, 1992; Torrance & Galbraith, 2006; Van Waes & Schellens, 2003). It is possible, then, that both groups had similar needs to pause. As novice writers, their cognitive capacity is more limited (Cowan, 2010; McCutchen, 2000), and thus, revising and planning should be equally effortful for both groups. Previous studies with dyslexic children did find differences in the number of pauses (Sumner et al., 2013), but it has to be noted that dyslexic children have been found to have working memory, executive functions and short-term memory deficits (Connelly et al., 2006; Cruz-Rodrigues et al., 2014; Reiter et al., 2005), whilst our WD children did not show any cognitive differences from TD children in Chapter 3. In addition, our results fall in line with Connelly et al.'s (2012), who did not find significant differences in the overall number of pauses, although they did find that DLD children paused more than their TD peers, and these pauses were highly related to spelling mistakes that children produced during writing. Therefore, whilst pauses are not as productive for WD children, they may allow TD children to retrieve and develop more content, and provide them with more control over text generation (Chanquoy et al., 1990; Torrance & Galbraith, 2006), as the TD children write texts that are longer, as has been seen with the number of bursts.

Moreover, the most commonly used pause threshold in developmental studies (Alves, 2019; Alves & Limpo, 2015; Connelly, Dockrell, Walter & Critten, 2012; Schilperoord, 2002; Sumner et al., 2013) may not suffice for reporting pausing data of children, as a lower threshold which had been discarded in previous studies on the grounds that lower thresholds record pauses that are due to transcription processes (e.g., punctuation). Further exploration on this issue should be carried on with larger samples and different thresholds for pauses. It should be reconsidered whether a 2 second threshold is wide to be able to capture more detailed differences in pauses, exploring pause differences at a small scale, which would account also for transcription abilities and would provide more detailed markers on the constraint that transcription abilities pose on the writing process. Notwithstanding, our results are in line and show a tendency to fall in line with the previous research of the writing process of children with learning disabilities.

Furthermore, Smartpens have not been used in other studies concerning children with Learning Disabilities, given that until now, the few studies on the writing process of children with learning disabilities have been carried out with eye-and-pen digitizing tablets or with keystroke logging (Beers et al., 2017, 2018; Medimorec & Risko, 2017; Sumner et al., 2013). Therefore, results may differ from previous studies for methodological issues, given that typing, writing on tablets and writing with pens that light up when turned on, may differ in terms of difficulty of use, ecological validity and motivation for participants.

In sum, this study has found that there were virtually no differences between the bursts and pauses of children with writing difficulties and children with typical development. The only measure on which they have differed is the total number of bursts, which is linked to text generation; that is, with a key component of the writing process (Berninger & Winn, 2006) and perhaps the most universal criteria for assessing writing development (Connelly, Dockrell, Walter, et al., 2012; Salas & Caravolas, 2019).

4.4. General discussion

This study aimed to address the two main shortcomings of Chapter 3, as well as of most previous literature on writing difficulties: to be able to longitudinally assess the prevalence of writing difficulties, as well as to build an online writing profile of the struggling writer. Hence, we firstly examined the writing process of children that had a history of writing difficulties, compared to a group of typically developing children. Secondly, we explored their bursts and pauses and pinpointed their struggles with online text construction.

We expected our at-risk groups to have maintained or even worsened their struggles, given that difficulties with literacy learning do not disappear but, rather, they become more serious if not adequately treated (Altmann et al., 2008; Bishop & Clarkson, 2003; Hatcher et al., 2002; Juel, 1988; Snow et al., 1998; Snowling et al., 2016). Our findings fully supported this hypothesis, and showed that these children's writing difficulties were not only apparent but had become more pervasive. We found that most of the single writing difficulties (SWD) groups experienced a decline in their abilities, especially the Low Text Generation group who, 18 months later, added problems with handwriting and spelling, whilst the Low Handwriting group was also experiencing problems with spelling. Nonetheless, the Low Spelling group showed significant only in handwriting ability. At the same time, however, LowSpell children were no different to the other WD groups across tasks, showing that they still fitted the impaired profile.

It was clear, however, that writing difficulties affected children to different extents. Therefore, we argue that writing difficulties might be best considered as a spectrum, on which severity will vary between children, from those who only experience problems with a single writing skill (e.g., spelling or handwriting), to those who suffer an overall difficulty with the writing process. Similar claims have been made for most other learning disabilities such as DLD, ASD, ADHD or dyslexia (Bishop & Snowling, 2004; Di Martino et al., 2013; Geurts & Embrechts, 2008; Grzadzinski et al., 2013; Murphy & Pollatsek, 1994; Pérez-Crespo et al., 2019; Rumsey & Hamburger, 1990). Not all children are identically affected by their learning impairment. The most relevant example may be the Autism Spectrum Disorder, which includes children with a wide range of performance and severity levels. For example, it encompasses both a child with 'high-functioning ASD', to a child with a severe autism (Geurts et al., 2004; Happé et al., 2006; Myles et al., 2003; Zajic et al., 2018). Therefore, and in line with previous research (Bishop & Adams 1990), this study showed how difficulties in writing progress differently over time, but nonetheless they show a pervasive presence that can be followed across grades.

Writing difficulties, if unattended, result in affecting other subjects or dimensions, and school attainment in general (Walker & Nabuzoka, 2007), and they can also affect language development, as the development of oral and written language are inextricably related (Ravid & Tolchinsky, 2002). Regardless of the severity of the difficulties, detecting early struggles is key to ensure successful intervention and provide children with effective resources to overcome their difficulties (Berninger & Amtmann, 2003; Graham et al., 2001, 2012; Graham & Harris, 2002). Educational implications are further discussed in section 5.4.

Another goal of this chapter was to see differences in the writing process of the WD group in comparison with the TD group. The writing process has been found to develop across schooling (Alves & Limpo, 2015) and to be mediated by transcription skills (Alves et al., 2016; Beers et al., 2017; Limpo et al., 2017; Limpo & Alves, 2017; Sumner et al., 2013); therefore, it can be used as an indicator of writing difficulties. We compared the most used measures for assessing online composition, that is bursts and pauses.

Contrary to expectations, the writing process of the WD group was similar to that of the TD group for most measures, except for number of bursts. Number of bursts is highly related to number of words, which has been reported to be one of the major indicators of written language development across languages (Salas & Caravolas, 2019).

Moreover, bursts have been seen a good measure to identify struggling writers, since the number of bursts follows a clear developmental trajectory, where older students are able to write more and longer bursts (Alves et al., 2019; Alves & Limpo, 2015; Limpo & Alves, 2018).

Our lack of significant findings for the number or duration of pauses, though contrary to our predictions, has been found by previous studies (Connelly et al., 2012; Sumner et al., 2013). A possible explanation is that pauses are mainly considered spaces for planning and revising (Alves et al., 2007, 2008; Olive, Alves, et al., 2009; Schilperoord, 2002; Van Hell et al., 2008; Van Waes & Schellens, 2003). Therefore, given that most school-aged children are oblivious to planning strategies (Berninger & Swanson, 1994; Berninger, et al., 1996; Berninger et al., 1992; Limpo, Alves & Fidalgo, 2014), it seems logical that children with or without writing difficulties are equally constrained, as they have not yet acquired the resources or tools to carry out a good planning and revision process. A more in depths discussion on the role of pauses in writing development and writing difficulties is included in section 5.1.4.

Additionally, we did not find the expected results for average burst size, as children with WD produced similar bursts in length to the average burst size of the TD peers, although they produced less bursts. We expected to find burst size affected for children with WD, as had been seen as a language development marker, as well as a difference between children with writing difficulties and their TD peers in previous studies (Alves & Limpo, 2015; Connelly, Dockrell, Walter, et al., 2012; Dockrell et al., 2019). Burst size is mediated by transcription skills (Beers et al., 2018; Connelly, Dockrell, Walter & Critten, 2 012; Limpo & Alves, 2017, 2018) and, with more automated transcription skills, burst size will increase (Alves et al., 2016; Beers et al., 2018). When transcription skills are automated, there is a release of the working memory (McCutchen, 2000), and in turn, there is more available *space* for handling and managing the translation of ideas into words and subsequentially retaining these words before writing them, allowing the working memory to retain longer arrays of words. Therefore, the lack of differences between the burst size of children with WD and their TD peers can be explained by the similar WM results that they obtained, as there were no differences between WD and TD peers in the working memory (see Chapter 3). Burst size is linked with the development of writing (Alves et al., 2016; Beers et al., 2018; Connelly, Dockrell, Walter & Critten, 2 012; Limpo & Alves, 2017, 2018) and the slow rate of burst size development accounts for an exponential growth of a word per year (Alves et al., 2016; Limpo & Alves, 2018), and therefore, seeing that children with WD, in previous chapters have not been found of any developmental and cognitive differences regarding their TD peers, burst size should not be affected, but only constrained by their transcription abilities (Alves et al., 2016; Beers et al., 2017; Limpo et al., 2017; Limpo & Alves, 2017; Sumner et al., 2013). Nonetheless, differences in the results have to be considered regarding methodological issues that have to be taken into account such as the differences between the instruments for gathering the data process (i.e., Eye-and-pen and Smartpens), as well as the differences between cohorts in studies. Further limitations and implications are discussed in Chapter 5.

Chapter 5. General discussion

This thesis aimed to investigate writing difficulties independently of a concomitant learning disability diagnosis. To do so, three chapters addressed crucial aspects of writing development. Chapter 2 dealt with assessment issues, in the context of a minority language, Catalan, which does not count with standardized batteries to test spoken or written language. Chapter 3 examined children's written products and investigated underlying linguistic and cognitive skills, comparing children with various profiles of affected writing abilities to a group of age-matched controls. Finally, Chapter 4 involved a longitudinal assessment of children's difficulties with writing, as well as an exploration of their writing process with online measures.

5.1.1. Children without comorbid disabilities experience sustained difficulties with written expression

This thesis found sound support for the existence of a profile of a student who experiments difficulties with writing. Most importantly, these writing difficulties may emerge in the absence of a learning or language disorder. Writing difficulties can be identified as early as Grade 2 and usually persist or worsen in the following school years, at least if not treated properly. While novel in the context of a semi-consistent orthography, this finding is in line with previous research in English that advocated for the existence of struggling writers and children at-risk of writing difficulties (Coker et al., 2018; Graham & Harris, 2002; Mason et al., 2011; Ritchey & Coker, 2014). The Writing Difficulties (WD) profile includes children who struggle with key components of writing (e.g., spelling, handwriting, text generation) to various extents; that is, while some children may experience issues with one writing component in particular (e.g., handwriting), other may struggle with most aspects of written composition (Coker et al., 2014; Coker et al., 2017; Dockrell et al., 2019; Graham, Harris & Larsen, 2001; Graham & Harris, 2005).

Throughout the thesis, we have insisted on the fact that previous studies of writing in LD populations tend to point to similar struggles. Typically, struggling writers across LDs produce less text, make more spelling mistakes, and may have issues with handwriting fluency (Connelly, 2014; Connelly et al., 2006; Dockrell et al., 2014; Mackie et al., 2013; Myles et al., 2003; Puranik et al., 2007; Re & Cornoldi, 2010). In this sense, this thesis has contributed to the field of writing disorders, by showing that the writing profile of our struggling writers is strikingly similar to that of children with ADHD, ASD, DLD or dyslexia(Connelly et al., 2006; Dockrell et al., 2014; Re & Cornoldi, 2010). While research that looks at writing difficulties from the lens of concrete learning-disabled (LD) populations is fundamental to ensure adequate treatment for the affected children, we have provided evidence that there is also value in addressing writing difficulties independently of children's learning disabilities. From the point of view of research, this broader approach to writing difficulties should be useful in informing models of writing and the main bottlenecks in the typical and atypical development of writing. From the point of view of education, considering writing as a difficulty on its own might be useful to provide tailored intervention to children who struggle when writing, whose needs may remain unattended if dependent on another LD diagnosis (Connelly & Dockrell, 2016; Graham & Hall, 2016; Graham & Harris, 2002).

5.1.2. Cognitive and Linguistic Deficits Underlying Writing Difficulties

One goal of the thesis was to provide a thorough account of the cognitive and linguistic profile of struggling writers. This aim is important because it could lead to the identification of early markers of difficulty that could make intervention more effective. Also, it could point to potential causes of writing difficulties, thus advancing our understanding of the field. We considered the most usually affected cognitive skills in most LD populations that have been proposed to affect the writing process, including working memory and executive functions (Berninger et al., 2010; Berninger & Winn, 2006; Bourke et al., 2014). We also considered the role of linguistic factors (e.g., vocabulary, grammar), given the abundant evidence of writing difficulties in language impaired populations (Dockrell et al., 2014; Puranik et al., 2007; Re et al., 2010). .

With regards to the cognitive profile of our struggling writers, we found no evidence of cognitive impairments or severely affected cognitive skills. . We expected to be able to link their writing difficulties to some cognitive disorder, as had been seen in previous literature (Berninger et al., 2008; Drijbooms et al., 2017; Pagliarini et al., 2015; Sumner et al., 2013). However, the exploration of cognitive abilities such as non-verbal intelligence, working memory or inhibition, have provided us with a profile of child who does not differ from the cognitive profile of typically developing children. Other language learning impairments have reported affected cognitive capacities. For example, inhibition (a core executive function) has been found to be impaired in students with ADHD, DLD and dyslexia (Craig et al., 2016; Cuperus et al., 2014; Robinson et al., 2009). Although a vast majority of studies found some affected cognitive skills, it has to be noted how studies by Dockrell et al. (2007) and Geurts et al. (2004) did not find working memory to be impaired in neither of their cohorts, DLD and ASD, respectively.

A possible likely cause for the absence of a link between cognitive skills, such as working memory and executive functions, and writing outcomes may lie in the measures used for assessing these specific cognitive skills. In general, they are quite simple and may not fall close to the high cognitive demands of writing. For example, the reverse-digits task (WISC, Wechsler, 2004) to assess working memory capacity, prompts children to verbalize a series of numbers in the reverse order that they have been heard, in lists that start with two numbers up to strings of 9 numbers. The cognitive load of reversing numbers is not, in our opinion, fully comparable to the demands in even the simple, knowledge-telling writing processes that children embark on (Bereiter & Scardamalia, 1987; Hayes, 2011). When children compose text they need to consider the prompt, retrieve content and rhetorical knowledge, make content- and discourse-adequacy tests, retrieve and select words and grammatical constructions to express their ideas, plan and execute graphomotor movements ensuring legibility, retrieve orthographic representations and ensure correct spelling, while, ideally, taking into account cohesion within and between sentences, text coherence , among other tasks. Certainly, most of the cognitive (e.g., inhibition, working memory) tasks typically used do match the cognitive effort of activating and managing all the cognitive resources required in a writing task (Berninger & Winn, 2006; Hayes, 2012b; McCutchen, 2000; Olive, Favart, et al., 2009). This is arguably a good reason why most tasks that assess working memory or other cognitive skills tasks may not be found to be related to writing outcomes, unless they are severely compromised. We would argue that children who struggle with writing specifically (as most of the children in our sample) may have a deficit with working memory and other executive functions that is only evident in high-demand situations, such as the one presented when composing written text. More research is needed that applies more demanding cognitive tasks, which should help clarify potential underlying cognitive deficits of children with writing difficulties.

We found no specific linguistic dimension that could help explain the writing difficulties observed. Children with writing difficulties did not struggle with receptive vocabulary or morphosyntax skills, similarly to what has also been reported by previous studies (Connelly et al., 2006; Myles et al., 2003; Williams et al., 2013). The linguistic profile of children with writing difficulties is in line with previous research that found that linguistic skills that mediate, enhance and constrain writing performance, yet the main skills that pose the major constraints and mediate the writing process are transcription skills (Dockrell et al., 2019; Kim et al., 2011, 2014; Wagner et al., 2011). For example, Wagner et al. (2011)found evidence for five factors that would account for the dimensionality of writing: handwriting, macro-organization of text, complexity, productivity and spelling. Their findings showed that handwriting constrained other vital aspects, including textual macro-organization. Additionally, Kim et al. (2014) study also found evidence that transcription skills were highly related to multiple dimensions of writing (e.g. letter writing automaticity was related to every dimension except syntactic complexity whilst spelling was a predictor of syntactic complexity). Likewise, previous literature found extensive support for how literacy skills mediate and influence the writing process (Abbott et al., 2010; Arfé & Pizzocaro, 2016; Dockrell et al., 2019; Kim et al., 2014; McCutchen, 2000; Olinghouse & Leaird, 2009; Puranik et al., 2008; Wagner et al., 2011). For example, Kim et al. (2014) found that reading ability influenced substantive text quality, spelling and productivity. Moreover, some LD children (dyslexic and DLD children) have been found to have both writing as well as reading impaired (Connelly et al., 2006; Dockrell et al., 2007; Pagliarini et al., 2015). Interestingly, these subgroups of children appear to struggle with writing as a result of a language-related deficit. In contrast, the children in our sample did not experience issues with reading, with the exception of our most affected group of WD children, the Multiple Writing Difficulties group (MWD), who did show a disadvantage in word reading in comparison with age-matched peers.

To sum up, the writing difficulties observed in the studies across the thesis, as well as in part of previous research, point to a rather domain-specific issue. More research is needed to better understand the role of cognitive skills in struggling writers (particularly working memory and executive functions), that develops testing contexts that are a better match to the complexity of writing. Finally, while language disorders will usually be accompanied by writing difficulties, the reverse does not seem to be necessarily the case: children with normal language development may struggle with writing. We argue, thus, that writing difficulties may constitute domain-specific difficulty, which may or may not appear comorbidly with other learning impairments.

5.1.3. What does the text of a child with writing difficulties look like?

This thesis also intended to provide a thorough account of the characteristics of the written products of children with writing difficulties. One main observable sign of struggle is that children with writing difficulties tend to write less. This is consistent with previous findings in studies carried out in English (e.g., Coker et al., 2018; Graham & Hall, 2016; Graham & Harris, 2005; Ritchey & Coker, 2014). This finding is also in line with reports of written products of children with other learning disabilities (Altemeier et al., 2008; Connelly & Dockrell, 2016; Connelly, Dockrell, & Barnett, 2012; Dockrell et al., 2014; Mackie et al., 2013; Re & Cornoldi, 2010). That children who struggle with writing produce short texts is well aligned with most models of writing development, which posit that text generation may be constrained by children's transcription and executive function skills[4] (Berninger & Winn, 2006). In addition, there is substantial evidence that text length is a prime indicator of writing development across most of the life-span and across languages (e.g., Berman & Verhoeven, 2002; Salas & Caravolas, 2019).

Text length has been chiefly assessed in terms of the number of words that children produce. However, there are several alternatives in the literature, such as number of clauses (Mackie et al., 2013), correct word sequences (Dockrell et al., 2014), T-units (Puranik et al., 2007) or number of bursts (Connelly, Dockrell, Walter & Critten, 2012), a measure that is obtained by looking at the process of writing. Despite the various alternatives to estimate productivity, it appears that the number of words may be the most sensitive developmental marker, as well as a good indicator of potential writing difficulties. Our own results with texts of two different genres (narrative texts and an opinion essays), assessed both concurrently and longitudinally (18 months apart), revealed that text length was a good marker of writing struggles. Virtually all our productivity-related product and process measures (words, clauses, number of bursts) served to distinguish typically-developing from struggling writers. However, the number of words stands out, because it "may suffice as a quick and easy predictor of written language skills" (Connelly, Dockrell, Walter & Critten, 2012, p. 297). Words are counted more easily and with more reliability than counting either clauses (which require a fair amount of linguistic training) and bursts (which require specialized instruments, software training and a time-consuming analytic process). Finally, using the number of words as an indicator may also turn into an accessible resource for educators, who by

[4] Note that "executive functions" in the context of models of writing development does not solely refer to core executive function skills (e.g., inhibition, updating of working memory), but to a conglomerate of low- and, particularly, high-level skills, including planning, revising, self-regulation strategies, and others (Berninger & Winn, 2006).

simply enticing students to write more, already can result in a benefit to them, as attested in studies with LD populations. Importantly, once the teacher's encouragement to write more, makes children develop longer, better texts, which are nevertheless coherent Graham et al., 1991).

Overall, children with writing difficulties have produced texts of similar complexity as their peers. Only the initial LowHw group showed difficulties in the grammatical domain, having more grammatical mistakes in one text, and the MWD group, who had shown struggles with the syntactic complexity of their texts, with less words per clause in their texts. Besides these two specific findings, the texts of the rest of participants with writing difficulties showed no signs of impoverished vocabulary, ungrammatical constructions or fewer syntactic complexity as their age-matched peers, being aligned with the results on the linguistic dimensions reported in the previous section, where it was seen the lack of major problems in receptive vocabulary or morphosyntax skills. Mastering and controlling these linguistic skills can enhance the writing performance, as well as specific handwriting or spelling difficulties can constrain the ability to access and mange vocabulary and grammatical or syntactic constructions, which will entail an impoverished text construction (Dockrell et al., 2019; Kim et al., 2011, 2014; Wagner et al., 2011).

Another major marker of the texts of children with writing difficulties is that they are not only shorter length, but are also usually riddled with spelling errors. Another clear symptom is handwriting ability, which constrains fluent text generation. Transcription difficulties have been largely explored as a key dimension of the writing process (Berninger et al., 1994; Berninger & Winn, 2006; Salas & Silvente, 2019). Children experience writing difficulties when their transcription abilities are not automatized, given that they pose a cognitive burden, drawing a substantial part of their cognitive capacity (Alves et al., 2007, 2012, 2016; Berninger, 1999; Bourdin & Fayol, 1994; Limpo & Alves, 2013; McCutchen, 2000). Spelling and handwriting require a massive amount of writing resources to novice writers, which is reflected in both the product (Berninger et al., 1992; Bourke et al., 2014; Bourke & Adams, 2010; Kandel & Perret, 2015; Kim et al., 2014; Kim & Schatschneider, 2017) and in the process of writing (Alves et al., 2012, 2016; Beers et al., 2017, 2018; Connelly, Dockrell, Walter & Critten, 2012; Limpo & Alves, 2017; Medimorec & Risko, 2017; Olive, Alves, et al., 2009). Consequently, early interventions to target transcription skills are needed, in order to alleviate the cognitive load and allow children to focus on higher-level writing skills, to produce better quality texts (Berninger & Amtmann, 2003; Graham & Harris, 2005; Graham & Perin, 2007; Limpo & Alves, 2018; Lindsay & Dockrell, 2008).

To sum up, children who struggle with writing produce shorter texts, and often display problems with spelling and handwriting fluency. These core writing elements should be addressed for children with writing difficulties as early as possible, so that they are able to focus on other features of text construction.

5.1.4. What does the writing process of a child with writing difficulties look like?

While the texts of struggling writers look quite different from texts produced by TD children, there are few indicators of writing difficulties when examining the characteristics of the writing process. Children with writing difficulties tend to pause as much as TD peers and for a similar amount of time. Their bursts were also similar in average length, although there were fewer of them. This indicates that children with writing difficulties cease writing sooner than their TD peers, which is consistent with findings that their texts are shorter, that they are less motivated, and that writing is more effortful for them, as they cope less well with managing the various demands of writing (Alamargot & Chanquoy, 2001; Graham et al., 2005; Hayes, 2012b; McCutchen, 2000). Causes of the early cessation of writing activity that affects children with writing difficulties should be explored further, both examining the way in which they manage the writing processes and subprocesses, as well as by exploring further relevant motivational issues.

In adult writers online process measures (i.e., burst number, burst size, number of pauses and pause duration) may be used as reliable indicators of high-level writing skills (Alves & Limpo, 2015; Chanquoy et al., 1990; Chenoweth & Hayes, 2001; Hayes, 2012a; Van Hell et al., 2008), children, especially in younger ages, are more focused on low-level skills (Berninger et al., 1994). They have not yet mastered planning and revision processes, as they conceive texts as a unit, where topics are brought up sequentially (Chanquoy et al., 1990; Hayes, 2012b; Kellogg, 2008; Scardamalia & Bereiter, 1987). Therefore, the lack of differences between poor and TD writers can be explained due to the overall immaturity of writing processes across both populations of children (Connelly, Dockrell, Walter & Critten, 2012). Future investigations should provide a more detailed account of the development of process measures across ages, especially with larger samples, to determine whether these differences can be related to a specific age or developmental stage.

Moreover, it has to be noted how number of words (translated into number of bursts), seems to still be the main risk-marker that can be more easily assessed (with no need of technological interfaces and tools to assess the writing process) and a good indicator for educators (Berninger et al., 1992; Connelly, Dockrell, Walter & Critten, 2012; Connelly & Dockrell, 2016). This finding also supports that the written product offers a clear insight into the developing writer's writing process and can be as useful as writing process measures (Tolchinsky, 2013).

5.2. Importance of an Early Identification of Writing Difficulties

The early identification of writing struggles is essential to be able to intervene before it develops into a more pervasive disability. Different studies have focused on primary education children, but it difficulties with writing have been detected as early as the final stages of preschool (Coker et al., 2018; Kim et al., 2011; Puranik & Lonigan, 2012). What could have been a focused and restricted difficulty, affecting only one dimension, can broaden its scope and lead to more pervasive difficulties fairly quickly. This thesis has shown that untreated writing difficulties that are dimension-specific early on, tend to become more extensive and pervasive, impairing writing development across several dimensions. Other studies have found that problems with writing persist not only across childhood, but well into adolescence and even adulthood (Altmann et al., 2008; Berman, 2008; Clegg et al., 2005; Hatcher et al., 2002; Kellogg, 2008). Most crucially, writing difficulties may affect overall academic performance, given that writing is the main means of communication and assessment at schools, so writing difficulties can easily have a negative impact on achievement in other subjects (Bangert-Drowns et al., 2004; Preiss et al., 2013). Therefore, writing difficulties may lead to academic failure.

To be able to detect writing difficulties, especially in languages with no standardized tests, there should be a scanning of multiple writing tasks for each writing dimension, to detect consistent struggle. We have shown that looking for an overall deficit in writing performance only identifies a subset of children, those with a more severe impairment. However, we have provided evidence that, if identification criteria are too stringent, several children who do need extra support to writing skills, would be left unattended. Therefore, and until further research accrues, sustained difficulties in one or more of the main components of the writing process are a fair and sufficient indicator of writing difficulties; that is handwriting fluency, phonological spelling and text generation.

We have seen how domain-general cognitive assessments for working memory, inhibition or short-term memory have not reported any affection in our sample of WD children. Therefore, predictors for writing difficulties should not only entail cognitive general assessment but focus on assessing the writing process mainly with writing specific tasks, to be able to identify the difficulties. It is fairly documented how the ability of accessing the lexical and morpho-syntactical span influences on text generation and its quality (Beers & Nagy, 2009; Berninger & May, 2011; Plaza & Cohen, 2003). The influence of accessing the lexicon to transform ideas into text is mastered across schooling years and measures for sentence generation tap directly into the cognitive demand that the accessing the lexicon imposes on the writers (Arfé & Pizzocaro, 2016; Dockrell et al., 2019). Although sentence generation tasks have been mainly considered to assess grammatical knowledge in the standardized tests -- for example the Wechsler Individual Achievement Test-III (WIAT-II; Wechsler, 2009) or the Test of Written Language (TOWL-IV; Hammill & Larsen, 2009)-- sentence generation does not only provide a grammatical assessment, as it entails a small-scale activation of the whole writing process, which in turn allows to explore specifically the cognitive demand that writing process can pose, as it has to activate all the processes equally although in a micro-text scale and therefore it helps providing sufficient information to identifying writing difficulties (Arfé & Pizzocaro, 2016; Dockrell et al., 2019). Sentence generation entails to narrow down the writing process and, for example, specific work on sentence generation leads to an improvement of overall quality of the text (Berninger et al., 2010; Saddler et al., 2008).

Seeing this, further research should develop reliable word, sentence and text generation measures to be able to discern writing struggles in the three levels of the writing process, to, thus, be able to resort to an array of different writing measures to identify specific writing struggles (Bouwer et al., 2015; Dockrell et al., 2019; Rietdijk et al., 2017). Recent research has begun to accumulate suggesting that sentence generation tasks may be useful to detect children with writing difficulties (e.g., Arfé & Pizzocaro, 2016; Dockrell et al., 2019). What is interesting about this measure is that, while easy to obtain both in a research and a school setting, it requires to activate and manage virtually all processes and knowledge bases as composing text. In other words, it mirrors writing to a large extent and, while cognitive load and task difficulty should be reduced, it requires idea and text generation, handwriting and spelling (Arfé & Pizzocaro, 2016; Dockrell et al., 2019). This approach aligns well with our previous statement that writing assessment should include tasks and measures that more closely match the difficulty of a writing composition task. Cognitive and linguistic assessments are a good complement to identify writing difficulties, and be able to address more pervasive problems rooted in the overall cognitive and/or specifically linguistic issues that could indicate learning disabilities.

In sum, writing assessment at its early stages should become a key element in the educational system, given that one early identification may be paramount to prevent future difficulties (Berninger & Amtmann, 2003; Coker et al., 2018; Graham &

Harris, 2005; Kim et al., 2011; Lienemann et al., 2006; Puranik & Lonigan, 2012). This thesis has seen how, over time, difficulties become more pervasive and do not vanish without intervention. Of special importance are writing difficulties that may affect a single writing component (e.g., handwriting fluency), which may son evolve into a more severe writing impairment.

5.3. Implications for Writing Development Theory

The identification of children with writing difficulties is well in line with the not-so-simple view of writing (Berninger & Winn, 2006), which establishes that text generation, transcription and executive functions are the three axes of the writing process, with working memory as the omniscient controller and enabler of the cognitive resources. Indeed, transcription and text generation were the two skills with which children with writing difficulties struggled the most. Moreover, our finding that issues with one or more of these skills, soon develops into difficulties with one of the other skills (e.g., low handwriting soon led to problems with text generation), provides further support to this model, which poses a relationship between transcription and text generation across development.

Nonetheless, we have found strong evidence of these difficulties in the absence of executive functions (inhibition) and working memory problems. Models such as Berninger & Winn's (2006) remark the importance of working memory, as a general regulating core for writing ability, as its limitations may seriously constrain the execution of the various writing processes. Moreover, working memory deficits have been found underlying the writing difficulties across several learning disabilities (Bourke & Adams, 2010; Capodieci et al., 2018; Connelly et al., 2006; Cuperus et al., 2014; Vugs et al., 2014). Notwithstanding, we have found that in the writing difficulties profile, it does not have to be necessarily affected: whilst indeed a working memory would be a constraining agent for writing development (Kellogg, 2008; McCutchen, 2000; Torrance & Galbraith, 2006; Verhoeven & Van Hell, 2008); that is, writing difficulties can also arise in the absence of working memory problems. We have mentioned above that our findings should not be taken to mean that working memory (or executive function skills) is not behind at least some of the writing difficulties that these children experience, but that perhaps a domain-general assessment of working memory or rather “simple” working memory tasks may not be comparable to what writing entails. Put differently, we would argue that a working memory deficit might underlie writing difficulties, but either domain-specific and/or more complex tasks (that are a closer match to the demands of writing) are required for the deficit to be observed. Future studies should strive to develop alternative measures of working memory and executive functions that are better resemble the complexity and demands of writing.

5.4. Educational implications

Our findings point to some recommendations in terms of both writing assessment and writing pedagogy. This thesis has pointed at the existence of easy-to-obtain, objective measures to detect writing difficulties in the classroom (Connelly, Dockrell, Walter & Critten, 2012). In the first period of the school year, tests to assess children’s achievement level across several disciplines are carried out: reading assessment, mathematical reasoning or specific initial evaluations for academic subjects, are all useful instruments for educators to assess the initial level of the children in their classrooms. Adding writing tasks to these measures may be vital to detect students who might need tailored assistance to strengthen writing skills (Baker et al., 2009; Berninger, & Amtmann, 2003; Graham et al., 2001, 2012; Graham & Harris, 2002;

Lienemann et al., 2006; Saddler et al., 2008). With initial evaluations, educators can trace the development of their students across the school year (retesting writing abilities periodically) and therefore be able to identify either students who match a writing difficulties profile: children who write very short texts, those whose texts have a large percentage of spelling mistakes that are phonological in nature, or those struggle with handwriting.

Writing difficulties have to be addressed at early ages to be able to provide specific support to all children who struggle with writing, independently of a parallel diagnosis of another Learning Disability (Coker et al., 2018; Graham et al., 2005; Graham & Hall, 2016; Graham & Harris, 2005; Lienemann et al., 2006; Morphy & Graham, 2012; Ritchey & Coker, 2014). An early detection of writing difficulties prevents them from affecting other domains and from resulting in school failure (Graham & Harris, 2002, 2005; Hooper et al., 2013). Providing students with strategies to improve writing performance (Baker et al., 2009; Berninger et al., 2009; Berninger & Amtmann, 2003; Graham et al., 2001, 2012; Graham & Harris, 2002; Lienemann et al., 2006; Saddler et al., 2008; Saddler & Asaro-Saddler, 2013) is a preventive action to avoid future perceptions of poor text quality derived from writing difficulties (Connelly & Dockrell, 2016; Morphy & Graham, 2012; Ritchey & Coker, 2014). These, in turn, derive in impoverished self-efficacy beliefs, which are associated to poor writing skills (Bruning & Kauffman, 2016).

To provide children tailored assistance to address their writing difficulties, a vast array of evidence-based practices and methodologies are available that have shown to be effective to promote and develop the different writing dimensions. When working on handwriting, it has been seen that both legibility and fluency need to be addressed

(Caravolas et al., 2020; Feder & Majnemer, 2007; Puranik & AlOtaiba, 2012), where handwriting at the letter, word, sentence and text level are relevant (Alves et al., 2018). Moreover, spelling instruction that resorts to linguistic representations, and that brings orthographic patterns forward, avoiding rote memorization of words, has also shown to be effective (Alves et al., 2018). Spelling instruction should develop strategies for children to be able to apply phonological, morphological, orthographic and etymological knowledge to develop spelling as a logical problem (for detailed resources for handwriting and spelling instruction, see Alves et al., 2018; Graham & Harris, 2005). The effects of handwriting and spelling instruction are, in turn, effects that have an impact not only on handwriting ability, but that may transfer to other writing dimensions, with evidence that it may enhance sentence generation and overall text quality (Alves et al., 2016; Graham et al., 2000, 2018).

It has also to be noted that not only interventions on low-level skills have a positive impact on the development of writing, but also intervention on the higher-level skills of planning and revising has been shown to work for enhancing writing development (Graham et al., 2005; Graham & Harris, 2005; Limpo & Alves, 2018; Saddler et al., 2008). Process-focused writing interventions are particularly effective when they are paired with self-regulation strategies (self-regulation strategy development, SRSD; e.g., Graham & Harris, 2009). SRSD interventions are an effective method that has been shown to contribute to the writing development of both typically developing students (Limpo & Alves, 2018), as well as of children with language learning disabilities (Baker et al., 2009; Graham et al., 2005; Harris et al., 2003; Lienemann et al., 2006; Mason et al., 2011). Remarkably, there is evidence of its effectiveness in both English and in some

Romance languages (e.g., Limpo & Alves, 2013, for Portuguese; Salas et al., under review, for Catalan).

5.5. Limitations

An enterprise of the scope of this thesis could not be without its limitations. One limitation of this thesis has been the lack of standardized psycholinguistic updated tests in Catalan to assess oral and written language development. A second limitation was that we could not rule out underlying disabilities in our participants. It could well be that some of the children in our sample that were not diagnosed, before or over the duration of the study, did suffer from some kind of learning or language disorder. However, the overall rate of disabilities in the classrooms was similar to the typical percentage of learning disabilities across schools.

Another limitation of this study was not being able to factor in the level of bilingualism of the children. Catalan is a language in coexistence with a dominant language and cannot be disassociated from Spanish. Indeed, the fact that these children are constantly managing to languages and, importantly, two orthographic systems all the time, is likely to have an impact on their writing development Future studies should take into account the extent to which a child's type or level of bilingualism affects writing struggles. Readers should bear in mind this limitation, as it may be possible that the results for this thesis may not extend to other contexts.

5.6. Concluding remarks

This thesis has found that there is a group of children who, independently of having an learning disability (LD), show sustained difficulties with one or more aspects of writing that become more pervasive with time. Writing difficulties may become a severe impairment when not addressed in the early grades, as it could result in academic failure over time. Furthermore, writing difficulties have been found to be fairly domain-specific, and to occur in the absence of other cognitive or linguistic skills. Early markers of writing difficulties are problems with phonological spelling, with handwriting fluency, and with text generation. If a child struggles with one or more of these domains she should receive additional support to the learning of writing, if one wishes to prevent more severe and possibly irreparable damage.

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Appendix 1. Manuscript for Infancia & Aprendizaje: The cognitive profile and text-based traits of struggling writers

A1.1. Introduction

Writing is essential to succeed professionally and academically, so difficulties with writing may turn into a major obstacle for self-realization (Clegg, Hollis, Mawhood & Rutter, 2005). Writing difficulties have usually been considered a secondary outcome of other, more general or primary disability. Several studies have pointed out that people with a history of learning disabilities, such as dyslexia, autistic spectrum disorder (ASD), specific language impairment (SLI), or attention-deficit/hyperactivity disorder (ADHD), experience sustained difficulties with writing even until adulthood (De Bono et al., 2012; Hatcher, Snowling, & Griffiths, 2002; Hellendoorn & Ruijssenaars, 2000; Tops, Callens, Lammertyn, Van Hees, Brysbaert, 2012). More recently, however, a new line of research has emerged that intends to raise the status of writing difficulties and start considering them as a potentially primary impairment (Coker, Ritchey, Uribe-Zarain, & Jennings, 2017; Dockrell, Connelly & Arfé, 2019; Graham & Harris, 2005). There are three main advantages of bringing writing difficulties to the forefront: first, it facilitates an in-depth understanding of writing and writing processes by focusing on examples where writing develops atypically; second, it allows for specific remediation strategies that target writing behavior that needs improvement; third, it might uncover children who do not suffer from any learning disabilities but who, nevertheless, experience serious difficulties with writing. In this study we thus focused on building the writing and cognitive profile of children potentially at risk of writing difficulties, with or without comorbidities.

A1.1.1. Affected Text Features

A number of studies have found that there are specific text features affected in the writing of learning-disabled (LD) children. These include measures of lexical diversity and grammar (e.g., verb or noun agreement), which have been reported as affected in children with ADHD (Re, Pedron, & Cornoldi, 2007), ASD (Myles, et al., 2003), dyslexia (Puranik, Lombardino & Altmann, 2007), and SLI (e.g., Dockrell, Lindsay, Connelly, & Mackie, 2007; Dockrell, Ricketts, Charman, & Lindsay, 2014).

Most importantly, several studies have converged in pointing out that LD children often show impaired text generation skills, across various LDs including dyslexia, SLI, ASD, or ADHD (e.g., Connelly, Campbell, MacLean & Barnes, 2006; Connelly, Dockrell, Barnett & Lane, 2012; Dockrell et al., 2007, 2014; Mackie & Dockrell, 2004; Myles et al., 2003; Sumner, Connelly & Barnett, 2013; Zajic et al., 2016). Text generation is a writing-specific process (Berninger & Winn, 2006) responsible for the production of written text (measured in words, sentences, or ideas), and it is considered to be one of the best proxies for the overall quality of a text and one of the first dimensions of writing to emerge (Berman & Verhoeven, 2002; Salas & Caravolas, 2019; Salas, Llauradó, Castillo, Casas, & Martí, 2016).

Most models of writing consider that text generation is affected by a writer's transcription skills (i.e., spelling and handwriting), such that low levels of transcription are assumed to be at the root of poor text generation skills (e.g., Berninger & Winn, 2006; Juel, Griffith, & Gough, 1986). Accordingly, both spelling and handwriting have been reported to be affected in the writing of SLI (e.g., Dockrell et al., 2014), ADHD (e.g., Graham, Fishman, Reid & Hebert, 2016), dyslexic children (e.g., Arfé, Dockrell, & Berninger, 2014), and ASD (Dockrell et al., 2014; Kushki, Chau & Anagnostou, 2011).

A1.1.2. Affected Cognitive Processes

Writing is a cognitively demanding task and, as such, it involves the recruitment of several cognitive processes and resources (e.g., Hayes & Flower, 1980). Given that most learning disabilities involve some kind of processing or cognitive impairment, it is not surprising that a number of cognitive skills linked to writing have been found to be affected in LD populations. For example, working memory, that is, the ability to withhold information, while performing some kind of manipulation or operation (Baddeley, 1992) has been found to be impaired and to affect the writing skills of people who suffer from ADHD, ASD, SLI, and dyslexia (e.g., Capodieci et al., 2018, Nyeden, Gillberg, Hjelmquist, & Heiman, 1999; Vugs, Hendriks, Cuperus, & Verhoeven, 2014; Connelly et al., 2006). Moreover, inhibition, a core, low-level executive function (Diamond, 2013), which is instrumental to writing (e.g., Salas & Silvente, 2019), has also been found to abe affected in ADHD (Craig et al., 2016), ASD (Robinson, Goddard, Dritschel, Wisley, & Howlin, 2009), SLI (Cuperus et al., 2014), and dyslexia (Helland, & Asbjørnsen, 2000). In addition, short-term memory is also affected in SLI (Conti-Ramsden, Ullman, & Lum, 2015; Conti-Ramsden, Botting & Faragher, 2001; Mackie, Dockrell, & Lindsay, 2013) and dyslexic children (Varvara, Varuzza, Padovano-Sorrentino, Vicari, & Menghini, 2014).

A1.1.2. This Study

We have established that a few developmental disabilities, despite having different aetiologies, result in children experiencing some common writing difficulties and similar cognitive impairments. We argue that there may be a developmental disorder that affects writing, which affects LD populations as well as children without other developmental or learning disabilities. In line with previous studies (e.g., Coker et al., 2017; Dockrell et al., 2019), we aim to investigate the writing features and cognitive profile of children at risk of writing difficulties, whether they belong to an LD population or not.

To identify potential at-risk writers, we used data from a larger project on writing development and proceeded to identify children with marked difficulties on one or more aspects of written composition. Afterwards, we compared them to a group of age-matched controls on a number of text-based features and cognitive skills. Following Coker et al., (2017), we identified children based on their performance on three domains: handwriting, spelling, and text generation (number of words). Given that our study deals with children who are schooled in a minority language in Spain, Catalan, no standardized tests were available to measure writing skills. We identified children who scored below -1SD from the mean for their age group (Grade 2 or 4) on key writing features and skills. A criteria of -1SD has been typically used as a threshold for children to be considered as potentially at-risk group (Berninger et al., 2008; Conti-Ramsden et al., 2001; Williams, Larkin & Blaggan, 2013). Children who performed below -1SD from the mean for their age group across two tasks of handwriting fluency constituted the **Low Handwriting** (LowHw) group. We reasoned that having a deviant score across two tasks that estimate the same skill provided consistency to our identification criteria. Children who scored below -1SD from the mean for their age group in phonological spelling accuracy constituted the **Low Spelling** (LowSpell) group. Children completed a bespoke test designed to analyze their ability to represent each phoneme in the target word with a plausible letter. Catalan has a shallow orthography, similar to Spanish, Portuguese, and students are expected to represent the phonological structure of words by the end of Grade 1 (Generalitat de Catalunya, 2017). Therefore, difficulties to represent the phonology of the word at 2nd or 4th grade should be a sensitive indicator of difficulties with spelling. Children who consistently scored below -1SD inthe number of words across two separate writing tasks, a narrative text and an opinion essay, constituted the **Low Text Generation** (LowTG) group. In sum, we opted for consistency across multiple measurements (i.e., in handwriting and text generation) or for the severity of the impairment (i.e., spelling). During our classification process, we identified a group of children who showed difficulties across two or more of the above-mentioned domains (e.g., spelling and text generation). These children constituted the **Multiple Writing Difficulties** (MWD) group. Finally, we randomly selected a **Reference group** of typically-developing peers (TD) out of the rest of the children in the sample.

Our study had three main goals. First, we aimed to examine the text-based features of the at-risk groups. We expected that the MWD group would show lower levels of achievement across all text-based measures, in comparison with the TD group. We also expected the single-deficit groups (i.e., LowTG, LowSpell, LowHw) to be impaired for specific text features, although their problems would not be as pervasive as the MWD group's. However, given the codependency of the various writing skills and processes (Connelly et al., 2006; Cruz-Rodrígues et al., 2014; Mackie et al., 2013), their lower achievement might not be confined to the feature that led to their identification, but could affect other, related features as well. For example, the Low TG group could also show lower levels of handwriting fluency (Jones & Christensen, 1999). Second, we aimed to examine the cognitive profile of all at-risk groups, in comparison to the TD group. We expected that the children in the MWD group would be impaired in most cognitive measures, when compared to the TD group. For this reason, we administered a number of tasks and obtained measures of non-verbal IQ, short-term memory, and low-level executive functions (inhibition and updating). We also collected measures of children's levels of vocabulary and morphosyntax, in order to examine whether there were any language issues, a likely cause of writing difficulties (Dockrell & Connelly, 2009). A third goal was to determine the specificity of the writing difficulties observed. To pursue this goal, we obtained measures of word reading and reading comprehension, to determine whether children's struggles with writing were specific to the writing domain or if they were literacy-general.

A1.2. Method

A1.2.1. Participants

Potentially at-risk students were drawn from a sample of 357 2nd and 4th graders (188 male, 169 female) from a larger project. Students came from 5 public schools in districts with an average/high socioeconomic status in Barcelona, Catalonia (Spain). Information of parents' level of education was available for 315 children. Fifty-eight percent of mothers and 48.7% of fathers had completed university level education, 16.8% and 19.9% of mothers and fathers, respectively, had completed high-school education; and 4.5% and 3.1% of mothers and fathers, respectively, had only completed primary education studies. Catalan is a minority language which coexists with Spanish in Catalonia (IDESCAT, 2015). It is the main language of instruction at schools from preschool to college, ensuring the bilingual ability both for speaking and writing of all children in the region. While it is safe to assume that the children in our sample are speakers of both Spanish and Catalan --the language of interest for this study--, they vary in their exposure to it. Use of Catalan in the family context was determined by means of a questionnaire that asked children the language(s) in which they talked to their mother, father, siblings, etc. Of the children in our sample, 16.5% did not have a regular exposure to Catalan outside of school, while the rest did.

The final, post-identification sample consisted of 132 children (77 boys; 55 girls) from 2nd and 4th grade, with a mean age of 101.11 months (*SD* = 12.73, **Table A1.**0.1). Of the 132 students, only 24 had been previously diagnosed with ADHD (5 children), ASD (1 child), dyslexia (2 children), SLI (5 children), and 2 children had curricular adaptations at school. In addition, 8 children in the sample had been identified as requiring special needs. In this final sample, the percentage of children with no Catalan support outside of school was 35%, but a comparison of the rate of Catalan support outside of school indicated that it was similar across at-risk and reference groups, X^2 (5, 132) = 3.90, *p* = .420.

Table A1.0.1

Number of participants, distribution by grades and percentage of Catalan at home by group

	LowSpell	LowHw	LowTG	MWD	TD
N	15	39	17	11	50
2nd Grade	20	10	4	7	20
4th Grade	19	5	13	4	30
Catalan at Home	53%	56%	64%	63%	74%

Note. LowSpell= Low Spelling, LowHw = Low Handwriting, LowTG = Low Text Generation, MWD = Multiple Writing Difficulties, TD= Typical development

A1.2.2.Tasks and Measures

Written expression. Students elaborated two texts: a narrative and an opinion essay. In the narrative, children from three schools replied to one of two prompts "A boy/girl loses his/her pet" or "A boy/girl gets angry with his/her best friend". In the opinion essay, they answered to the prompt “Do you think that every boy and girl your age should go to school?” or “Do you think that children at school need recess?”. Prompts counterbalanced across classrooms. Children were given 10 minutes to produce a draft and 20 minutes to complete their opinion essay or their story. The first author and a trained research assistant transcribed all texts. We obtained the following measures from each text:

Number of words. This measured assessed text generation at the word level and was the feature that served as the basis of identification of the LowTG group. The number of words in both texts was automatically counted in CLAN (MacWhinney, 2000). Reliability (ICC) between the first author and a research assistant on 100 randomly chosen texts was .996.

Spelling mistakes. This measure assessed accuracy at the word level. Spelling mistakes were identified and then counted automatically in CLAN. Morphosyntactic errors, invented words, typical colloquialisms, and interferences from Spanish were not penalized. Reliability (ICC) between the first author and a research assistant on 100 randomly chosen texts was .856.

Lexical diversity. To assess this word-level text feature, we calculated the Mass Ratio, which provides a measure of different word use that is not sensitive to text length. The formula for this measure is $M = (\log n - \log t) / \log^2 n$ (Torruella & Capsada, 2013).

Number of clauses. This measure assessed text generation at the sentence level by segmenting texts into clauses, following Berman and Slobin’s (1994) criteria. Clauses were counted automatically using the FREQ command in CLAN. Reliability (ICC) between the first author and a research assistant on 100 randomly chosen texts was .958.

Word per Clause. This measure assessed syntactic complexity at the sentence level. It involved a calculation of the ratio of words per clause.

Grammatical mistakes. Accuracy at sentence level was assessed by identifying grammatical mistakes, such as morphosyntactic errors, inadequate use or absence of pronouns, incorrect noun or verb agreement, or grammatical replicas of Spanish constructions. The number of grammatical mistakes was counted automatically in CLAN and then divided by the total number of clauses in the text.

Alphabet task (Berninger et al., 1994). To assess handwriting skills, students were asked to write the alphabet from memory as fast and as many times as they could during one minute. Given that some schools in Spain do not teach the alphabet, the task was evaluated in two ways: one which penalized alphabetical order errors (strict) and one that did not (lenient). Correlation between the strict and lenient scoring was very high, r = .996. We proceeded to use the lenient score, as it allowed us to include all the participants in the sample. The score was the number of legible letters, regardless of the order, written within the first 15 seconds. Reliability with a second scorer on 20% of the sample was ICC = .984. A result below -1SD in this task, as well on the Days task (below) was used to identify children form the LowHw group.

Days task. This task aimed to measure handwriting fluency when writing highly known words. Students were asked to write the days of the week from memory, as fast and as many times as they could for one minute. The score was the number of legible letters written within the first 15 seconds. Spelling mistakes were not penalized. Reliability with a second scorer on 20% of the sample was .995. A result below -1SD in this task, as well on the Alphabet task (above) was used to identify children form the LowHw group.

Spelling. Children were administered a bespoke dictation task. Children were dictated 34 words, which were counterbalanced for frequency, length in syllables, and syllabic complexity. The administrator said each word out loud in isolation, then contextualized it with a sentence, and repeated it one last time, again in isolation. Words were presented in pseudo-randomized order and administered in two different sequences which were counterbalanced. All words in the task were scored for phonological plausibility. Words were counted as correct if the phonographic structure of the word was represented with a letter that has the intended phonological value, even if conventionally inaccurate. For example, for *hivern,* 'winter', the <h> is silent, and the <v> stands for phoneme /b/, which can be represented also by letter <b>. Therefore, *<ivern>, *<ibern>, or *<hibern>, although conventionally incorrect, were scored as phonologically plausible representations of the target word and afforded 1 point. The final score was the sum of all phonologically plausible representations. A trained RA scored a random 20% of the cases, and inter-rater reliability (ICC) was .989. Internal consistency of the task was also assessed; Cronbach's alpha = .919. Scores - 1SD in this task were used to identify children to form the LowSpell group.

IQ Raven Matrices (BAS II; Raven, 1999). Non-verbal intelligence was assessed with the Spanish adaptation of Raven's Progressive Matrices test. Reliability for this task is reported in the manual to have a Cronbach's α of .86.

Rapid Automatized Naming (RAN; Lervåg & Hulme, 2009). To assess rapid retrieval of well-known letters and produce a verbal output, children were asked to name a set of 5 letters out loud (a, s, d, p, o) from a stimulus sheet as fast as they could. The letters were displayed on an A4 sheet in 5 rows of 8 letters randomly distributed. There were two trials with a different ordering of the letters. The administrator noted the time that it took to complete each trial. The final score was the mean time in seconds between both trials. Reliability was the correlation between the trials, $r = .834$.

Word Span*.* This task assessed verbal short-term memory (after Caravolas et al. 2012). Students were asked to recall lists of short, high-frequency words. The length of the lists increased progressively, starting with two-word lists and up to eight-word lists. There were four lists per length. The test was discontinued when children failed to recall correctly three consecutive lists of the same length. Each correct list was scored with 0.25, so that a completely correct length scored 1 point. The total score was the sum correct (range: 0-8). Split-half reliability for this task was .739.

Digit Span (WISC-IV; Wechsler, 2004). To assess updating of working memory we administered the *Digits* subtest of the Spanish adaptation of the WISC-IV test battery (Wechsler, 2007). This test involves a baseline digit recall subtask in which children have to repeat lists of digits that increase in length, starting with 2 and of up to 8 digits. There are two lists (i.e., items) per list length. The test includes a second subtask, in which children need to repeat lists of numbers but in reverse order. Each correct item was scored with 1 point and the overall score was the sum of both subtasks. The manual reports a reliability of .74, but because the test is standardized to be administered in Spanish, not Catalan, we calculated reliability for our sample; Cronbach's α was .74.

Opposite Worlds (TEA-Ch; Manly et al., 2001). To assess verbal inhibition, children were shown a path made of blocks with the numbers “1” or “2”. In the baseline, “same world” trial, they were asked to say the numbers ‘1’ or ‘2’ printed on the path, as fast as they could. Two other trials ensued, in which children were asked to say the opposite of the number they saw (“opposite world” trials). The administrator wrote down the time (in seconds) to complete each trial. The final score was the mean time of the two “opposite world” trials. Test reliability was the correlation between the opposite-world trials, $r = .823$.

Morphosyntax. Because there are no standardized measures of morphological or syntactic development of Catalan, we adapted a sentence reading test (PROLEC-R, Grammatical Structure test; Cuetos, Rodríguez, Ruano & Arribas, 2007) and used it to estimate a receptive morphosyntax measure. The administrator read a sentence to the children and asked them to point to one of four pictures, choosing the one that best matches the sentence. A virtually identical procedure can be found in the TROG-II test (Bishop, 2003). The task was discontinued if the children failed five consecutive answers. There were 16 items in total and one point was given for each correct answer. The final score was the sum correct (range: 0-16). Cronbach's α was .83.

Vocabulary (WISC-IV; Wechsler, 2004). Because there are no standardized tests of Catalan vocabulary, we adapted the Vocabulary subtest of the WISC-IV Spanish test battery. A group of expert researchers in the field of language teaching in Catalan, as well as primary teachers were consulted to find words that were similar to the Spanish items in terms of frequency of use, register/tone, age of acquisition, and overall difficulty. The final instrument consisted of 26 items of increasing order. Children were asked to provide a definition for each word. For example, the administrator asked “What is a *clock*?” or “What does *emigrate* mean?”). The first 6 items were awarded 1 or 2 points depending on depth and specificity of the definition, whilst the next 20 items were awarded a maximum of 1 point. Answers defining the term in Spanish were accepted, given that we evaluated the knowledge of the Catalan term, yet only the translation of the word was not awarded any points. The final score was the sum of all points obtained across items. Six well-trained research assistants collected and scored

16% of the sample each, and a seventh research assistant scored the entire sample. The average *r* for each 16th percent of the sample was .958 (range .940 - .984). In addition, we estimated the internal consistency of the task; Cronbach's α = .887.

Word Reading. This subtest of the PROLEC-R reading test battery (Cuetos et al., 2007) was used to assess children's word reading ability. Students were asked to read aloud 40 words. One point was given for each correctly read word and the total score was the sum of all correct answers. The manual reports a Cronbach's α of .79.

ACL (Català, Català, Molina & Monclús, 2004; 2008). To assess reading comprehension, we adapted the standardized test *Avaluació de la Comprensió Lectora* (ACL, Català et al. 2004; 2008). The test requires children to read brief texts of various genres and then answer multiple-choice questions. There are different versions of the test according to the school year the children have last completed. Therefore, the 2nd and 4th grade children completed the Grade 1 and Grade 3 version (as per the test instructions), respectively, and we added the first two texts of the Grade 2 and Grade 4 instrument, respectively. This procedure was followed to ensure that the test would be able to capture children whose skill level is above grade level. The final instrument administered to 2nd graders included 9 texts with 31 questions, while the 4th graders answered 33 questions from 9 texts. Children had 45 minutes to complete the test. One point was awarded to each correct answer and the final score was the proportion of correct responses. The manual reports a reliability (KR-20) of 0.80 for the Grade 1 subtest and 0.72 for the Grade 3 subscale.

A1.2.3. Procedure

Children were assessed on all measures in individual sessions in quiet rooms, with the exception of the Raven, Spelling, ACL, and Written Expression tasks, which were administered to the entire class in their classroom. All tests instructions, items, and administration were in Catalan. Testing took place during the first trimester (October-December) of the school year, except for the Written Expression task which took place in the second trimester (February-March). The order of administration of the tests was counterbalanced to avoid conditioning between tests.

A1.3. Results

Descriptive statistics can be found in **Table A1.**0.2. Children were off-ceiling in all measures, but differences between groups were apparent. Data were generally normally distributed, with skewness values within -1.27 and 1.61, and kurtosis values ranging between -2.26 and 2.16. To address our goals, namely, which text-based measures and cognitive skills distinguish typical from at-risk writers, we ran a series of one-way ANCOVAs, controlling for the effect of age, on each text-based measure and cognitive skill. We included planned comparisons (Simple method), where the four at-risk groups (LowHw, LowSpell, LowTG, and MWD) were compared against our reference group of TD children. We used the Benjamini-Hochberg (BH) correction for false discovery rate (FDR), in which p-values are adjusted to the number of repeats and weighted by their order (Benjamini & Hochberg, 1995). This correction method reduces the probability of type I errors that may occur due to multiple comparisons. Unlike other known methods, the BH correction integrates the number of repeats and amount of significant results.

A1.3.1. Identification tests

We first tested whether groups were statistically significantly different from the reference group in the key aspects of writing that led to their classification into each of the at-risk groups. There was a significant main effect of Group in both measures of handwriting fluency, the alphabet task, *F*(4, 119) = 16.51, $p < .001$, $\eta_p^2 = .04$, and the days task, *F*(4,82) = 12.25, $p < .001$, $\eta_p^2 = .037$. Planned comparisons revealed that the LowHw group scored significantly below the reference group in both tasks (p <.001 in both the alphabet and days tasks). The MWD group obtained lower scores in both tasks ($p < .001$), while the LowTG group obtained significantly lower scores in the alphabet task ($p = .008$). For phonological spelling accuracy, there was a significant effect of Group, *F*(4, 125) = 67.04, $p < .001$, $\eta_p^2 = .68$. Planned comparisons reflected a significantly poorer performance of the LowSpell ($p < .001$) and MWD groups ($p < .001$). With regards to number of words, there was a significant Group effect in the narrative texts, *F*(4, 117) = 14.75, $p < .001$, $\eta_p^2 = .33$, and in the opinion essays, *F*(4, 116) = 11.10, $p < .001$, $\eta_p^2 = .28$). Planned comparisons revealed that the reference group wrote significantly more words than the LowTG group (*p*s < .001). In addition, the MWD group performed significantly below the reference group in both text types ($p < .001$ for both texts). Finally, the LowSpell group produced significantly less words than the reference group in the opinion essay ($p = .004$).

These results confirmed the selection criteria for all at-risk groups. In addition, some groups showed difficulty with traits for which they had not been identified, while the MWD group scored significantly poorer than the reference group across all traits.

Table A1.0.2

*Means and SDs of all identification tasks per group**

Writing measures	Groups				
	LowHw	LowSpell	LowTG	MWD	TD
Mean Age	96.20 (12.23)	100.00 (11.78)	107.29 (12.76)	95.90 (11.83)	102.40 (13.11)
Mean SES	52.00 (14.87)	52.42 (12.18)	58.48 (10.46)	59.63 (15.36)	59.21 (12.57)
Spelling Phon.	23.67 (5.09)	5.59 (5.94)	26.12 (3.95)	12.27 (12.22)	25.28 (5.53)
Hw ABC	2.93 (1.49)	7.03 (3.05)	6.88 (2.55)	3.45 (0.82)	8.06 (2.50)
Hw Days	5.67 (1.92)	12.83 (4.45)	13.73 (5.51)	5.56 (2.24)	15.18 (4.30)
Words OP	31.87 (22.54)	33.03 (19.09)	16.00 (7.98)	10.64 (6.68)	44.17 (31.31)
Words NA	86.60 (37.72)	104.25 (67.91)	42.94 (24.05)	38.70 (45.52)	101.43 (50.57)

Note. LowSpell= Low Spelling; LowHw = Low Handwriting; LowTG = Low Text Generation;

MWD = Multiple Writing Difficulties; TD= Typical development; Spelling Phon = spelling task with phonographic accuracy scoring Hw ABC = handwriting fluency Alphabet task; Hw Days = handwriting fluency Days task; OP = opinion essay; NA = narrative text.

*Standard deviation in parentheses

A1.3.2. Writing Profile of Each At-risk Group

Means and Standard Deviations for the text-based measures can be found in Table A1.0.3. Word-level writing features were assessed in terms of spelling accuracy and lexical diversity (Mass Ratio). Results showed a significant main effect of Group for the proportion of spelling errors, but only in the opinion essays, $F(4, 116) = 3.74$, $p = .007$, $\eta_p^2 = .114$. Planned comparisons showed significant results for the LowTG group ($p = .009$) and for the MWD group ($p = .007$) but not for the LowSpell group ($p > .05$). For lexical diversity, no significant main effect of Group was found in the narratives, $F(4,112) = 1.83$, $p = .128$, $\eta_p^2 = .06$, or in the opinion essays, $F(4,89) = 0.60$, $p = .660$, $\eta_p^2 = .03$.

Sentence-level writing features were assessed by the total number of clauses, the average number of words per clause, and the proportion of grammatical mistakes. For the number of clauses, there was a main effect of Group in the narrative texts, $F(4,115) = 10.74$, $p < .001$, $\eta_p^2 = .27$, as well as in the opinion essays, $F(4,116) = 7.77$, $p < .001$, $\eta_p^2 = .21$. Planned comparisons indicated that the LowTG group scored significantly below the reference group in both text types (*p*s <.001). The MWD group also produced significantly fewer clauses on average in the narrative texts ($p = .002$) and in the opinion essays ($p = .022$). A measure of words per clause showed no significant main effect of Group in the narrative texts, $F(4, 115) = 0.49$, $p = .740$, $\eta_p^2 = .17$. Words per clause in the opinion essays did show a main effect of Group, $F(4, 116) = 5.03$, $p = .001$, $\eta_p^2 = .15$. Planned comparisons revealed that the MWD group scored significantly below the reference group ($p < .001$). Finally, for grammatical accuracy, there was a significant effect of Group in the average proportion of grammatical errors in the narrative text, $F(4, 116) = 3.60$, $p = .008$, $\eta_p^2 = .110$. The reference group significantly outscored the LowHw ($p = .001$). This means that children with low handwriting fluency had difficulty with text generation at the sentence level.

Table A1.0.3
Mean and Standard Deviations of text-based measures by group.*

Writing measures	Groups				
	LowHw	LowSpell	LowTG	MWD	TD
No. Words NA	86.60 (37.92)	104.25 (67.91)	42.94 (24.05)	27.11 (28.64)	101.43 (50.57)
No. Words OP	31.87 (22.54)	33.03 (19.09)	16.00 (7.98)	9.30 (5.27)	44.17 (31.31)
Spelling errors NA	24.68% (12.44)	18.92% (11.17)	15.73% (8.72)	21.83% (10.79)	15.95% (12.58)
Spelling errors OP	37.52% (20.33)	28.20% (16.99)	35.56% (18.98)	45.72% (13.56)	27.01% (16.02)
Mass NA	0.05 (0.02)	0.05 (0.02)	0.04 (0.01)	0.05 (0.02)	0.05 (0.01)
Mass OP	0.05 (0.03)	0.04 (0.02)	0.04 (0.03)	0.07 (0.06)	0.05 (0.03)
No. Clausules NA	16.07 (8.62)	20.03 (13.43)	9.00 (4.90)	5.25 (4.65)	19.49 (9.22)
No. Clausules OP	8.27 (5.40)	8.42 (5.41)	4.41 (2.06)	5.10 (4.23)	10.62 (6.96)
Word per Clause NA	5.69 (0.93)	5.49 (1.30)	5.57 (2.42)	5.51 (1.84)	5.28 (0.90)
Word per Clause OP	3.76 (1.11)	4.14 (1.30)	3.60 (0.89)	2.34 (1.03)	4.10 (1.24)
Grammatical Errors NA	2.27 (1.75)	1.18 (1.17)	1.41 (1.46)	1.80 (1.48)	0.93 (1.14)
Grammatical Errors OP	0.87 (1.41)	0.57 (0.88)	0.69 (1.14)	1.11 (0.93)	0.61 (0.94)

Note. LowSpell= Low Spelling; LowHw = Low Handwriting; LowTG = Low Text Generation; MWD = Multiple Writing Difficulties; TD= Typical development; No.= number; OP= opinion essay; NA= narrative text
*Standard deviation in parentheses

A1.3.3. Underlying Cognitive-linguistic Profile

In order to compare groups on a number of key cognitive and linguistic skills, as well as in their reading skills, we ran another series of one-way ANCOVAs, controlling for age (**Table A1.**0.4). Children in all at-risk groups did not differ from the reference group on a measure of non-verbal intelligence (Raven test), $F(4,118) = 1.83$, $p = .128$, $\eta_p^2 = .06$). No significant Group effect was found either for verbal short-term memory (word-span task), $F(4,119) = 1.15$, $p = .335$, $\eta_p^2 = .04$). The core executive functions of inhibition (Opposite-worlds task) and updating of WM (Digit-span task) did not show a significant Group effect, $F(4,118) = 2.10$, $p = .085$, $\eta_p^2 = .07$, and $F(4,119) = 2.27$, $p = .065$, $\eta_p^2 = .07$, for inhibition and WM, respectively. Finally, there was no significant effect of Group in the RAN task, $F(4,118) = 2.08$, $p = .088$, $\eta_p^2 = .07$). These results indicate that at-risk children had similar levels in key cognitive skills in comparison with the reference group.

To obtain the linguistic profile of the at-risk children, we compared them with the reference group in terms of their morphosyntactic skills and vocabulary knowledge. Results showed that there was no significant effect of Group in morphosyntax, $F(4, 119) = 0.30$, $p = .878$, $\eta_p^2 = .01$, or in vocabulary, $F(4, 118) = 1.48$, $p = .214$, $\eta_p^2 = .05$.

We finally compared children's reading skills, in order to ascertain whether their writing difficulties were specific or literacy-general. There was a significant main effect of Group in word reading, $F(4, 112) = 3.15$, $p = .017$, $\eta_p^2 = .10$). Planned comparisons showed that the MWD group performed significantly below the reference group ($p = .006$). In contrast, we found that the main effect of Group was non-significant for reading comprehension, $F(4, 115) = 1.77$, $p = .139$, $\eta_p^2 = .06$).

Table A1.0.4

Mean and standard deviations of text-based measures by group.*

Cognitive measures	Groups				
	LowHw	LowSpell	LowTG	MWD	TD
Hw ABC	2.93	7.03	6.88	3.40	8.06
	(1.49)	(3.05)	(2.w54)	(0.84)	(2.50)
Hw Days	5.67	12.83	13.73	5.56	15.18
	(1.92)	(4.45)	(5.51)	(2.24)	(4.30)
Spelling	23.67	5.59	26.12	13.50	25.28
	(5.09)	(5.94)	(3.95)	(12.15)	(5.53)
Raven	27.27	34.33	32.94	29.70	35.00
	(9.71)	(10.86)	(10.61)	(11.93)	(10.41)
RAN	29.40	27.73	24.64	35.29	24.83
	(9.36)	(10.40)	(7.10)	(11.03)	(8.16)
Word Span	2.57	2.79	2.72	2.67	2.91
	(0.50)	(0.53)	(0.49)	(0.58)	(0.65)
Digit Span	11.53	11.77	12.82	10.50	12.69
	(1.96)	(2.04)	(2.38)	(1.90)	(2.14)
Opposite Worlds	48.87	45.62	46.18	56.40	44.20
	(12.10)	(11.74)	(12.66)	(9.65)	(11.62)
Morphosyntax	11.27	11.26	12.12	11.10	11.85
	(2.46)	(2.39)	(2.15)	(2.92)	(2.59)
Vocabulary	15.64	17.37	18.59	14.10	18.69
	(5.27)	(5.28)	(4.66)	(6.76)	(4.42)

Table A1.0.4

Mean and standard deviations of text-based measures by group.*

Cognitive measures	Groups				
	LowHw	LowSpell	LowTG	MWD	TD
Reading Comprehension	19.39 (8.49)	22.67 (5.55)	21.33 (6.43)	23.56 (4.93)	27.67 (2.08)
Single Word Reading	32.20 (5.12)	36.00 (4.43)	36.06 (9.15)	29.00 (8.20)	36.06 (5.50)

Note. LowSpell= Low Spelling; LowHw = Low Handwriting; LowTG = Low Text Generation; MWD = Multiple Writing Difficulties; TD= Typical development; OP= opinion essay; NA= narrative text; Hw ABC = handwriting fluency Alphabet task; Hw Days = handwriting fluency Days task.

*Standard Deviation in parentheses.

A1.4. Discussion

This study aimed to build a profile of the struggling writer, independently of whether there were comorbidities with other learning disorders. We started by following the composition of at-risk groups proposed by Coker et al. (2017) and found 71 children who showed consistent or severe struggles with handwriting (*n* = 15), spelling (*n* = 39), or text generation (*n* = 17). Moreover, in line with Dockrell et al. (2019) and Connelly, Dockrell and Barnett (2005), we were able to identify a group of children who presented difficulties with several aspects of writing (*n* = 11). Notably, only a few (3) of these children had been diagnosed or identified with a learning disability. A first outcome of this study is, thus, that there are children who struggle with writing despite not having been diagnosed. In our data, the prevalence of struggling writers was around 3%, but epidemiological studies are needed to add precision to our findings.

Nevertheless, this figure is comparable to other learning disabilities like dyslexia, whose prevalence has been reported to be around 5% (e.g., Lagae, 2008), ADHD with 4.3% of prevalence in populations under 15 years old (Coll & Pons, 2017) or ASD, whose prevalence in Catalonia is around 1.23% (Pérez-Crespo et al., 2019).

Our first goal was to examine the nature of the texts of the at-risk groups and to determine the extent to which they differed from their TD peers. For this reason, we compared them on a series of text-based measures. Children in the LowHw group had difficulties with the mechanics of letter-writing fluency. However, this defining trait did not limit most aspects of their writing performance: these children showed no marked difficulties with spelling, lexical diversity, syntactic complexity or, crucially, the amount of text generated (measured either in words or clauses). Nevertheless, they made more grammatical mistakes in the narratives, indicating that the extra effort of handwriting could be limiting their ability to keep track of grammatical agreement. The LowSpell group was unable to comply in an age-appropriate manner with the basic phonographic requirements of writing. Nonetheless, these children seemed to have found a way around this difficulty that prevented them from affecting other features of their texts. The exception was the amount of text produced in an opinion essay. This is well aligned with the abundant evidence of the constraining role of spelling in text generation (e.g., Abbott, Berninger, & Fayol, 2010; Juel et al. 1986). In addition, it has been suggested that children may develop an early awareness of their difficulties with spelling, which could also be motivating them to write less (Hayes, 2012). The LowTG group was identified because they produced substantially fewer words across two texts. Their difficulties were confirmed when measured in number of clauses, meaning that children in the LowTG group struggled to generate text at the word and sentence levels. They also scored significantly below their TD peers on handwriting fluency. This seems to indicate that, while not severely impaired on handwriting as the LowHw group, at least part of the difficulties to generate text of the LowTG group may stem from disfluent handwriting skills, again in accordance with a robust line of research pointing to the key role of handwriting in writing development (Limpo & Alves, 2013; Jones & Christensen, 1999; Salas & Silvente, 2019). To sum up, it appears that struggling even with one process of writing composition is likely to have repercussions on other processes. Over time, children with problems on a single aspect of written composition could suffer from a more pervasive problem with written expression. We would like to suggest that these children should receive tailored treatment for their writing difficulties, in order to guarantee that they will be able to cope with the ever-increasing demands of writing tasks.

Finally, the MWD group provided the profile of the struggling writer. Of the 11 children identified in this group, only 2 had been previously diagnosed with SLI, and 1 student was receiving a curricular adaptation. Their texts, as we expected originally, were shorter, contained a larger proportion of spelling mistakes, and less syntactic complexity. Notably, the affected writing features were strikingly similar to reports of the writing difficulties experienced by children with learning disabilities (e.g., Connelly et al., 2006; Dockrell et al., 2014; Re et al., 2010).

Our second goal was to investigate the cognitive profile of all groups of writers. A critical finding of this study is that all groups of children at-risk of writing difficulties showed a similar cognitive profile to the reference group, at least in terms of non-verbal intelligence, short-term and working memory, inhibition, and RAN. This means that children's struggles with writing cannot be explained on the basis of cognitive impairments.

Our third goal was to determine whether the writing difficulties we observed were due to poor language skills, and whether children's difficulties were writing-specific or if they affected literacy in general. Our data revealed that our struggling writers showed similar levels of vocabulary and of receptive morphosyntactic skills, as well as normal levels of reading comprehension. However, the MWD group had difficulties with word reading. Therefore, we claim that there is a profile of student who struggles with writing quite specifically, and in the absence of language issues, although issues with reading deserve further exploration.

To conclude, we found that around 3% of children attending early and middle elementary school may suffer from a developmental disorder that targets writing specifically, without the necessary existence of comorbid developmental disorders, abnormal IQ, or poor language skills. In line with previous findings by Dockrell et al. (2019) and Connelly, Dockrell, Walter & Critten (2012), these children produce short texts, make more spelling mistakes, and have disfluent handwriting. We found compelling evidence that, at the root of their writing profile, there are no affected cognitive processes; critically, executive functions, RAN, and short-term or working memory were unaffected across the board. These children arguably require a timely identification, so that an intervention program can be put in place early on. Future studies should strive to explore further its causes and its relationship with other learning disorders, as well as to determine effective remediation strategies.

A1.5. Limitations

A major obstacle in the development of the present study was the practical absence of standardized psycholinguistic tests in Catalan, which made the identification of the at-risk groups much harder. It would be interesting to compare our findings with future studies in languages that can resort to standardized test batteries.

This study was limited by the lack of resources to have an exhaustive screening of possible diagnoses. We cannot rule out underlying disorders that have not yet been detected by specialized practitioners. In addition, it was out of the scope of this study to be able to go into further detail into the causes of the discrepancies across studies. Finally, another limitation with this and several studies on writing, is that writing performance should be explored not only with writing products but also looking at the online writing processes. A study is underway of a subsample of the children in this paper that explores online writing processes in TD vs. at-risk children.

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Appendix 2. The Handspy Interface

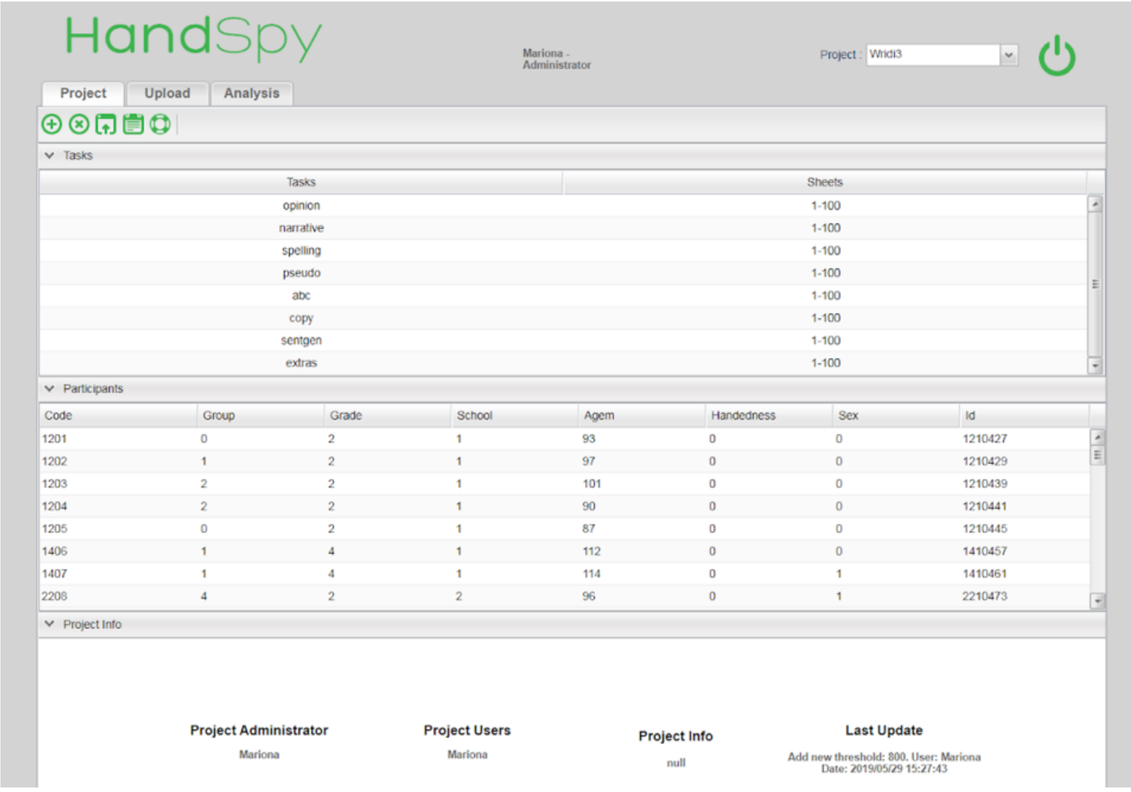
To be able to access the Handspy web (https://handspy.up.pt/) managers have to grant access to a user, so that they can create a new project where all the data is stored and analyzed, as well as users and passwords. Therefore, all the work done on the web is private and only the members of the project can access the data.

A2.1. Creating the project

Firstly, the researcher has to add methodological information in the 'Project' tab listing all tasks carried out, as well as defining participants. By listing the tasks carried out, the protocols are be sorted into categories (e.g., handwriting, spelling or a text) as can be seen in Figure A2.1. Moreover, the participants that were involved in the study need to be defined, uploading a participant list in .cvs format, with specific categorizations such as numeric code, age, gender, handedness, or condition (e.g., for intervention studies). These features allow visualizing the protocols either by tasks or applying specific filters such as genre, sex, handedness (e.g., the interface only shows the opinion texts of left-handed girls). This first step allows coding the different uploaded protocols, where each protocol is matched with the corresponding task and participant that undertook it.

Figure A2.1

The Project tab to manage the Tasks and Participants.



A2.2. Transferring data from SmartPen to HandSpy

In the 'Upload' tab the members of the project can import the protocols. Each protocol corresponds to the digitized pages used in the task. The app, using a *.neonotes* extension, stores the recorded data in notebooks that correspond to the different pages used, as can be seen in Figure A2.2. Therefore, to be able to read the protocols in the HandSpy web-based application, it entails a conversion to XML format.

Figure A2.2

Neonotes app screenshot with the different notebooks. Each notebook contains up to 100 pages with the recorded data from the pens

The XML format allows separating each page into one file or protocol, meaning that the data collected is now transformed from a readable file in the app to an encoded document in markup language, designed to be interpreted by computers and conserving not only the handwriting information but also strokes and pauses data, (see Figure A2.3). When the XML protocols are uploaded, each file is displayed as a readable thumbnail on the left side of the web. Once the files are uploaded, the researcher has to pair each file with the identification code and the task to which it belongs to be able to start coding the bursts.

Figure A2.3

Raw code from the XML format. This code afterwards is transformed into legible text and strings of numerical values for the burst and pauses in the HandSpy interface


```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?
<ns2:protocol xmlns:ns2="protocol">
  <header>
    <layout Layout="A" Page="47"/>
  </header>
  <strokes start="1526304190075" end="1526304191607">
    <stroke X="698" Y="488" Time="1526304190075"/>
    <stroke X="700" Y="488" Time="1526304190082"/>
    <stroke X="703" Y="488" Time="1526304190090"/>
    <stroke X="705" Y="488" Time="1526304190097"/>
    <stroke X="707" Y="488" Time="1526304190105"/>
    <stroke X="712" Y="487" Time="1526304190120"/>
    <stroke X="714" Y="485" Time="1526304190127"/>
    <stroke X="717" Y="481" Time="1526304190142"/>
    <stroke X="718" Y="479" Time="1526304190158"/>
    <stroke X="717" Y="480" Time="1526304190180"/>
    <stroke X="715" Y="480" Time="1526304190195"/>
    <stroke X="713" Y="481" Time="1526304190225"/>
    <stroke X="715" Y="481" Time="1526304190285"/>
    <stroke X="714" Y="481" Time="1526304190368"/>
    <stroke X="716" Y="478" Time="1526304190556"/>
    <stroke X="718" Y="477" Time="1526304190571"/>
    <stroke X="720" Y="477" Time="1526304190638"/>
    <stroke X="722" Y="474" Time="1526304190781"/>
    <stroke X="723" Y="472" Time="1526304190788"/>
    <stroke X="725" Y="472" Time="1526304190803"/>
```

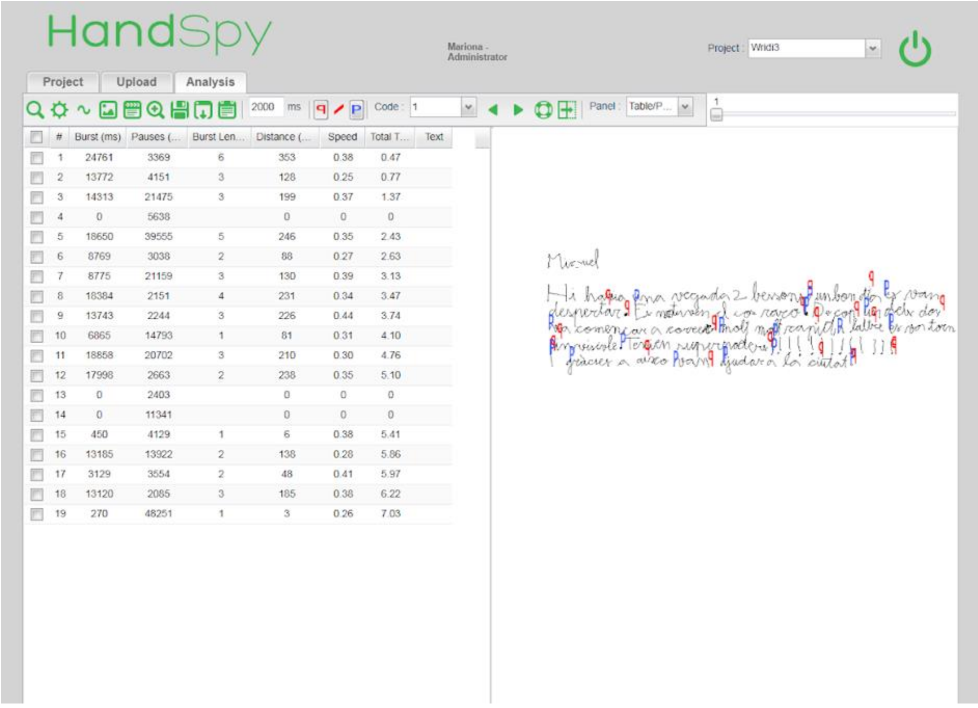
```
<stroke X="726" Y="471" Time="1526304190818"/>
<stroke X="728" Y="470" Time="1526304190848"/>
<stroke X="729" Y="470" Time="1526304190863"/>
<stroke X="729" Y="469" Time="1526304190901"/>
<stroke X="729" Y="469" Time="1526304190916"/>
<stroke X="730" Y="469" Time="1526304190923"/>
<stroke X="728" Y="469" Time="1526304190931"/>
<stroke X="728" Y="465" Time="1526304191051"/>
<stroke X="725" Y="462" Time="1526304191066"/>
<stroke X="724" Y="461" Time="1526304191074"/>
<stroke X="722" Y="460" Time="1526304191081"/>
<stroke X="722" Y="460" Time="1526304191104"/>
</strokes> </ns2:protocol>
```


A2.3. Analyzing the data

To start analyzing the protocols, the researcher has to select first which task are analyzed and afterward select the participant from a pop-up window. Only participants who had an associated protocol in this task is displayed. As can be seen in Figure A2.4, the main screen is divided into two: On the right side of the screen, one can find the protocol, which is shown with the bursts, indicated with a red P, and pauses, marked with blue Ps. On the left side, numbered rows are displayed of the different bursts and pauses that have been registered. Each row of the list contains the information for each registered burst. Columns show the # of bursts, burst and pause duration (in milliseconds), burst length (which has to be manually filled by the user indicating the number of words per burst),distance (in millimeters) and speed (in mm/s).

Figure A2.4

HandSpy's analysis tab where the different measures of bursts and pauses can be found enumerated on the left side, whilst in the right side there is the display of the text



	#	Burst (ms)	Pauses (...	Burst Len...	Distance (...	Speed	Total T...	Text
	1	24761	3369	6	353	0.38	0.47	
	2	13772	4151	3	128	0.25	0.77	
	3	14313	21475	3	199	0.37	1.37	
	4	0	5638		0	0	0	
	5	18650	39555	5	246	0.35	2.43	
	6	8769	3038	2	88	0.27	2.63	
	7	8775	21159	3	130	0.39	3.13	
	8	18384	2151	4	231	0.34	3.47	
	9	13743	2244	3	226	0.44	3.74	
	10	6865	14793	1	81	0.31	4.10	
	11	18858	20702	3	210	0.30	4.76	
	12	17998	2663	2	238	0.35	5.10	
	13	0	2403		0	0	0	
	14	0	11341		0	0	0	
	15	450	4129	1	6	0.38	5.41	
	16	13185	13922	2	138	0.28	5.86	
	17	3129	3554	2	48	0.41	5.97	
	18	13120	2085	3	185	0.38	6.22	
	19	270	48251	1	3	0.26	7.03	

A2.4. Data cleaning

Before analyzing the data and extracting results, each protocol has to be revised. Usually, the pen records from the first time that it touches the paper to the last stroke until it is closed. Nonetheless, not everything that it records is text and the investigator has to revise and define criteria to ensure that the final registry is text only. For example, the first row may often correspond to the participant's name and date of the task, and therefore has to be left out. Moreover, in the end, it is possible that the participant finished before his/her peers and left the pen connected, or he/she made a drawing whilst waiting for the task to end. The last entries must be revised to exclude everything that is not exclusively text.

Once the protocol has been cleaned, each burst has to be defined and analyzed to be able to determine its length and size correctly. The minimum unit for a burst is the word; therefore, burst size is the number of words between two pauses. When the writer makes a pause in the middle of a word, this word is absorbed by the burst where the largest part of the word is written, as it can only be counted once. Especially when novice or LD writers are involved, there are likely to be wordless bursts. These bursts are constituted by repeated pauses within a word, punctuation signs or crossed out words. In these cases, the period of time is counted as a pause. To be able to only record the pause time, all the values for burst, distance and speed are deleted, given that it does not count as text production.

To sum up, HandSpy (De Sousa & Leal, 2013; Monteiro & Leal, 2012; Monteiro & Leal, 2013) has been designed to manage and analyze the writing process as collected by Smartpens (Alves et al., 2019; Monteiro & Leal, 2012). It is an effective and reliable visual approach that eases the writing task for the participants and offers objective empirical evidence of writing processes within a natural writing environment (Alves et al., 2019; De Sousa & Leal, 2013; Monteiro & Leal, 2013). However, data analysis is a laborious task that starts before data collection: technical requirements need to be met scrupulously, as well the data entry process. The protocols must be strictly paired and afterward checked individually to clean the registries that distort the timings, as well as the subjective counting of words per burst.

Appendix 3. Pseudowords Task

Table A3.0.1

Pseudo-words and phonological plausible options

Pseudo-word	Phonological plausible options
Glorus	*Glorus, gloros*
Arpita	*Arpita, erpita, harpita, herpita*
Printega	*Printega, printegue*
Mepic	*Mepic, mapic*
Gueixo	*Gueixo, gueixu*
Bapa	*Bapa, vapa*
Ascrilla	*Ascrilla, escrilla*
Borc	*Borc, vorc, borg, vorg*
Escraó	*Escraó, ascraó*
Tilpé	*Tilper, tilpé*
Òccil	*Òccil, òxil*
Becurdol	*bacurdol, becurdol, bacordol, becordol, vecordol, vacordol, vecurdol, vecordol*
Espètel	*Espètel, aspètel*
Troc	*Troc, trog*
Trumfeja	*Tromfeja, trumfeja*

Table A3.0.1

Pseudo-words and phonological plausible options

Pseudo-word	Phonological plausible options
Mony	*Mony*
Siople	*Siople, siopla, sioble, siobla*
Antoll	*Antoll, entoll*
Ucleres	*Ucleres, ucleras, ocleres, ocleras*
Llegre	*Llegre, llegra*
Llambatge	*Llambadge, llembadge, llanvatge, llenvatge*
Pocle	*Pocle, pocla*
Gesen	*Gesent, gesen, jasen, jasent*
Trensia	*Trencia, trensia, trancia, transia*
Pricte	*Pricte, pricta*
Prentja	*Prenja, prentja, prentge*
Llon	*Llont, llon*
Oxperin	*Oxperin, uxperin*
Tarnó	*Tarnor, tarnó, ternor, ternó*
Triontal	*Triontal, triuntal*
Prejonta	*Prejonta, prejonte, prajonta, prajonte*

Table A3.0.1

Pseudo-words and phonological plausible options

Pseudo-word	Phonological plausible options
Bridot	*bridot*
Sàrcal	*Sàrcal, sàrquel*
Sufitut	*Sufitut, sofitut*
Talungé	*Talonger, talongé, talunger, talungé, telonger, telongé, telunger, telungé*
Carifa	*Carifa, carife*
Pen	*Pent, pen*
Crispall	*Crispall*
Asdut	*Asdut, esdut*
Acaniret	*Acaniret, ecaniret*
Munaló	*Munaló, monaló, munalor, monalor*
Dractan	*Dractant, dractan*
Ansatgesa	*Ansatgesa, encetgesa, ensetgesa*