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Sumner, E. J. (2013) *Children with dyslexia: Spelling as a constraint on writing development.* PhD Thesis. Oxford Brookes University.

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Children with Dyslexia: Spelling as a Constraint on Writing Development

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This thesis is submitted in partial fulfilment of the requirements of the award of Doctor of Philosophy

January, 2013.

Acknowledgements

First of all, I would like to thank my Director of Studies, Professor Vincent Connelly, and second supervisor, Dr. Anna Barnett. Thank you for the invaluable advice, for helping me to develop academically, and for the constant support and encouragement throughout the course of this project. I am so very grateful for the opportunity to work with you both.

The whole experience would not have been the same without my fellow PhD students in B1.01. Likewise, the support provided by my family and close friends has been incredible, thank you.

The schools and, in particular, the children that took part in this project were crucial to my research. I am forever grateful for their participation.

Finally, thanks go to the Waterloo Foundation and Oxford Brookes University for funding this project over the past three years.

Abstract

Background. Developmental dyslexia is characterised as a specific learning difficulty with written language: namely, reading and spelling. To date, little research has been conducted to examine the role of spelling when writing and, in particular, in the writing of young children with dyslexia. This is surprising when considering that spelling is an active process used when transcribing written text. Thus, this thesis aimed to investigate the impact of spelling ability in four areas: the quality of the written compositions produced, spelling error analyses, vocabulary choice when writing, and handwriting execution.

Method. Thirty-one children with dyslexia (15 boys, 16 girls; 9 years) were compared to two typically developing groups: the first matched by age and the second by spelling-ability. Participants completed tasks that assessed cognitive ability, spelling, reading, working memory, narrative writing, vocabulary level, motor skill, and handwriting performance. A digital writing tablet was used to record and identify the temporal characteristics of handwriting.

Results. Children with dyslexia scored significantly below their peers for written text quality, wrote less overall, and demonstrated a higher number of phonetically and orthographically inaccurate spelling errors. Limited vocabulary choices and a more disfluent handwriting profile were characteristics of the writing by children with dyslexia. These children with dyslexia did not have motor difficulties and demonstrated that handwriting execution speed was in fact similar to their peers. Rather, children with dyslexia paused more frequently before misspellings and within-words, a similar pattern to the younger spelling-ability matches. Spelling ability was found to predict a large proportion of variance in handwriting speed, written vocabulary choice, and the quality of the written text produced by children with dyslexia.

Conclusions. A new model of the interacting writing processes was proposed, emphasising the importance of acquiring strong foundations in proficient spelling for writing to progress. The proposed model relates to atypical and typical development. The findings are related to theories of dyslexia and avenues for future research are discussed in relation to expanding the new writing model.

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General Introduction

1.1 Writing

Writing is a complex activity involving the orchestration of many cognitive, linguistic, and motor processes. Models of writing (Berninger & Swanson, 1994; Hayes, 2012; Hayes & Flower, 1980) and research to support these models emphasise the need to proficiently develop the lower-level transcription skills (spelling and handwriting), in order to free working memory resources for the higher-level cognitive processes of planning the discourse structure, and reviewing the written text (Berninger, Cartwright, Yates, Swanson, & Abbott, 1994; Graham & Harris, 2000; McCutchen, 1996).

Models of writing illustrate the many processes that are engaged while composing a written text (Hayes, 2012). For beginning writers, the transcription skills have been found to constrain written text length and quality (Berninger et al., 1994). However as children progress through education, this constraint lessens and research examining the cognitive writing processes has demonstrated that more resources are then available to devote to consulting the task demands (Hayes, 2012; Olive, Favart, Beauvais, & Beauvais 2009).

Literacy is an umbrella term used to describe reading, spelling, and writing (Mehta, Foormann, Branum-Matin, & Taylor, 2005). These skills are a necessity for educational progress and achievement. The English school curriculum specifically targets and maps literacy development from the very beginning years of education, using the Early Years Foundation Stage profile (EYFS; Department for Education, 2012), through to the later Key Stages in primary and secondary school (DfE, 2011). As children progress through school there is a shift from assessments of reading and spelling ability to a focus on an individuals' level of written ability to express subject knowledge. Certainly at further education and university level, for many subjects, writing is the main mode of assessment either in the form of coursework or written examinations.

In a forever evolving literate society, reading and writing are frequently used as a communicative tool and to enhance learning. This begins with learning to read and then progressing to reading and writing to learn. Through learning to write we can consolidate knowledge while composing written text: applying a personal involvement and conceptualising comprehension. Reading and writing share common ground and draw heavily upon phonological and orthographic knowledge (Harris, 2010; Shanahan, 2006), but they do develop at different rates. Reading can act as a resource to writing by providing opportunities to acquire representations of genre structures and to develop vocabulary knowledge (Nagy, 2007; Shanahan, 1984). In particular, reading assists the development of phonological and orthographic awareness that will feed into spelling ability (Frith, 1985; Siegel, 2008). However, a detailed review has shown that the shared variance between the cognitive processes of reading and writing is between 25-50% (Fitzgerald & Shanahan, 2000). This highlights that while these two skills overlap in cognitive demand, there is a sufficient amount of independence too.

Spelling is a prerequisite to writing development and one of the initial skills to be taught when entering primary education, alongside the motor act of handwriting to transcribe spellings (DfE, 2011). Spelling in itself is a complex process that requires accurate phoneme to grapheme correspondence, consideration of orthographic and morphological conventions of the language, and acknowledgement of the semantic and syntactic properties of the specific word. We spell and put words on a page to translate our ideas into written language so that others can read them coherently. We use spelling to form words to publically express knowledge, opinions, and feelings. Indeed, spelling is often observed as “a facet that does influence perceptions about a child’s competence in writing” (Graham & Harris, 2006, p. 64).

To date, dyslexia research has had a dominant focus on the reading and spelling impairment that both children and adults with dyslexia are presented with. Investigating the nature of these difficulties and the development of these skills has helped to identify causal factors that relate to the behavioural outcome, but also to inform the typical route of reading and spelling development by highlighting the importance of phonology for these tasks. With these acknowledged problems with written language, it is not surprising that practitioners report writing difficulties in children with dyslexia from a young age (Mortimore, 2008; Reid, 2011; Rose, 2009). Furthermore, writing problems appear to be long-standing when considering that university students with dyslexia reported persistent difficulties with expressive writing throughout education (Mortimore & Crozier, 2006).

Research into writing development has become increasingly popular over the past 30 years, but remains a relatively new direction in comparison to the reading literature. Thus, research that examines the writing of a specific group like children with dyslexia is particularly scarce. For children with dyslexia who have a specific written language-learning weakness (Berninger, Abbott, Thomson, & Raskind, 2001), it is conceivable that poor literacy foundations (reading and spelling) will transfer to difficulties with acquiring written skills also.

Dyslexia research that isolates spelling fails to consider the impact this skill has at a wider level of producing text. Spelling is not only a word-level skill; it can influence, and is influenced by the act of composing written text (Apel, Masterson, & Niessen, 2004; Wengelin, 2007). Initial predictions can be made for the writing performance of children with dyslexia in terms of spelling acting as a constraint, a barrier to writing development, by consuming cognitive resources that should otherwise be devoted to the higher-level processes. Whereas, for typically developing writers that acquire spelling knowledge at ease, this skill supports the written compositional process by assisting the translation of text (Apel et al., 2004; Berninger & Swanson, 1994; Singer & Bashir, 2004).

The failure to connect the influence of spelling when writing means opportunities to gain insight into the psychology of dyslexia and writing, and thus to provide appropriate support are being missed. This thesis goes beyond the examination of the nature of the spelling errors children with dyslexia produce, to identify how the cognitive writing processes are influenced when one key factor (spelling) is poorly developed.

The initial step was to establish the relationship of spelling to the overall quality of the writing produced by children with dyslexia, and then to break this down by looking at its relationship to the 'lower-level' writing processes: vocabulary and handwriting. These processes were the focus of the investigation, as the importance of developing strong foundations to progress in writing proficiency has been shown by research in typical populations (Berninger & Swanson, 1994; Olive et al., 2009). As a word-level skill, it is important to examine the role of spelling in vocabulary choice when writing (another word-level process) and handwriting execution, which is typically associated with spelling under the heading of 'transcription' (Berninger & Swanson, 1994; Hayes, 2012). Predictions for these relationships are supported by the thorough review of the current literature in the subsequent chapters.

Thus, overall the research direction of this thesis was to examine whether the writing difficulties that children with dyslexia exhibit (Mortimore, 2008; Reid, 2011) are explained by their spelling difficulties. Similar to research in reading, by examining the psychology of writing using a dyslexic population, the empirical studies aimed to inform current models of typical writing development by providing an understanding of the specific function of spelling. The contribution to the understanding of both typical and atypical development is accentuated by the use of typically-progressing comparison groups (matched by age and spelling-ability) to pinpoint the level at which children with dyslexia are performing at. A dual-comparison indicates where children with dyslexia differ in the strategies used to respond to task demands, or are developmentally delayed in the presented tasks. These comparisons are central to the research approach to identify general or specific behavioural characteristics to dyslexia and the causal influences of such characteristics. The studies presented in this thesis not only investigated a new topic for dyslexia, but the rigorous methodology employed validates the arguments made. Overall conclusions proposed in this thesis contribute a novel understanding to the dyslexia and writing literature.

1.2 Dyslexia and writing: child samples

The reason for investigating the writing of children with dyslexia was two-fold. First of all, reading, spelling, and writing are all developmental skills; likewise, dyslexia is a developmental disorder. For children with dyslexia an “arrest” in development in the area of phonology, reading, and spelling can be observed (Frith, 1985), resulting in slower literacy progress. Yet, little is known about the written ability of this population. It is important to target this younger age group in order to understand and explain the act of writing from a developmental perspective. This way, constraints of writing development can be identified and compared to typical development to contribute to the understanding of how dyslexia might impact on the psychological development of writing and vice versa. Once the written ability of these children has been profiled this can lead towards suggestions for future research towards targeting appropriate support, with the long-term hope of preventing children with dyslexia leaving primary school disadvantaged in writing.

Literacy standards have been reported as falling in the later primary years of schooling (Paton, 2012[1]; Vasager, 2012[2]), raising concerns about meeting the more demanding assessments that follow in secondary school and further education. Thus, research targeted from a young age is required, especially since performance in writing at the end of Key Stage 2 has been found to be a strong predictor of written ability at the end of Key Stage 4 (Dockrell, Lindsay, & Connelly, 2009).

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[1] “Ofsted: English standards in primary schools ‘too low’” *The Telegraph*

[2] “Raise literacy target in primary schools, says Ofsted chief” *The Guardian*

The second reason for selecting a child sample for this thesis was because the majority of evidence that currently surrounds dyslexia and writing has been derived from university students with dyslexia. Research using adults with dyslexia has provided useful indicators regarding the writing characteristics of this group. Poorer quality ratings of the written compositions, a higher number of spelling errors, shorter texts, and fewer words written per minute are noted characteristics in comparison to university students without dyslexia (Connelly, Campbell, MacLean, & Barnes, 2006; Gregg, Coleman, Davis and Chalk, 2007; Sterling, Farmer, Riddick, Morgan, & Matthews, 1998), and for these students with dyslexia spelling ability was a unique predictor of written text length and quality (Gregg et al., 2007). Therefore, it would be interesting to determine whether these weaknesses are evident in the writing of a younger sample too.

By expanding the investigation to focus on a younger age group, cross-sectional comparisons can be made to determine the developmental nature of writing skills and whether constraints on written performance vary as a product of age and experience.

1.3 Structure of the thesis

The overarching aim of this thesis was to investigate writing through four research strands: (1) examination of the written compositions produced, to identify what exactly is poor about the writing of children with and without dyslexia; (2) the nature of the spelling errors produced; (3) vocabulary choices made when writing; and (4) the profile of handwriting execution using a digital writing tablet to record and analyse the fluency and speed of handwriting production when composing a written text. Within each of these strands the role of spelling was investigated.

The following three chapters constitute a review of the literature in order to establish the development of the research questions for the empirical studies in this thesis. The route of typical writing development is first illustrated to provide a framework for later predictions. Cognitive theories and behavioural characteristics of dyslexia from the reading and spelling literature highlight the nature of theses difficulties and possible causes that may also influence writing development. The final literature review chapter (4) gives a general overview of the focus of current research into dyslexia and writing, which had a formative influence on the research hypotheses. Research questions are further developed in the specific empirical chapters, along with a more detailed critique of the literature to link to methodological decisions.

Chapter 5 outlines the empirical nature of the thesis, detailing the methodological steps, such as school and participant selection. Details of the group selection criteria and the measures used are provided as a background profile to the following studies, for which the same pools of participants were used.

Chapters 6-9 address the four research strands. First of all, Chapter 6 presents the examination of the written compositions produced by the three groups. Chapter 7 provides a detailed analysis of the linguistic nature of the spelling errors produced in the written compositions and those from the standardised spelling task. These analyses were related to current theories of dyslexia and were used to further conceptualise the present sample.

Chapter 8 is presented next, as it leads on from the syllable analysis of misspellings to consider the level of vocabulary demonstrated in the writing of children with dyslexia and the comparison groups. The aim of this chapter was to investigate the assumption that children with dyslexia avoid writing words they cannot spell, thus testing the role of spelling in written vocabulary choice. This leads on to the final empirical chapter (9), examining the handwriting performance of children with dyslexia using a digital writing tablet. The first study presented in Chapter 9 addressed speed of handwriting execution, while the second delved further into the influence of spelling on the temporal characteristics of handwriting execution.

The findings from the empirical chapters are integrated in Chapter 10. Together the findings contributed to the proposal of a new model of the writing processes. The proposed model references to atypical and typical development and the interactions between the writing processes. Findings are also discussed in relation to theories of dyslexia.

1.4 Summary

Children with dyslexia have significant problems with reading and spelling, however their written ability has received less attention in research. Spelling is a direct skill used when composing written text and therefore it is conceivable that poor spelling will have repercussions for written ability. In order to contribute to our understanding of dyslexia and writing, the empirical work presented in this thesis was concerned with four key areas: the quality of text produced, spelling, vocabulary, and handwriting; with the intention of demonstrating how the latter three processes interact and contribute to the written product.

2

Models of Typical Writing Development

2.1 Introduction

Cognitive psychologists investigate underlying processes that contribute to an end product, and how they develop. Writing researchers have followed this path by identifying cognitive processes that are actively engaged while composing a written text. The first established model of writing by Hayes and Flower (1980) outlined the many processes that are used by skilled writers. However, the most influential model to discuss in the present chapter was the developmental model of typical writing (Berninger & Swanson, 1994), as it is useful to later compare to and accentuate if, and where, children with dyslexia reflect asynchronous development.

Acknowledging the writing processes provides a template for identification of where children may be underperforming. Educational frameworks for assessing writing show a progression from focusing on word (spelling and handwriting) and sentence-level skills in the initial years, through to the final stage of primary school where expectations are raised to the wider discourse level (English national curriculum, DfE 2011). As children progress they are expected to become more independent in their writing and to develop a level of metacognitive awareness when writing.

A criticism of only looking at the expectations from the school curriculum is that there are significant missing pieces of how the cognitive, motor and memory processes develop, and are used. As a result, when certain aspects of writing development deviate from what would be expected, the cause of the behavioural outcome is difficult to pinpoint. In this way, psychological models of writing can contribute to educational models of writing expectations.

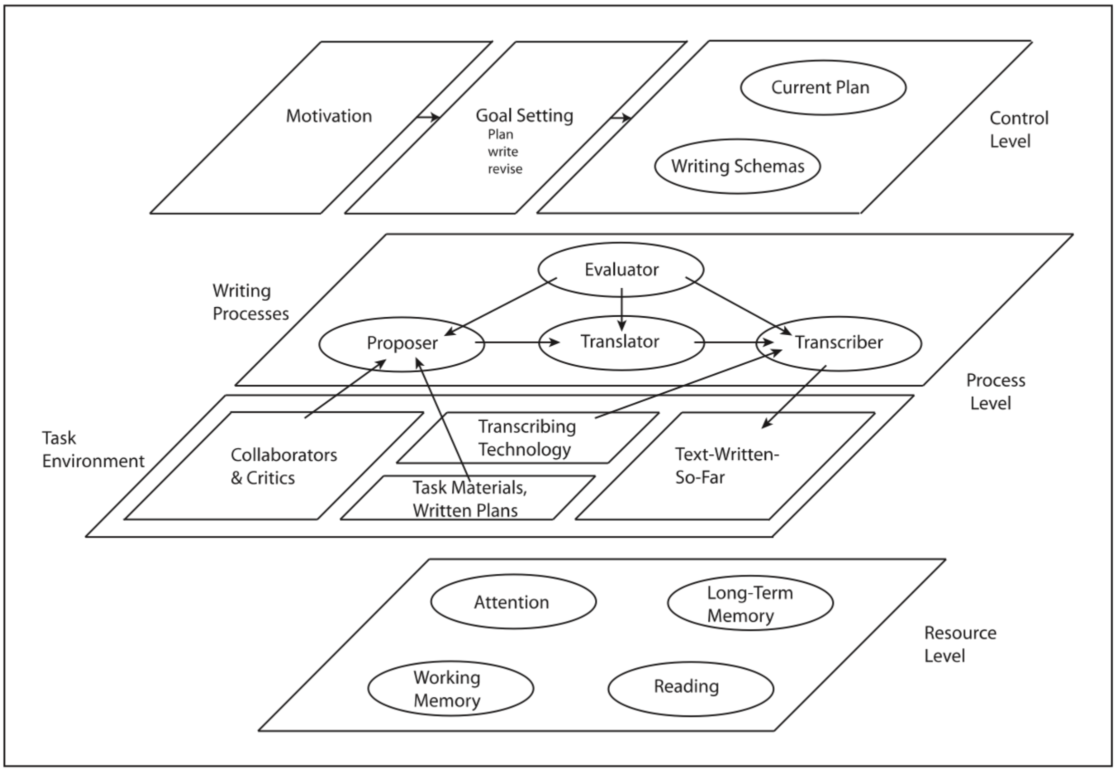
2.2 Models of writing

Models of skilled writing are addressed first in this section to emphasise the many cognitive processes that are expected to develop. The focus then shifts to a developmental perspective and findings from the literature that lends support to this model.

2.2.1 Hayes (2012) cognitive model of writing

The first model to define the cognitive processes engaged while composing written text was by Hayes and Flower (1980), devised from think-aloud protocols of adult writers. Writing was illustrated as a goal-directed process and three key components were identified: planning, translating, and reviewing. These processes are regularly addressed in the writing literature as the 'higher-level' processes, which are activated recursively to meet the task demands. However, the original model was criticised for failing to recognise the 'lower-level processes' of transcription: how these ideas are translated through the hand. Since then, a new model has been proposed by Hayes (2012) based on his previous account and subsequent research findings, shown in Figure 2.1.

Figure 2.1 Hayes (2012) an update of the Hayes & Flower (1980) model of the cognitive writing processes (modelling and remodelling writing, p. 371).



In both the early and more recent models, Hayes demonstrated that the writing assignment influences the ideas that are generated (proposer), which feeds into the translation component. Looking at the process level in Figure 2.1, ideas are translated and then transcribed all the while being analysed by the evaluator of the text (reviewing and editing mechanisms). The interactive thought processes behind the written product are emphasised and Hayes (2012) noted that these processes are self-regulated by the writer.

At the control level, new additions to the model are: motivation, pre-planning and later revision strategies. Motivation is shown to influence goal setting. This control level is perhaps more suited to skilled writers than developing writers who are still acquiring knowledge of writing strategies, how to plan a text, etc. For this reason, the focus of the work in the present thesis was directed more so to the 'lower-level skills' of transcription, which developing writers need to acquire first, perhaps before those more sophisticated strategies listed on the control level in Figure 2.1.

The resource level in Figure 2.1 lists attention, memory, and reading. Hayes & Flower (1980) initially included long-term memory as the source of retrieving topic knowledge and writing schemas. The role of working memory when composing written text is now incorporated and has been supported by numerous studies by Kellogg and colleagues (Kellogg, 1990, 1996, 2008; Kellogg, Olive & Piolat, 2007).

Working memory deals with the temporary storage and processing of information (Kellogg, 1994). Using working memory, information is retrieved from long-term memory and manipulated to meet the task demands (Baddeley, 1986). This is a multi-store memory model with a small capacity. It consists of a central executive that governs two 'slave' systems: the phonological loop and the visuo-spatial system (Baddeley & Hitch, 2000). The central executive is able to switch attention between the two slave systems, which code speech-based information and the visual characteristics of a stimulus. In relation to writing, an efficient working memory store is required to hold a representation of the generated ideas from long-term memory whilst executing the lower-level skills (transcription) of writing (Kellogg, 2008).

Using a triple-task method to investigate working memory when composing a written text, Kellogg (1987) reported that college students found the planning and reviewing processes more cognitively demanding, than the translating process. This conclusion was determined by asking students to respond to an auditory probe while writing and stating whether they were engaged in: planning, translating, or reviewing the text at the time. Longer reaction times were found when the students were planning and re-reading the text, indicating a higher cognitive load in these processes that took longer to switch attention from. The role of working memory in developing writers and how this component deals with the development and execution of these new skills is discussed later in relation to the Berninger & Swanson (1994) model.

Finally, of importance here, reading is included as a resource while writing (Hayes, 2012). Research has demonstrated how reading can help to develop knowledge of written genre structures and to acquire vocabulary knowledge, which can then be applied while writing (Cunningham & Stanovich, 2001; Nagy, 2007). Reading is also used as an online process while reviewing the text written (Breetvelt, van den Bergh, & Rijlaarsdam, 1996).

Overall, Figure 2.1 highlights the complex nature of the cognitive processes involved while writing, and those processes contributing to writing at a resource level. However, this model (2012) and its ancestor (1980) lack detail about how these processes develop and evolve. Little is known about how these processes are activated and how they interact. Therefore, difficulties are presented in relating these models to a sample of developing, less experienced writers.

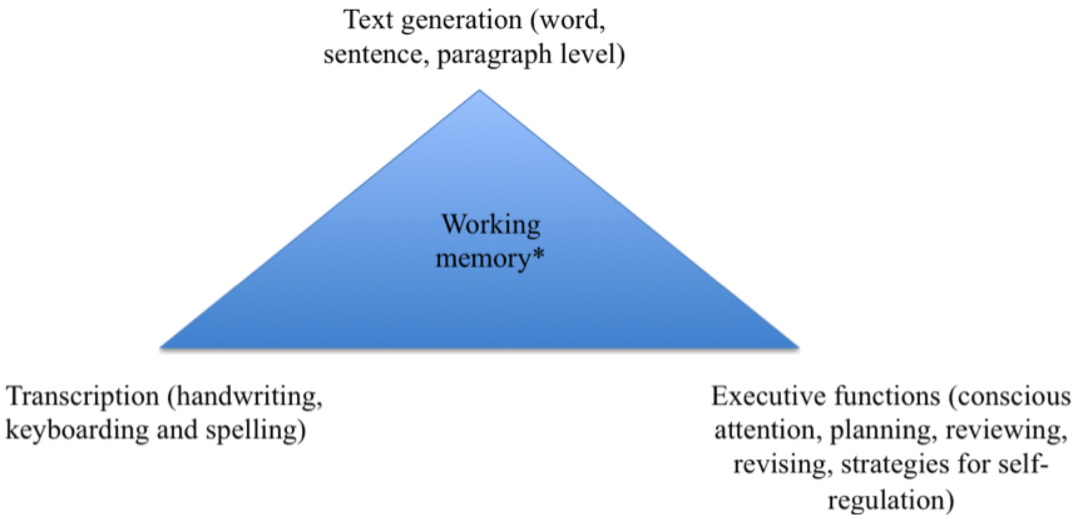
Another criticism of this model still remains with the transcription component. Hayes (2012) refers to this in terms of handwriting or the computer assisted technology used. No further information is given with regards to how these complex motor skills are learned and how they are influenced, namely by spelling knowledge. In particular, spelling is not included as a cognitive process engaged while writing.

In spite of the above criticisms, the Hayes & Flower (1980) and Hayes (2012) models' add a significant contribution to the cognitive writing literature that was absent beforehand. Their early work was extremely influential to the development of new writing models.

2.2.2 Berninger & Swanson (1994) developmental model of writing

The 'simple view' developmental model was compiled from research findings examining the writing produced by children in the USA across the primary, intermediate and junior years (ages 6-15). These findings were from studies conducted by Berninger and colleagues that tracked the developmental trajectory of skills/processes used when writing (Berninger, Yates, Cartwright et al., 1992; Berninger et al., 1994; Swanson & Berninger, 1994). A simple view of this model is shown in Figure 2.2.

Figure 2.2. A simple view of the Berninger & Swanson (1994) model (taken from Berninger & Amtmann, 2003).



*Note *Activates long-term memory during composing; short-term memory during reviewing*

Berninger & Swanson (1994) used the original Hayes & Flower (1980) model as a template to establish a developmental model. The first notable difference is that they modified the translation component by identifying two separate actions: transcription (handwriting and spelling) and text generation (the process of transforming ideas into language representations). Importantly, this model includes spelling as a component and recognises that text is processed at the word, sentence, and paragraph (discourse) level.

The higher-level processes are grouped together under the heading of executive functions and working memory is illustrated as supporting each of the three components on the triangle points. In agreement with Hayes & Flower (1980), the authors acknowledged that the activation of the lower- and higher-level processes is a recursive process. In particular, they note that the executive functions are self-regulated, meaning that planning and reviewing is an internal process activated by the writer when required. However, with the inclusion of the transcription and text generation components, they build upon the work of Hayes and Flower (1980) and highlight that writing is not only a cognitive process but also one that encompasses motor, linguistic, and working memory processes too.

Berninger & Swanson (1994) stress that the transcription processes are the first writing skills to be learned and thus the first to act as a constraint for beginning writers. Berninger et al. (1992) found that both motor skill, measured by performance on a finger succession task, and orthographic coding (remembering letter clusters in a word) predicted text length and quality ratings of written compositions produced by typically developing children aged 6-9 years. As children develop and have more opportunities to practise the transcription skills, the weight of a writing constraint shifts to language skills (text generation). Berninger et al (1994) demonstrated that for children aged 9-12 years vocabulary skill and the ability to generate new sentences from given stimuli were the strongest predictors of compositional quality.

The last component to discuss from Figure 2.2 that links to being a constraint for children in the next age group (aged 12-15, secondary school) is the executive functions. For this age group, the cognitive skills play a more important role than the motor act of writing, as the lower-level skills should be successfully learned and require little cognitive attention at this age. Rather, Swanson & Berninger (1994) demonstrated that planning and drafting (revising) strategies now influence compositional quality; with those students that produced more detailed revised drafts leading to an overall higher quality of written work. The authors' note that the higher-level processes of planning and reviewing only reach the stage of self-regulation once each developmental process has evolved separately and to its full potential.

Finally, working memory oversees the orchestration of the writing processes in Figure 2.2. In a systematic review of the working memory literature, McCutchen (1996) argued that the more efficient the writing processes are, the lower the cognitive load placed on working memory. The capacity theory of working memory posits that when the cognitive demand is too costly, sequential processing of information occurs rather than parallel processing, as working memory has a very small capacity (McCutchen, 1994). In relation to writing, when the cost of transcription is high for beginning writers the working memory resources are devoted to this lower-level skill. As these skills become automatic, an almost unconscious act, resources can be allocated to the higher-level processing demands and thus a stronger piece of written work should be produced by more experienced writers, reflecting evidence of planning and reviewing (Swanson & Berninger, 1994).

Correlational approaches demonstrate the link between working memory capacity and written performance in children; with lower memory spans relating to poorer text quality (Berninger & Swanson 1994; McCutchen, Covil, Hoyne, & Mildes, 1994). Similarly, the importance of working memory as a resource while composing written text has been demonstrated by Chenoweth & Hayes (2003) by using an articulatory suppression method, asking students to repeat a syllable (*ba*) while completing a sentence generation task. The authors discovered that inhibition of phonological processing increased the number of spelling errors made on the task and slowed down the rate of transcription. This can be related back to the capacity theory of working memory; when the cognitive cost is too demanding, the execution of text suffers. Furthermore, Chenoweth & Hayes (2003) pinpointed the role of verbal working memory in transcription, an issue that will be addressed later in relation to what might be expected from the writing of children with dyslexia who have poor phonological skills.

Interestingly, suppression of the visuo-spatial dimension of working memory by removing visual feedback while writing has not been found to reduce text quality in the handwritten (Olive & Piolat, 2002) or typed compositions produced by students (Oxborough & Torrance, 2012). An explanation for this could be that experienced writers create a mental representation of their text before starting to write and, in turn, can adequately rely on this representation when the visual feedback is removed. Yet, if this were the case it might be expected that verbal working memory is being overloaded and thus weaker translation would be evident, perhaps shown by weaker text quality or a high number of spelling errors. This was not true in these two studies; however, a different pattern could be expected for developing writers that have not reached this level of expertise.

In sum, the Berninger & Swanson (1994) model emphasised a developmental progression of acquiring the lower then the higher-level writing processes, and the need for the lower-level skills to be automatic to allow working memory resources to be devoted to the composing process. Research evidence is provided next to validate these conclusions.

2.2.2.1 Lower-level processes

When learning to spell children require awareness of phonology, orthography and morphology (Siegel, 2008). The English language has a deep orthography, which means that phoneme-grapheme correspondence is not always consistent. On top of spelling demands, beginning writers must learn the motor act of handwriting; that is, to control and coordinate the movements of the pen to produce graphemes associated with each spelling (Van Galen, 1991). The two transcription skills work closely together to translate ideas into written text.

In particular, the strain that handwriting can impose on working memory has been demonstrated by Bourdin & Fayol (1994). Children aged between 7-9 years recalled fewer items in a written recall condition, compared to a verbal recall condition. However, no differences between these conditions were found for adults, whose handwriting skill would be expected to be automatic. These findings were supported in German speaking children and adults, when Gabrowski (2005) replicated the Bourdin & Fayol (1994) study. However, a criticism of this work is that they ignore the influence of spelling; the fewer words written could be the result of children having difficulties with accessing spellings fluently. Thus, these studies should perhaps be referred to as demonstrating the role of transcription (handwriting and spelling) on working memory.

To expand on this, Bourdin & Fayol (1994) later asked adults to recall a list of words either orally, in lower case letters, or using upper case cursive letters. The latter condition was expected to impose an extra demand on working memory by requiring careful attention to execute unpractised grapheme patterns. Adults recalled significantly fewer items in this condition, leading to the conclusion that less practised handwriting imposes a higher cognitive cost that hinders written language production.

The predictive value of speed of handwriting in relation to the quality of written text produced and text length has been confirmed from a number of studies of typically developing children (Berninger et al., 1992; Berninger & Swanson, 1994; Graham, Berninger, Abbott, Abbott, & Whittaker, 1997). In these studies, Berninger has assessed ‘automaticity’ in handwriting by asking children to write the correct sequence of the alphabet as fast as possible in 15 seconds. It is believed that this alphabet task requires little cognitive cost, as it does not involve the formation of words or spellings but it does require orthographic-motor integration, which is perceived as a strong representative of transcription skills.

Similarly, in a study of beginning writers aged between 5-7 years, handwriting speed (this time measured using the alphabet task over a one minute timeframe) and general spelling ability was found to significantly correlate to scores given for written expression (Puranik & Alotaiba, 2011). Children with a faster handwriting speed (more letters produced in a minute) and greater spelling knowledge produced a higher quality of written text overall. Together these measures confirm the contribution of transcription skills to the end written product, which act either as an aid or constraint.

In typically developing research handwriting has been the focus of the transcription component, as these children are able to efficiently grasp spelling rules. Therefore, investigating children with dyslexia will inform models of writing development about the role and importance of spelling when producing written text also.

2.2.2.2 Higher-level processes

Scardamalia & Bereiter (1987) proposed that as children develop they move from a knowledge-telling stage, whereby ideas are reported in writing as they come to mind, to a knowledge-transforming level. In the former stage children will plan as they generate text, rather than beforehand (for research in support of this stage see Berninger, Fuller, & Whitaker, 1996; Graham, Harris, MacArthur, & Schwartz, 1991). In contrast, knowledge-transforming goes through the process of using goals to direct text generation and shape the relevant information. At this level, the most appropriate information will be presented in the final draft and thus texts should be well structured. The development of these higher-level processes can succeed once the transcription skills have reached an adequate level of fluency (Berninger & Swanson, 1994).

Berninger & Swanson (1994) argued that more experienced writers are able to engage in online planning and reviewing strategies before, during or after translation (text generation and transcription) and can process either the whole text or smaller sections. When children enter secondary school, these strategies develop more strongly as the transcription skills are firmly acquired and an increase in metacognition is found in terms of developing knowledge of text structure (Berninger & Swanson, 1994; Berninger et al, 1996). The benefits of implementing and self-regulating these higher-level processes are mirrored by a higher standard of written work (Berninger, 1999; DfE, 2011; Graham & Harris, 2000).

Typically achieving adults and children as young as 12 years old have been shown to rapidly re-read over their written text whilst continuing to write (Alamargot, Chesnet, Dansac & Ros, 2006; Alamargot, Plane, Lambert, & Chesnet, 2009). This was identified using an eye-tracker and digital writing tablet to capture performance. Furthermore, the strength of being able to review text while writing has been associated with an increase in the quality of the writing produced (Breetvelt et al., 1996). Overall, it would appear that when writers can manage the lower-level demands of writing in working memory they are able to focus attention on the monitoring of the quality of text produced and, as a result a stronger piece of written work is generated.

2.2.2.3.Evaluation of Berninger & Swanson (1994)

The few specified components in this model could still be developed further. How the lower-level skills initially develop and interact with one another has not been addressed. For example, a requirement of spelling development is to acquire knowledge of phonology, orthography, and morphology (Fitzgerald & Shanahan, 2000); and handwriting incorporates cognitive and motor processes that are not discussed by the authors.

The least developed component in the model is text generation, which ignores how vocabulary knowledge is drawn upon, and yet this skill has been shown to correlate with writing quality (Gregg et al., 2007; Nagy, 2007). Furthermore, the interactions between the sub-components are not discussed. It is conceivable that spelling will affect speed of handwriting production. Similarly, it is possible that spelling ability will influence the vocabulary choices made when writing and this relationship is bidirectional.

In terms of using this model as a template for comparisons to the writing of children with dyslexia, it was informative and illustrates the need for strong foundations (lower-level skills) to progress to more proficient writing. However, as children with dyslexia exhibit significant problems with accurate and fluent reading and spelling, these literacy skills and their contribution to writing development at a resource level need to be considered in more depth. The lack of information about how the writing processes might feed forward or back to other processes or components makes it difficult to draw conclusive predictions at this point.

2.2.3 Other influences: bridging the gap

Characteristics of language have evolved from speaking to writing (Hooper, 2002), yet the role of oral language development was not considered in the Berninger & Swanson (1994) writing model. Berninger has since argued (Berninger, 2000; Berninger, Abbott, Abbott, Graham et al., 2002; Berninger Abbott, Jones, Wolf et al., 2006) that language is driven through four pathways: language by ear (listening), by mouth (speaking), by eye (reading), and by hand (writing). Spoken language production, reading, and spelling development are considered, as they are most relevant to the direction of the present work.

2.2.3.1 Language production

Language is processed in the Broca and Wernicke regions in the left hemisphere (Vigneau et al., 2006). Vygotsky (1964) argued for the close relationship between the acquisition of language and the development of thought (cognition). Oral language production is the first mode of communication that typically developing children will acquire to express needs, using their mental lexicon to progress from single words to sentences (Treiman et al., 2003). Children need to acquire linguistic knowledge of phonology, semantics, syntax, and pragmatics in order to develop their language skills (Scott, 2011). Each of these aspects is relevant to written language too. Phonological awareness is crucial for reading and spelling development (Snowling, 2000) and general oral language ability has been shown to significantly correlate with how much a child chooses to write (Abbott & Berninger, 1993).

Oral language ability provides the basis for the development of written language skills (Scott, 2002), which are introduced at a later stage. For both children and adults written language production is more cognitively demanding than spoken language production (Bourdin & Fayol, 1994), as the role of transcription changes to mastering motor control of a pen.

Children with language learning difficulties have receptive and expressive oral language problems (Singer & Bashir, 2004) and those with specific language impairment (SLI) reflect these difficulties too, but in particular when generating ideas in writing (Dockrell, 2009) and applying appropriate written grammar (Windsor, Scott, & Street, 2000). Poor oral language skills act as a barrier to writing development. The need for strong foundations is emphasised, this time acknowledging language as well as transcription that was previously discussed. Thus, the processes that can be drawn upon while writing may be deeper rooted than proposed by the Berninger & Swanson (1994) model.

2.2.3.2. Reading

Language by eye (reading) requires recognition of single-words and comprehension of sentences and a whole text. Frith (1985) was one of the first psychologists to propose a model of reading development, highlighting three key progressive stages: logographic, alphabetic, and orthographic. These stages recognised the visual, phonological and orthographic cues that inform word decoding. Research has since demonstrated that there are four ways of identifying new words: by sight, by using decoding strategies, the process of analogy, and arriving at the word from the context of the sentence (Cain, 2010; Ehri, 1997).

Phonological awareness assists the decoding method by applying grapheme-phoneme correspondence (associations between letters and sounds) to build up the word and phonological skills have been consistently found to be a strong predictor of reading success (Goswami & Bryant, 1992; Nation & Hulme, 2011; Shaywitz et al., 2008). Similarly, analogy can be derived from phonology and orthography (word-specific knowledge) too (Ehri, 1997); for example, recognising that two words look similar, and making associations to their pronunciations. Orthographic awareness is the process of recognising acceptable letter strings in the English language, which can be visually recognised through reading (Goswami & Bryant, 1992). The dual-route cascade model of reading depicts the reading aloud processes as following the path of analysing the lexical orthographic properties when a word is irregular, or the non-lexical phonological analysis route for novel and non-words (Coltheart, Rastle, Perry, Langon, & Ziegler, 2001). Models of reading place a strong emphasis on the combined use of phonology and orthography in word recognition and these components are developed through reading and relate directly to the development of spelling knowledge.

Connections between reading and vocabulary development have also been made. A longitudinal study mapping performance of children when first starting school (4-5 years) over a two-year period highlighted that phonological skills and letter knowledge consistently predicted word reading, and furthermore word recognition skills and vocabulary level predicted comprehension (Muter, Hulme, Snowling, & Stevenson, 2004). Berninger et al (2002) proposed that in the language by eye (reading) system word recognition feeds into the syntactic processor and eventually to discourse comprehension at the text and situation level (Berninger et al., 2002). Thus, children who read more often develop large vocabularies (Nagy, 2007), which is often evident in their written texts too (Shanahan, 1984). Furthermore, more frequent exposure to print results in a greater awareness of written language conventions and topic knowledge (Cunningham & Stanovich, 1997; Cunningham & Stanovich, 2001; Fitzgerald & Shanahan, 2000); supporting the notion of reading to learn (DfE, 2011).

New language skills are acquired from reading, namely the addition of orthography to oral language skills and enhancing vocabulary and topic knowledge. In turn, these skills would be likely to influence writing development and proficiency. Reading ability is a strong resource and a process that a writer will activate while composing, as shown from eye-tracking studies previously discussed (Alamargot et al., 2006; Alamargot et al., 2009). Correlational analyses between reading ability and written performance would shed light on the influence of global literacy measures when composing a written text.

2.2.3.3 Spelling

Theories of spelling development are addressed in more detail in Chapter 7 when analysing the linguistic nature of the spelling errors made by children with dyslexia. However, the development of spelling knowledge and its direct relevance to writing is summarised here.

Frith (1985) identified how spelling develops alongside reading, highlighting spelling as driving the acquisition of phonological knowledge and assisting the reading process, whereas reading was thought to assist the acquisition of orthographic knowledge for spelling. This model emphasised the close connection between these two language systems. There is large support for a phonetic stage in children's early spellings (Treiman, 1994) and a continued influence of phonological awareness on spelling performance (Caravolas, Hulme, & Snowling, 2001). As children develop, with practise and exposure to print, they will gain knowledge of orthographic consistencies in English spellings (Steffler, 2001). Dual-route models have been proposed for the process of activating spellings. Tainturier & Rapp (2001) propose a functional architecture of the spelling system (pp. 264), which illustrates two pathways. When a child needs to spell a word that they recognise they will rely on the phonological analysis of the target word, which activates the phonological, semantic, and orthographic lexicon. Once these conventions have been established the graphemic buffer is activated to produce the conversion from sound to graphemes on the page. On the other hand, the second route accounts for how children spell unfamiliar words but manage to do so correctly. The system that is engaged in this process relies on the 'phonology-orthography conversion system'. Tainturier & Rapp (2001) argue that this conversion system requires sound knowledge of these two areas to be able to use orthographic conventions to accurate spell a word. Such as, knowledge that an initial /s/ sound would never be /ss/ even when the sound is extended. Parallels to the dual-route of reading can be seen here.

While spelling models have been insightful with regards to the language processes involved when spelling, they do not describe the route that these linguistic and cognitive processes take to be transcribed. This is where language by hand differs to the other language systems, as producing spelling requires the motor execution and coordination of handwriting. The embedded role of spelling in writing is more intricate than is shown in current models of writing development (Berninger & Swanson, 1994). Generation of ideas requires language representations at the word, sentence, and text level, which stimulate vocabulary and semantic knowledge. Vocabulary leads on to the activation of spelling (phonology, orthography, morphology) and in turn triggers the motor transcription processes at a letter, grapheme, or morpheme level to produce written text. However, when spellings are too difficult it is possible that these processes will undergo a course of reorganisation, and alternative word choices will be made. Therefore, further demands are being placed on the language system when generating text in writing.

Spelling ability has been previously reported as relating to written text length and quality (Abbott & Berninger, 1993; Berninger et al., 2002; Graham et al., 1997; Wagner et al., 2011). Yet, little is known about how general spelling ability, as measured using a standardised assessment, relates to these text characteristics. As shown above, spelling could influence the execution of the lower-level writing processes in many ways, whether through handwriting or vocabulary choice. The analysis of the role of spelling in the writing produced by children with dyslexia will help to pinpoint how influential spelling is to the cognitive writing processes.

2.2.3.4 Drawing parallels across the language systems

Oral language skills underpin reading and writing development (Bishop & Snowling, 2004). Phonological and orthographic skills predict spelling ability and speed of letter writing, orthographic-motor integration (Berninger, 2000). Berninger et al (2002) reported that the reading and writing language systems are connected at the word level. Significant correlations were identified between word recognition and spelling ability, which was proposed as reading facilitating orthographic awareness and letter knowledge, but handwriting and spelling were also found to predict word recognition skills. This finding suggests that there is a bidirectional relationship between the development of reading and spelling knowledge.

Similarly, reading and writing are likely to draw on similar cognitive resources, as they require activation of linguistic information. However, writing is a production method using cognitive, linguistic, and motor processes, and reading is a recognition task that does not require motor execution. Therefore, it is not surprising that when Fitzgerald & Shanahan (2000) reviewed the literature and Shanahan (2006) conducted experiments exploring the similarities across domains, shared variance between reading and writing never exceeded 50%. Writing has the potential of being influenced and constrained by reading and oral language ability (Cunningham & Stanovich, 2001; Dockrell, 2009). Yet, when writing a level of independence is required to initiate self-expression. Either way, the absence of reading from models of writing development and the lack of detail about the spelling component and the language processes that support it is a serious omission and one that ought to be considered when investigating the writing of children with dyslexia.

2.3 Overall summary

The need for the lower-level writing processes (including transcription and text generation at the word-level) to become fluent in order to free working memory resources to devote to the higher-level processes has been consistently demonstrated by studies of typically developing children (Graham et al., 1997; Graham & Harris, 2000). Current models of writing provide a useful template to compare the later findings to (Berninger & Swanson, 1994). However, it was noted that these could be further developed to consider the specific role of spelling when writing and the consequences of poorly developed skills in this area.

Scott (2011) proposes that difficulties in one language domain can act as a linguistic ‘gatekeeper’ and limit the development of similar language skills. Children with dyslexia have significant difficulties with reading and spelling (Snowling, 2000) and therefore it is reasonable to propose that they would deviate from typical writing development by demonstrating weaknesses in the transcription component. Further characteristics of dyslexia will be addressed in the next chapter before making explicit predictions about their written skills.

3

Dyslexia: Definitions, Theories, and Research to Date

3.1 Introduction

This chapter moves forward to provide a comprehensive review of the prevalent characteristics of developmental dyslexia. Accounts of the most prominent cognitive theories of dyslexia are highlighted, which will be drawn upon later when addressing the overall findings of this thesis.

3.2 Defining dyslexia

Dyslexia is a developmental disorder typically described as a specific learning difficultly with written language, at the word-level (Berninger, Nielsen, Abbott, Wijsman, & Raskind, 2008; Catts, 1996). Prevalence rates vary from between 6-10% and depend largely on how dyslexia is defined (Miles, 2004; Pennington, 2009). Furthermore, this condition has often been reported as more common in boys. However, researchers in this field have suggested that higher numbers of dyslexia in young boys may be the result of a referral bias favouring boys due to more disruptive behaviour in the classroom; and it has been noted that young girls are better able to mask literacy difficulties with their verbal ability (Shaywitz, Shaywitz, Fletcher & Escobar, 1990; Pennington, 2009).

In the UK, the issue of defining dyslexia has been the subject of debate by many researchers and practitioners (Brooks, 2007). This prompted a thorough review, commissioned by the UK government, to address how to identify and teach young people with dyslexia. The report described dyslexia as:

> “a learning difficulty that primarily affects the skills involved in accurate and fluent word reading and spelling. Characteristic features of dyslexia are difficulties in phonological awareness, verbal memory and verbal processing speed. Dyslexia occurs across the range of intellectual abilities. It is best thought of as a continuum, not a distinct category, and there are no clear cut-off points. Co-occurring difficulties may be seen in aspects of

> language, motor co-ordination, mental calculation, concentration and personal organisation, but these are not, by themselves, markers of dyslexia...” (Rose, 2009, p.30).

As can be seen in the above definition, writing is not directly referred to as an area of difficulty for children with dyslexia. However, the co-occurring difficulties that are listed include language and motor co-ordination: two key skills that are active while writing (Berninger et al., 2002).

Definitions of dyslexia within the research community differ slightly from the government proposal (Rose, 2009). Berninger and colleagues have been strong pioneers in the area of literacy development and atypical development, and provide the apt definition of dyslexia below:

> “Individuals with developmental dyslexia exhibit impairment in word-level processes in written language, that is, in oral reading and written spelling. However, their verbal comprehension or listening comprehension is spared. Once they learn to read words they can usually understand reading material. (See Berninger, 2001a.) More than three decades of research in English speaking countries has identified three marker measures that are not oral reading or written spelling per se but tend to be impaired in dyslexics and explain their problems with learning written words: phonological coding, orthographic coding, and rapid automatic naming...” (Berninger et al., 2008, p. 2).

Berninger et al (2008) places a strong emphasis on difficulties being apparent across both reading and spelling, thus conflicting with the new proposals for the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) which excludes spelling from the dyslexia definition (see Snowling & Hulme, 2012). In a later report, Berninger stated that: “Although many think that dyslexia is a reading disorder, dyslexia is a writing and reading disorder in which spelling is the persisting feature” (Berninger, 2009 pp. 10; supported by the US National Institutes of Child Health, 2002 and research by Bruck, 1992; Maughan, Messer, Collishaw et al., 2009). In contrast to Rose (2009), Berninger et al (2008) takes the view that dyslexia is a specific disorder of language by eye (reading) and by hand (writing) consolidating the link between these two language pathways, although noting that the language comprehension system is spared. Namely, the focus is on the markers from the language system (phonology, orthography, and rapid naming) that affect the behavioural word-level characteristics (poor reading and spelling performance) of dyslexia.

Berninger et al (2008) keeps the focus of the behavioural characteristics of dyslexia to the word-level problems as opposed to Rose (2009) who lists possible co-occurring difficulties. Understandably, co-occurring disorders would influence the severity of problems but by considering populations with overlapping difficulties, the sample becomes heterogeneous and is no longer a specific written language-learning disorder. Berninger et al (2008) argues firmly that developmental dyslexia should be treated as a specific disorder, rather than a general learning disorder (Berninger & May, 2011), to discern the causal pathway of written language difficulties. To strengthen all conclusions that are drawn in this thesis, the Berninger et al (2008) definition of dyslexia was adhered to when recruiting participants.

3.2.1 Diagnosis

Dyslexia is often diagnosed based on a discrepancy between reading performance and stronger cognitive ability, and when this reading weakness is not expected after consideration of age and educational opportunity too (Bell, McPhillips, & Doveston, 2011; Lyon, Shaywitz & Shaywitz 2003; Shaywitz, Morris & Shaywitz, 2008).

This route of diagnosis has faced criticism because it is seen as a ‘wait to fail’ model (Cain, 2010). In this sense, young children struggling with reading and/or spelling will not be picked up until the discrepancy is notable. Furthermore, the usefulness of cognitive tests to predict learning potential has been questioned because these tests may underestimate poor readers, as low IQ may in fact be a consequence of poor reading – the so-called ‘Matthew effect’ (Lyon, Fletcher, & Barnes, 2003; Stanovich, 1986). However, in research the discrepancy method has remained popular so as to not introduce a more heterogeneous group of children reflecting a wider spread of problems when cognitive ability is too low.

3.2.2 Comorbidity

Rose (2009) highlighted dyslexia as been linked to a number of different developmental disorders. The presence of an additional disorder will create more barriers to learning and at a more complex level. On the topic of writing, a review of the literature of dyslexia and co-occurring language and motor difficulties was prompted. These studies are elaborated on in the relevant empirical chapters that assess vocabulary (Chapter 8) and handwriting (Chapter 9).

There has been speculation of the overlap between dyslexia and problems with oral language (Catts, 1996; Hulme & Snowling, 2009). Research has shown that children with initial speech and language difficulties later develop literacy problems (Bishop & Adams, 1990; Catts, Adlof, Hogan, & Weismer, 2005). However, a number of thorough reviews (Bishop & Snowling, 2004; Catts et al., 2005; Pennington & Bishop, 2009) clearly assert that children with dyslexia are distinct from those with wider language problems, such as specific language impairment (SLI). These reviews of the two disorders illustrate that dyslexia and SLI have overlapping behavioural characteristics reflecting word-reading problems that stem from a phonological processing deficit. However, additional language generation problems and difficulties with using grammar are reported in children with oral language problems (Larkin & Snowling, 2008). Thus, if children with dyslexia are found to have wider language difficulties their behavioural characteristics (reading, spelling and writing) will be more complex to address as they may be showing symptoms of SLI, which would require a different method of support. These issues were considered later in the initial recruitment stage of participants and when testing vocabulary performance on standardised measures.

Similarly, movement difficulties have also been recognised in some children with dyslexia (Iversen, Berg, Ellertsen, & Tonnessen, 2005) and co-morbidity with developmental co-ordination disorder (DCD) has been reported (Chaix, Albaret, Brassard, Cheuret, Castelnau et al, 2007; Kaplan, Wilson, Dewey, & Crawford, 1998). Although not directly related to reading, the issue of motor difficulties would have a direct path to writing and, more specifically, to the transcription component. Problems with motor control would more than likely affect the execution and co-ordination of handwriting. This issue needs to be unpicked because if children with dyslexia produce shorter written texts or they take longer to complete a writing task, it may be that poor motor coordination is impacting on performance and not solely their reading and spelling difficulties. However, a review by Ramus et al (2003) postulates that motor difficulties account for only 30% of this particular population. Notably, studies have shown that children with dyslexia that do exhibit motor problems have also been found to score highly on scales testing for attention-deficit-hyperactivity-disorder (ADHD), which raises questions about further comorbidity issues and what might affect performance (Chaix et al., 2007; Wimmer, Mayringer, & Raberger, 1999). These points are considered in the methodological design of this thesis.

3.3 Explanations for dyslexia

Difficulties with reading, poor spelling, and possible co-occurring problems in other areas, reflect a number of observable behaviours of dyslexia. To fully understand the nature of certain behaviours it is important to identify the cause. The explanations, or the origin, for these difficulties and possible writing difficulties could have shared influences or stem from different pathways. Figure 3.1 illustrates the levels of causation identified from developmental disorders.

Figure 3.1. Levels of causation for developmental disorders. Taken from Bishop & Snowling (2004). *Dyslexia and SLI: Same or different?*

Etiology, neurobiology, and the cognitive processes are shown to feed into the behavioural output. Dyslexia is reported to have a genetic influence (Berninger et al., 2008), with longitudinal studies identifying children whose parents have dyslexia are more at-risk at developing dyslexia themselves, than those whose parents do not (Pennington & Lefly, 2001; Snowling, Gallagher & Frith, 2003). However, the difficulty with trying to establish etiology from family studies is to tease apart the role of the environment (Bishop & Snowling, 2004). Lack of environmental input and exposure to print could be a factor that hinders reading development in these children (Cunningham & Stanovich, 1997; Senechal et al., 1998). The dotted arrow in Figure 3.1 indicates that behaviour can also influence the environment we live in, which will feed back to cognition.

The role of neurobiology in dyslexia has also been demonstrated by brain imaging studies that depict less activation in the left hemisphere of children with dyslexia when completing reading exercises, in comparison to typically developing children (Shaywitz, Lyon & Shaywitz, 2006; Temple, Poldrack, Salidis et al., 2001). However, the focus of this thesis was the cognitive writing processes and thus the cognitive explanations for dyslexia follow in more detail.

3.3.1 Cognitive theories

Various theories have been put forward in an attempt to explain the cognitive mechanisms underlying dyslexia, although unanimity is not reached (see Papadopoulos, Georgiou &

Douklias, 2009). The magnocelluar theory (see Stein, 2001) has received the least attention in the literature and has provided inconclusive results. For this reason and the fact that visual processing is beyond the scope and direction of this thesis, this theory is not elaborated on further. Instead, the focus remains on those that have the most consistent support and can be discussed in relation to writing.

3.3.3.1 Phonological deficit theory

The most popular direction of the literature supports the specific problems children experience in phonological processing (Ramus et al., 2003; Snowling, 2000; Vellutino, Fletcher, Snowling, Scanlon, 2004). When reading, recognisable phonemes from the target word are identified and then combined to form whole words (Coltheart et al., 2001). Phonological awareness plays an important role in recognising and analysing these sounds and has been found to be a strong indicator of both reading and spelling attainment (Lyon et al., 2003; Mehta et al., 2005; Stanovich & Siegel, 1994).

In a study of children prior to reading instruction, phonological awareness and naming speed were found to be strong predictors of reading capabilities in the following school years (Kirby, Parrila, & Pfeiffer, 2003), as well as letter knowledge transferring to reading ability too (Troia, 2004). Several established tasks can been used to assess phonological awareness, such as asking a child to detect rhyme patterns and alliteration. Other more advanced tasks can focus on an individuals' ability to manipulate phonemes, through phoneme deletion, phoneme blending, or phoneme reversals (saying the sounds of a word backward). For children and adults with dyslexia these tasks impose a high cognitive demand. An abundance of research has shown that children and adults with dyslexia display impaired phonological awareness when compared to typically developing peers, when assessed using the segmentation tasks or spoonerisms (Bruck & Treiman, 1990; Hatcher, Snowling, & Griffiths, 2002; Lyon et al., 2003; Marshall, Snowling, & Bailey, 2001; Sperling, Lu, & Manis, 2004). These poor phonological skills are mirrored by poor literacy development, and in particular poor reading and spelling ability (Snowling, 2009). Furthermore, slow lexical retrieval and poor verbal short-term memory may be consequences of impaired phonological awareness (Wiseheart, Altmann & Lombardino, 2009).

As well as problems with reading accuracy, fluency is a difficulty for children with dyslexia (Rose, 2009; Snowling, 2000; Snowling & Hulme, 2012). If children have impaired phonological skills it might be expected that the phonological loop in working memory would also be affected; this has been confirmed in research (Hansen & Bowey, 1994; Snowling, Nation, Moxham, Gallagher, & Frith, 1997). Associations between fluency and memory processes could be made, as phonological information needs to be encoded and retrieved quickly and easily. In the Hansen & Bowey (1994) study, children with dyslexia also struggled with phonological analysis (identifying the words that did not rhyme from a list). More specifically, these skills were found to account for a unique contribution of variance in the reading ability of this group, even after the effects of verbal working memory were controlled for. Together these findings lend support to the phonological deficit theory and demonstrate that the influence of phonology on reading ability is still strong even after memory performance is accounted for (Hansen & Bowey, 1994).

In addition, the strengths of the phonological deficit theory are echoed by its formative influence on reading interventions (Shaywitz et al. 2004; Temple et al, 2003, 2004). When children with reading difficulties were presented with ‘phonics’ based interventions, the intervention group improved significantly in reading accuracy compared to a control group (Nicolson et al. 1999). Instruction in phonics differs to the notion of phonological awareness, as phonics training focuses on consolidating the letter-sound relationship in written words (Stahl, 2002). In contrast, phonological awareness relates to the auditory skill of hearing and reflecting on phones (or onsets and rimes) in spoken language; as discussed above, through tasks requiring blending, segmenting, or deleting recognised sounds. The successful findings from phonics training (Nicolson et al., 1999) are important because of the persistent nature of dyslexia. We know that adults with dyslexia continue to struggle with reading and spelling (Mortimore & Crozier, 2006) and, therefore, introducing suitable interventions at an early age may help to support these individuals appropriately; in this instance, ensuring that letter-sound correspondence is proficient. Furthermore, phonological deficits have been identified in dyslexia across many languages (Papadopoulos et al., 2009) adding to the breadth of this theory.

The finding of additional problems of children with dyslexia in orthographic coding, as well as in phonology (Berninger et al., 2002; Bernstein, 2009; Siegel, 2008), might have been expected when considering that in typical paths of reading development phonology is the base that supports orthographic and morphological development (Ehri, 1997; Perfetti, 1997). Poor phonological skills inhibit the development of orthographic knowledge (Fayol, Zorman, & Lete, 2009). Thus, children with dyslexia find it difficult to make associations and store representations of word-specific spelling conventions (Bruck, 1992; Olson, Wise, Johnson, & Ring, 1997). Orthographic awareness is actively used when spelling words and in children with dyslexia has accounted for a significant proportion of variance in both reading and spelling ability (Siegel, 2008).

The phonological deficit theory recognises dyslexia as a core cognitive deficit, with a main focus on the reading and spelling outcome. As phonology, orthography, and morphology are interrelated skills that develop through reading and spelling practise it could be hypothesised that multiple deficits in each of these language processing areas could be expected from children with dyslexia. In relation to written ability, these language systems are key resources as in reading. Thus, it may be expected that poor phonological foundations, which have an impact on spelling, would in turn influence the transcription component of writing and the efficiency of the writing processes.

3.3.3.2 Speech and auditory processing deficits

More recent work has been targeted at investigating the underlying mechanisms of phonological awareness and their role in reading development, and particularly dyslexia. The frequency of peaks and troughs in the speech system can help to discriminate between phonemes (Thomson, 2009). The English language has been described as a stress-timed language and stressed points within words, often at the syllable level, can give an indication to segmental information (Wood, Wade-Woolley, & Holliman, 2009). Sensitivity to metrical stress has been associated with phonological awareness and also shown to predict reading and spelling ability, even after controlling for age and vocabulary (Wood, 2006; Holliman, Wood, & Sheehy, 2010). The control of vocabulary in these studies is a particular strength, as children with larger vocabularies tend to perform better on phonological awareness tasks, perhaps because of word frequency effects (Metsala, 1999).

Thomson (2009) argues for an auditory processing deficit in dyslexia. Identification of syllables in words depends on sensitivity to longer modulations in the rate of speech. Lorenzi, Dumont & Fullgrabe (2000) examined the ability of children with and without dyslexia to discriminate between modulations of varying depth and length. They were found to have a higher detection threshold showing less sensitivity to modular changes. This lack of sensitivity is conceivable to influence reading attainment. Poor auditory discrimination skills were also found in children with dyslexia with adequate vocabulary and cognitive ability and the amplitude envelope discrimination skills of this group were found to explain significant variance in phonological processing skills (Richardson, Thomson, Scott, & Goswami, 2004). However, it is possible that sensitivity studies that use a verbal cue can still activate a certain level of phonemic processing.

Instead, Mody, Studdert-Kennedy, & Brady (1997) used tones as a stimuli that were void of verbal cues and asked skilled and poor readers to identify transitions between frequencies. In fact, no differences between these two groups were shown on discrimination performance, arguing against perceptual difficulties. Whereas, in contrast, when Goswami, Thomson et al (2002) used non speech stimuli (a beat rise-time detection task) to test the auditory processing deficit theory of children with dyslexia the results supported those by Loenzi et al (2000), illustrating that children with dyslexia are less sensitive to rise time than age-controls. Furthermore, the level of auditory processing was found to significantly predict both reading and spelling after controlling for IQ and vocabulary.

Goswami et al (2002) proposed that the phonological deficit in dyslexia is prominent at the onset-rime level. This paper suggested that children with dyslexia have underlying language acquisition difficulties that influence the detection of phonological patterns and speech-sound processing. It seems that wider difficulties in phonology are shown when trying to detect syllable boundaries. A new direction in the psycholinguistic literature of the temporal aspects of handwriting production has shown that the spellings of French (a syllabic language) words are driven by syllable boundaries (Kandel, Peereman, Grosjacques, & Fayol, 2011). That is, children tend to mark pauses in production at syllable boundaries before continuing to write the final constituent of the word. This direction of work has not yet followed suit into dyslexia spelling research but would provide useful findings to this theory.

However, a review of dyslexia theories demonstrated that auditory processing difficulties account for only 40% of cases (Ramus et al., 2003). Troia (2004) argues that the majority of children that have difficulties with speech perception consist of children with SLI (Corriveau, Pasquini, & Goswami, 2007). It is possible that this 40% have co-occurring language or attention difficulties that are influencing performance, or that certain verbal tasks will be tapping phonology which children with dyslexia already present a weakness in. More recent studies by Wood and Goswami have shown strong associations between speech sensitivity and reading attainment; however, using an ability-level design could strengthen whether children with dyslexia represent a deficit or delay in development.

3.3.3.3 Double-deficit theory

Wolf & Bowers (1999) proposed the double-deficit theory of dyslexia, incorporating phonological processing and speed of rapid automatised naming (RAN): both of which were listed as markers of dyslexia by Berninger et al (2002). RAN tests an individual’s ability to process and retrieve information from memory, by naming the presented stimuli as quickly as possible, which could be letters, objects, or digits. Performance in RAN tasks has been accurate in differentiating between good and poor readers (Cutting & Denckla, 2001). Poor performance on these tasks has been found in both children and adults with dyslexia (Araújo, Inácio, Faísca, Petersson, Reis, 2011; Berninger et al., 2001). Furthermore, ability on RAN tasks was found to predict reading level even after controlling for phonological awareness (Kirby et al, 2003; Manis, Doi, & Bhadha, 2000), suggesting that these two factors are independent predictors.

Wolf & Bowers (1999; Wolf, Bowers & Biddle, 2000) suggest that one group of children with dyslexia might express a weakness in phonological awareness, another might show a difficulty in RAN, and a final group might have these deficits combined. The latter would have an additive effect and mark the more severe cases of dyslexia (Lovett, Steinbach & Frijters, 2000). However, concern surrounds this theory because the cause of such a deficit is unclear and the issue of depending on arbitrary cut off points to define deficits in these domains. This concern is supported when phonological awareness and RAN scores are found to correlate and, therefore, it is difficult to conclude whether children in the double-deficit group perform worse overall because of the two present deficits or because of the severity of these problems (Schatschneider, Carlson, Francis, Foorman & Fletcher, 2002). Nevertheless, this theory can be considered in terms of speed of processing and accessing language representations.

3.3.3.4 Cerebellar theory

The cerebellar deficit theory is often referred to as the automatisation hypothesis (Nicolson & Fawcett, 1990; Nicholson & Fawcett, 1994). The cerebellum is typically associated with motor control; however, evidence has been provided for its role in processing speech too (Booth, Wood, Lu, Houk, & Bitan, 2007). This theory suggests that difficulties with literacy and becoming automatic (fluent) in these skills are a product of abnormal functioning in the cerebellum. Spelling and handwriting are expected to become automatic as shown in models of literacy development, with slower handwriting shown to impact on written text quality (Berninger et al., 2008; Graham et al., 1997). Nicolson & Fawcett (1994) believe that lack of automaticity leads to problems with balance and motor control for children with dyslexia, and that a phonological deficit is a consequence of a more widespread motor processing problem. Therefore, connections could be made between the cerebellar deficit and writing if poor motor control is found for children with dyslexia.

Nicolson, Fawcett and Dean (2001) argued that weak performance on RAN tasks could be accounted for by the cerebellar deficit. They believe that the lack of automaticity in processing and retrieving phonological codes could be responsible for the insufficient, rapid processing of stimuli. This is partly supported by the findings of Araújo et al (2011) who demonstrated that for children with dyslexia inter-item pause rates of retrieving the names of the stimuli in RAN tasks was in fact the reason for fewer items recalled, rather than longer motor-articulation time. However, tests of other additional co-occurring difficulties, such as language, were not tested for in this study.

Furthermore, the findings from Nicolson and Fawcett (1990; 1994) that suggest children with dyslexia have poor motor control can be criticised because of the large age range of the participants and the small sample size. Their findings have not been replicated when narrowing the age range and considering additional co-occurring difficulties, such as attention (Wimmer et al., 1999). There is little support for the idea that the cerebellar deficit is a cause of phonological and reading problems. However, research in this area has highlighted how the presence of other disorders can influence the validity of the results significantly. It is possible that the cerebellar/automatisation deficit may account for the more severe cases of dyslexia alongside the phonological deficit theory, when additional difficulties are present.

3.3.3.5 Working memory deficit

The final theory to be discussed is the working memory deficit hypothesis. In support of this theory, McLoughlin, Leather and Stringer (2002) wrote:

> "Developmental dyslexia is a genetically inherited and neurologically determined inefficiency in working memory, the information-processing system fundamental to learning and performance in conventional educational and work settings. It has a particular impact on verbal and written communication..." (p.19).

The relevance of working memory (WM) to models of writing has been discussed in Chapter 2. In relation to reading, the phonological loop processes the verbal information from the text while the visuo-spatial sketchpad accesses the visual and spatial information. WM is thought to process the text and store overall representations about the theme of the text while reading (Carpenter & Just, 1989). In this sense the efficiency of the reading processes in WM is crucial for decoding and text comprehension (Daneman & Carpenter, 1983).

WM spans have been found to be below average in children with dyslexia across the ages of 6 -11 years (Gathercole, Alloway, Willis, & Adams, 2006) and, as in typically developing research (McCutchen et al., 1994), WM capacity was found to significantly relate to reading ability and to written ability for adults with dyslexia (Connelly et al., 2006; Reiter, Tucha & Lange, 2005). Correlations between verbal WM and vocabulary in typically developing adults and children have been demonstrated (Baddeley, Gathercole & Papagno, 1998), as the phonological loop plays an important role in assisting the learning of new words. Therefore, if children with dyslexia have impaired phonological skills it is likely that verbal WM and vocabulary learning would be hindered too. On the other hand, it may be that impaired phonological skills are a result of an inefficient phonological loop within working memory. This would inhibit the rehearsal of the phonological codes that is required when reading and producing spellings. However, it is difficult to separate the phonological loop from the central executive, which monitors the two slave systems. It could be that the central executive is poorly developed and this is affecting the control of the phonological loop (de Jong, 2006; de Kleine & Verway, 2009), yet this still remains unclear.

While research is progressing in this area, more is needed to clarify the strength of a working memory deficit in dyslexia. In relation to writing, the findings from the Chenoweth and Hayes (2003) study provide a good example of what might be expected if children with dyslexia do have a working memory deficit. In their 2003 study they discovered that when the phonological loop is hindered, poorer written texts are composed. Weaker working memory spans would limit the amount of resources to be drawn from and with the cognitive load of phonology when spelling it would be likely that the writing processes and in turn the written product would suffer.

3.3.2 Theoretical perspectives of dyslexia: are they integrated?

A review of the cognitive theories has emphasised that there is no agreed cause of dyslexia. Berninger et al (2008) lends strong support to the phonological deficit theory and recognises that problems with phonology can spread to weaker orthographic awareness and slower processing of verbal information. However, as Rose (2009) highlighted additional co-occurring difficulties can be present in children with dyslexia, it is not surprising that many theories have been generated to try and explain other areas of weaknesses that this population have shown in research. It is possible that those children that have a range of symptoms outside of the core difficulty with phonology will overlap in more than one cognitive deficit, which is what the double-deficit hypothesis proposed for the more acute cases. Therefore, could it be that these theories are integrated to some extent?

The main theme from this review is that there are two directions to explain dyslexia. On the one hand, there is the phonological deficit that is the main cause of poor reading and spelling. In contrast, the remaining theories postulate that phonology is part of a more widespread symptomalogy: whether that lies with impairments in processing, language perception, or skill automatisation. The auditory processing hypothesis could be largely influenced by additional language difficulties, the double-deficit hypothesis may be influenced by attention problems, and the cerebellar theory could explain those individuals with dyslexia that have co-occurring motor difficulties. While they provide a comprehensive account for the additional difficulties often seen in this population they are not considering the root cognitive cause, yet all of these theories accept a phonological impairment as the dominant characteristic.

3.4 The current focus of the literature

Research has largely been devoted to how children and adults with dyslexia deviate from the typical pathway of reading development. A brief overview of this area is covered first and then focus is directed to the spelling impairment.

3.4.1 Children with dyslexia: a "developmental arrest"

Frith (1985) suggested that children with dyslexia experience a "developmental arrest" in the logographic stage of reading due to insufficient phonological skills that hinder the development of orthographic knowledge (Ziegler et al., 2008). A failure to acquire these principles is evident by poor reading of new words and nonwords (Ramus et al., 2003; Snowling et al., 1997; Stanovich & Siegel, 1994). Although a relatively old theory now, the idea of an arrest in development (Frith, 1985), or a delay, holds true for children with dyslexia (Berninger et al., 2008; Rose, 2009).

Reading fluency is another issue for children and adults with dyslexia (Elbro, Nielsen, & Petersen, 1994; Hatcher et al., 2002; Ziegler & Goswami, 2005). General difficulties with speeded naming of visual stimuli have been found in children with dyslexia (RAN tasks; Wolf & Bowers, 1999) and reflect a strong correlation to reading ability. Thus, retrieval as well as identification of phonological codes is a problem area for these children.

Poor reading or lack of exposure to print can have a detrimental effect on vocabulary development (Nagy, 2007), and therefore it might be expected that children with dyslexia would have smaller vocabularies in comparison to their peers. Fortunately, their difficulties with reading do not extend to problems with reading comprehension (Elbro et al., 1994; Nation & Snowling, 1998) or syntactic knowledge (Shankweiler et al., 1995). In fact, Nation & Snowling (1998) demonstrated that children with dyslexia are able to use discourse to their advantage, using context to aid decoding skills. Therefore, it could be that children with dyslexia can use their knowledge of written language to their advantage when composing written text also. As comprehension is not impaired for these children it might be predicted that they would not have problems with idea retrieval or generation when writing. On the other hand, the capacity theory in relation to the writing processes, suggests that the cognitive demand of poor spelling could constrain the resources needed for text generation.

3.4.2 Dyslexia and spelling

University students with dyslexia report spelling as the more persistent problem in comparison to reading (Mortimore & Crozier, 2006) and, in support of this, longitudinal studies of dyslexia demonstrate the weight of a spelling impairment through to adulthood (Bruck, 1993). Difficulties with phonology are evident in the analysis of spelling errors made by university students with dyslexia (Coleman, Gregg, McLain & Bellair, 2009; Sterling et al., 1998). However, a growing literature now points to spelling problems in orthography as well as phonology for both children and adults with dyslexia (Berninger et al., 2008; de Jong & Messbauer, 2011; Gayan & Olson, 2001; Snowling, 2009).

University students with dyslexia were found to make a large proportion of errors when attempting to spell derived orthographically simple words (e.g. deceit-deceitful), which the authors attribute to difficulties with memorising specific conventions (Kemp, Parilla & Kirby, 2009). Similarly, a large sample of children with dyslexia (mean age of 10 years) was found to make a high number of orthographically inappropriate errors in a constrained spelling test (Bernstein, 2009). Yet, difficulties with phonology were still apparent when asked to spell nonwords. In relation to Tainturier & Rapp's (2001) dual route theory of spelling, it could be hypothesised that due to initial difficulties with phonology and orthography the conversion system that children with dyslexia rely on is poorly developed. Thus, when trying to spell unfamiliar words, lack of orthographic knowledge is apparent in their errors.

Finally, considering morphology and spelling. Adolescents with dyslexia have been found to score significantly below their peers and also a reading-matched group in a task assessing morphological awareness when spelling base and derived words (Tsesmeli & Seymour, 2006). With a sample of only 10 participants with dyslexia these results are difficult to generalise, but morphological knowledge has been shown to be the last spelling component to develop for typically achieving children (Nunes, Bindman, & Bryant, 1997). This suggests that problems with phonology extend to other aspects of spelling knowledge.

3.5 Overall summary

To conclude, children and adults with dyslexia reflect significant word-level difficulties when dealing with print, which cannot be explained by low cognitive ability. The proposed cognitive theories of dyslexia emphasise that difficulties with reading and spelling may be the outcome of a number of different pathways. The most popular consensus is that poor reading and spelling are strongly influenced by a phonological deficit. Problems with developing adequate orthographic and morphological awareness have been shown from the reading and spelling literature too. Possible additional co-occurring difficulties were noted by Rose (2009) and may partly explain the numerous theories that have been hypothesised for this one condition, some stronger than others. Linking the message from the review of the language systems to the reading and spelling impairment, it is conceivable that weak language foundations will hinder writing development.

4

Dyslexia and Writing

4.1 Introduction

Although not included in the definition of dyslexia, practitioners have recognised that children with dyslexia present weaknesses in expressive writing too (Reid, 2011; Rose, 2009). The aim of this chapter was to expand the literature review to specific research on dyslexia and writing. Since work in this area on children is limited, the review includes studies on university students with dyslexia.[3]

The literature in this area has highlighted four key areas: the quality of the end product, spelling error analyses, vocabulary, and handwriting. An overview of this research is provided, which generated the general research questions for the empirical strands of this thesis (reported at the end of this chapter). The methodological approaches of the reviewed studies are critiqued in greater detail in the relevant empirical chapters.

4.2 Dyslexia: written compositions

To assess the written ability of young children, researchers can use a narrative writing task because this genre is similar to what they will be writing in the classroom (DfE, 2011). In contrast, older students might be asked to complete a more demanding task, such as an expository or persuasive text. The different genre demands should be considered when evaluating findings across studies. Furthermore, scoring writing in different genres may list different criteria as important.

In general, writing tends to be analysed for the overall quality of the composition and the number of words written. The latter is often found to correlate strongly with the first (Connelly et al., 2006; Graham & Harris, 2006; Singer & Bashir, 2004), with a longer text reflecting a better quality of writing. However, this correlation may be a result of the experimental nature of the task. The reason for a longer task equating to a better quality of

[3] This review of dyslexia and expressive writing formed part of a book chapter, Sumner, Connelly & Barnett (in press; see Appendix A)

text is unclear, as surely the content should determine quality ratings. Imposing a time constraint in experimental writing tasks has repercussions for ecological validity. If participants were free to spend as long as they chose on their written compositions, they might edit their text to make it more concise, a more refined composition, and thus this opportunity to work on the content would hopefully produce a better quality of text overall. Therefore, the findings from constrained writing tasks should be considered in the way that, are the findings a result of experimental design or behaviour that what be observed from the classroom? Either way, studies of writing do detect characteristics that contribute to our understanding of the cognitive processes involved while composing a written text.

In particular, studying the writing of individuals with dyslexia can be particularly fruitful for understanding the psychology of writing by pinpointing the role of spelling. The majority of studies in this area have focused on university students. Sterling, Farmer, Riddick et al (1998) asked university students with dyslexia and typically achieving age-matched peers to complete a writing task about their life as a student. All participants were given prompts about what they could include in their compositions and time to plan their answer. Students with dyslexia wrote significantly fewer words and made a high percentage of spelling errors in comparison to their peers. Although this study did not rate the overall quality of the compositions, they did consider mean sentence length and their ability to mark sentence boundaries using punctuation: for which they found no group differences. Sterling et al (1998) considered these measures to be an assessment of whether students were able to organise their thoughts into well-formed sentences. However, as no exact measure of the organisation and coherence of the text, or the linking of the sentences to form a discourse, were taken the usefulness of such a measure is questionable. The finding of no group difference may have been confounded by the nature of the writing task, which for university students was a very simple task that did not require the use of more complex genre schemas (Scott, 2005).

University students with dyslexia writing less while making significantly more spelling errors than other individuals of the same age is a consistent finding across studies (Connelly et al., 2006; Coleman, Gregg, McLain & Bellair, 2009; Gregg et al., 2007). In addition, Connelly et al (2006) found that a holistic measure of writing quality from an expository writing task revealed that university students with dyslexia scored significantly below a chronologically age-matched group; although their performance was similar to a group matched on spelling ability. In an attempt to further distinguish the differences in writing between these two groups a more detailed analytical scoring was applied and found that students with dyslexia had weaker scores for vocabulary and capitalization/punctuation. Connelly et al (2006) discovered that these students do not differ in the written characteristics thought to reflect the higher-level processes: ideas and development, organisation, sentence structure, and grammar. This would suggest that the lower-level skills (spelling and vocabulary) adversely influence the overall holistic scoring of the compositions.

In support of this, Gregg et al (2007) demonstrated that as well as producing a high number of spelling errors, the holistic scoring of the expository compositions produced by students with dyslexia were significantly lower than their peers. Furthermore, students with dyslexia wrote significantly fewer words with longer syllables and were limited to one-syllable words, suggesting that vocabulary usage was weaker in their compositions. It is reasonable to predict that spelling capabilities may influence written word choices for students with dyslexia. Regression analyses revealed that lexical complexity (the number of words above two syllables), spelling ability, and the total number of words significantly predicted their overall holistic score. This finding confirms that university students with dyslexia have a specific language based difficulty when writing, a word-level difficulty that impacted on the quality of the compositions produced. In relation to models of writing, working memory resources may be constrained by these lower level skills, thus hindering the regulation of the higher level processes required to ensure the composition is of a good quality. In contrast, only the number of words measure was found to contribute significantly for students without dyslexia. Comparisons to a spelling-matched group would have contributed more to our understanding of whether students with dyslexia demonstrate a delay in development or use different writing strategies.

The problem with using alternative scoring systems can be highlighted from the findings of Connelly et al (2006) and Gregg et al (2007). The holistic scoring in these studies addressed different characteristics, although they were in agreement that students with dyslexia produced a lower quality of writing in comparison to their peers. Yet, when a more focussed analytical scoring method was used by Connelly et al (2006) no differences between these two groups were found on some of the measures (organisation and sentence structure) that were noted as being assessed by the holistic scoring adopted by Gregg et al (2007). Conflicting findings in this area demonstrate that the holistic method may be influenced by spelling and/or word choice more generally, and fails to pinpoint written strengths/weaknesses that are picked up in an analytical scoring procedure.

Nevertheless, differences in writing were highlighted between university students with dyslexia and their peers. Findings of many spelling errors and fewer words written and, moreover, studies reporting that students with dyslexia fail to complete the task within the given time (Gregg et al, 2007; Hatcher et al., 2002) suggest that the process of completing the writing task is particularly effortful for these students. This assumption is supported by the findings from a questionnaire survey, whereby students with dyslexia reported persistent difficulties with expressing ideas in writing and organising written answers, throughout education (Mortimore & Crozier, 2006).

When searching for studies investigating the quality of written work produced by children with dyslexia only two were found. The first was an exploratory study in which children with dyslexia were compared to a language-impaired group and typically achieving controls (Puranik, Lombardino, & Altmann, 2006). All participants were required to listen to the examiner read a text and then they were asked to write about this text from memory. Children with dyslexia did not differ from the age-controls on the number of words written and the number of ideas produced, in fact for these measures both groups outperformed the language-impaired group. However, at the sentence level children with dyslexia produced fewer complex sentences, made more grammatical errors, and exhibited a higher number of spelling errors than the control group. This would suggest that a word level problem extends to the sentence level. Although these findings are intriguing, scoring of the syntactic errors of the sentences may have included counting errors in inflexional morphology. Inflexional morphology is a specific spelling weakness for individuals with dyslexia (Joanisse, Manis, Keating, & Seidenberg, 2000). Therefore, the report of syntactic problems from the Puranik et al. (2006) study may be confounded by spelling difficulties. A criticism of this study is that they did not score for the quality of the ideas produced and how they were presented, and the overall findings are difficult to generalise because the dyslexic group spanned across the ages 11-21 years and consisted of only 13 participants.

On a much larger scale, Berninger et al (2008) worked with 122 children that met the inclusion criteria for dyslexia. These children were tested on a battery of measures, most of which related to the processes involved when writing and will be addressed in section 4.3. Of most importance here is that on a standardised measure of written expression, from sentence generation and short compositional tasks, the overall mean score of children with dyslexia was more than one standard deviation below the age mean from the norms of the test. Unfortunately, this paper does not provide the topics for the writing task, it does not address further characteristics of the compositions produced (i.e. text length, spelling errors), and a direct comparison group was not used. However, the authors did report that spelling (measured using a separate standardised test) was found to be a unique predictor of written expression in this sample. As also suggested from the Gregg et al (2007) study, this finding links spelling as a constraint on writing for young children with dyslexia. An opposite pattern was found for typically achieving children whereby handwriting is the strongest predictor of written performance for this age group, although a comparison across tasks is not possible and the prompts were not made available (Graham et al., 1997).

In summary, the written compositions of university students with dyslexia were notably different to their peers. Spelling errors are a distinct characteristic in their writing and it was demonstrated that the lower-level processes influence the written product for this population. It would be naive to believe that university students with dyslexia did not have difficulties with writing until later in life. Thus, further research focussing on children is required to contribute to the developmental writing profile of dyslexia and to highlight whether writing difficulties differ between these age groups.

4.3 Dyslexia and the writing processes

In spite of the shortage of research that examines the quality of writing, some studies have addressed the lower-level writing processes that were shown in the Berninger & Swanson (1994) model. Spelling performance in written compositional tasks is explored first.

4.3.1 Spelling in free writing

Sterling et al (1998) demonstrated that spelling errors produced in the written compositions of university students with dyslexia reflect difficulties with phonological processing. Similarly, Coleman et al (2009) reported that their spelling errors were scored as phonetically implausible and showed difficulties with marking correct morphology, even in high frequency words with only one or two syllables. In contrast, studies of dyslexia have not considered the nature of spelling errors made by children with dyslexia when composing written text.

Rose (2009) identified that children with dyslexia have poor verbal memory and Berninger et al (2008) highlighted problems with rapidly accessing verbal information. If processing and retrieving spelling information from memory is effortful, it is reasonable to propose that the high proportion of spelling errors made while writing (Connelly et al., 2006; Gregg et al., 2007; Puranik et al., 2006; Sterling et al., 1998), could have partially been responsible for the fewer number of words written when composing text in the equivalent time as their peers without spelling difficulties. Students with dyslexia struggle to finish writing in a set time, as their peers are able to (Gregg et al., 2007; Hatcher et al., 2002), this may be due to hesitations around spelling errors influencing the fluency of the execution of text by frequent pausing and, furthermore, lower productivity correlates to poorer text quality (Gregg et al., 2007), as shown in typically achieving populations too (Beauvais, Olive, & Passerault, 2011). The time constraints often imposed by psychological experiments has been discussed as a possible task variable that could influence this correlation. In addition, when taking part in writing experiments children and adults with dyslexia may try harder with their spellings, than they would with writing when the experimenter is absent. This could influence how much they write through the amount of effort expended on task. If individuals with dyslexia have smaller verbal working memory spans and they are focusing on the phonological information of spelling, few resources are left to devote to the higher level composing process.

Problems with spelling when composing text may be expected to be a constraint on working memory resources, but might be likely to have more widespread consequences on the word-level skill of vocabulary selection. It is important to acknowledge that as well as the contribution of spelling ability Gregg et al (2007) illustrated that vocabulary related to the overall compositional quality score for university students with dyslexia.

4.3.2 Vocabulary choices

Vocabulary knowledge requires both phonological and semantic representations and is derived from reading experience (Wise, Sevick, Morris, Lovett, & Wolf, 2007). Poor vocabulary might be expected from children with dyslexia due to reduced print exposure. Research has shown that children at-risk of developing dyslexia do present with problems in oral language before starting education (Gallagher et al., 2000). However, oral language difficulties found in children with dyslexia do not reach the severity as shown by those children with SLI when assessed on semantics and syntax (Catts et al., 2005). It is possible that children with dyslexia acquire much of their vocabulary through spoken conversation. Yet, when analysing vocabulary production in writing it is important to determine whether individuals with dyslexia have either a general difficulty with vocabulary, or one that is specific to writing.

When composing written text, children with dyslexia have the added cognitive load of spelling the vocabulary choices they make. Limited written vocabulary could be a by-product of poor spelling. It is common in the literature to read anecdotal reports of children with dyslexia avoiding writing words they cannot spell, such as:

> "Many participants in our research studies lament that they cannot write compositions that express their ideas without limiting those ideas to the words they think they can spell without embarrassment." (Berninger et al, 2008. p.17)

Berninger suggests that spelling is constraining vocabulary when writing. Research in Swedish appears to show a link between spelling and written vocabulary choice in university students with dyslexia (Wengelin, 2007). Lexical diversity (a measure of how many different words are used in proportion to the total word count) was calculated using a formula of theoretical vocabulary that requires mathematically transforming the number of different types of words written in a sample based on a smaller section of the overall text. This method was used to control for the varying text lengths collected, as longer texts will reduce the diversity calculation by introducing more opportunities for function words (i.e. the, and) to be repeated. Another measure of vocabulary was also taken for this study, which was a measure of lexical density. Density refers to the percentage of open-class words (nouns, verbs, adjectives and adverbs) used in the text. University students with dyslexia performed at the same level as their peers on both of these vocabulary measures when composing text verbally (Wengelin, 2007). In contrast, in the written compositions, students with dyslexia scored significantly below their peers in these measures.

Wengelin's (2007) findings emphasised that students with dyslexia experience difficulties with regards to vocabulary that is specific to writing. It must be noted that these were university students and therefore would be required to read a lot more than adults with dyslexia that were not at university. A different pattern may be observed in younger children who still have profound difficulties with reading and are at the stage of acquiring new vocabulary. Nevertheless, the findings by Wengelin (2007) support the above quote by Berninger et al (2008) and suggest that spelling ability may have a role in vocabulary choices in writing. Unfortunately, this research direction has not been conducted on English participants.

In a sample of younger participants, Puranik and colleagues (2006) illustrated no differences between individuals with dyslexia and the control group in the number of different words written. Rather, participants with a language-impairment scored worse in this measure, suggesting that children with dyslexia do not exhibit problems with expressing vocabulary in writing and are distinct from those with a wider language problem. In support of this finding, and using the same measure to calculate lexical diversity, Connelly et al (2006) found no difference between a sample of university students with dyslexia and a chronological age matched group using an expository writing task.

By way of contrast, a number of studies of university students with dyslexia have highlighted that this group use many one-syllable words when writing; rarely using words consisting of up to three syllables (Coleman et al., 2009; Gregg et al, 2007; Sterling et al., 1998). Moreover, this finding is in comparison to their age-matched peers who used proportionally more words of three syllables and longer, which is considered to reflect a higher level of vocabulary. The difference between these two groups is further emphasised when considering that a high percentage of the simple one-syllable words written by students with dyslexia were also misspelt (Coleman et al., 2009).

Mixed results can be seen and may be attributed to the difference in scoring for vocabulary performance. For example, the number of different words may be considered to reflect the breadth of an individual's vocabulary knowledge or expressing ideas differently, whereas it could be argued that longer syllable length is related to a greater extent to more complex, advanced vocabulary. The question, therefore, should be related back to which of these measures has an impact on the overall quality of the writing. Gregg et al (2007) found that syllable length contributed as a predictor for the essay writing scores in students with dyslexia, but not for those without dyslexia. Similarly, Connelly et al (2006) demonstrated that lexical diversity accounted for the highest proportion of variance (22.9%) in the essay writing scores of these students. As both of these writing tasks were expository, it could be argued that the genre demands on the writer were equal. However, the written prompt in the Gregg et al (2007) study was not referenced and, therefore, these tasks could have differed in complexity. Furthermore, the absence of a measure of the level of spoken vocabulary of these participants makes it difficult to assert whether vocabulary is a general or more specific problem for students with dyslexia. Thus, conflicting results mean that the extent to which individuals with dyslexia alter vocabulary choices when writing still remains open to debate. This debate has not yet been investigated in developing children with dyslexia.

4.3.3 Handwriting skill

Practitioners often report that children with dyslexia are slow at handwriting (British Dyslexia Association, 2011; Rose, 2009). Berninger et al (2008) provides support for this statement by demonstrating that children with dyslexia performed more than one standard deviation below the mean on the alphabet automaticity task, asking them to write the letters of the alphabet as quickly as possible in 15 seconds. Although no comparison group was used the results were compared to norms collected in a previous study (Berninger & Rutberg, 1992).

Slow handwriting in this population is partly supported by an earlier study, whereby children with dyslexia were slower to write single words and to copy a sentence than an age-matched comparison group; however, this difference was not found to reach significance (Sovik & Arntzen, 1986; Sovik, Arntzen & Thygesen 1987). Conflicting with these findings, children with dyslexia have demonstrated the ability to copy a list of single words and a sentence in the same time as their peers (Martlew, 1992). A pattern of mixed results is not uncommon in dyslexia research due to the different tasks used. In each of the three studies discussed so far, different methodologies were adopted to examine handwriting speed ranging from an alphabet task to preselected word lists and sentences.

When considering explanations for a slow speed of handwriting in children with dyslexia, there are two pathways to explore. It is possible that slow handwriting may be a direct consequence of poor motor control and coordination. The Rose (2009) review states that dyslexia can co-occur with motor difficulties, but does not provide evidence to support this. On the other hand research into DCD has demonstrated that these children show characteristics of dyslexia, poor reading and spelling (Chaix et al, 2007; Iverssen et al., 2005). However, of the studies discussed at this point only one considered the assessment of motor performance and its relation to handwriting speed. Berninger et al (2008) included a timed finger succession task that required the child to touch the thumb to each finger in sequence while the hands are out of sight. Interestingly, both the results from this task and the alphabet writing task were not found to predict the written compositional quality of the writing produced by children with dyslexia in the late primary grades, while spelling skill did. Spelling was considered to be the more dominant constraint and lead the authors to conclude that dyslexia is not characterised by a general fine motor planning deficit.

In the Martlew (1992) study reported above children with dyslexia were not found to be slow at handwriting, however, the author did note that even when copying the stimuli, children with dyslexia made a number of spelling errors. It may have been that these children rush to complete the task without focussing on accuracy. It could be argued that if they had taken time to consider the spellings of these words they would have taken longer after all, which in turn slows handwriting speed (time taken to complete the task). Thus, the second explanation for slow handwriting could relate to spelling difficulties rather than motor problems. Difficulties with spelling and letter knowledge (linking this back to phonology and orthographic awareness) may hinder the speed at which handwriting is processed.

When trying to spell a difficult word, children with dyslexia might pause more frequently to try and identify the appropriate phoneme-grapheme correspondence. It has been demonstrated in keystroke logged essays that Swedish adults with dyslexia produce more pauses overall and in particular more inter-word pauses when composing written text, than age-matched controls (Wengelin, 2007; Wengelin & Stromqvist, 2000). The authors noted that difficulties with spellings disrupted the typing of these students, highlighted by the inter-word pausing and deletions/alterations of word choices (Wengelin, 2007). Sequential processing of spelling and handwriting might occur when the demands are too costly in working memory. However, to date research has not explored the link between spelling difficulties and the execution of handwriting in children with dyslexia.

4.4 Overall summary

Although practitioners report that children with dyslexia struggle with writing, this review emphasised that, at present, little research is available to support this. The majority of studies that do confirm this weakness are based on university students who were consistently found to exhibit a large proportion of spelling errors within the text, a variable that was found to predict the quality of written compositions produced.

The weight of the constraint that spelling can impose was emphasised, shown in text quality but also speculated in terms of the effect on the lower-level skills of vocabulary choice and handwriting speed. Predictions to the processing of writing demands have been made in terms of spelling placing a high cognitive load and, in turn, impacting on the efficiency of the writing processes.

A criticism of the majority of the reviewed studies is that they did not screen for possible language or motor difficulties. Therefore, it is viable that additional difficulties may have influenced their findings to some extent. Moreover, this type of research would have benefited from comparisons to spelling-ability matches to determine if children and adults with dyslexia follow the path of typically progressing individuals. Another criticism is that research in this area of dyslexia tends to focus on one aspect rather than pulling the influence of different processes together. The present thesis aimed to correct this by generating a model of how these lower-level writing processes interact and contribute to the written product.

4.5 General research hypotheses

The overview of the background literature of dyslexia highlighted three theories that could plausibly affect writing: the phonological deficit theory, automatisation hypothesis, and the working memory deficit. While the aim of the present work was not to test each theory, it was anticipated that the findings from the following empirical studies would lend some support to these three theories of dyslexia.

Research supporting the models of typical writing development has provided a strong framework to compare the findings from writing produced by children with dyslexia. The overarching aim of this thesis was to explore how spelling influences wider aspects of writing. One section of the analyses had a specific focus on the spelling difficulties children with dyslexia exhibit. The other areas of exploration focused on different aspects of writing (quality, vocabulary, and handwriting). An age matched comparison group were used and also a spelling ability matched design was employed to help understand the influence of spelling level on writing. Comparisons to both of these groups were used to test each of the following research questions and to provide in-depth analyses to identify where differences are found and if they are a consequence of developmental differences or a delay.

Four main hypotheses are presented here. Each hypothesis constitutes an area of empirical study and will be presented as individual chapters (6-9). More specific research questions and predictions are given in the individual chapters following a critique of methodological issues.

1. Children with dyslexia will produce **written compositions** that are graded as poorer than their age-matched peers.

Berninger (1999) demonstrated that when the transcription demands are high they have a stronger predictive value on written text length and quality. It is likely that poor spelling will hinder the composing process, by requiring more cognitive attention on this lower-level skill. By imposing more effort on the composing process, productivity would be expected to suffer. The strong link between text length and text quality has been consistently shown in research (Connelly et al., 2006; Graham et al., 1997; Gregg et al., 2007; Wagner et al., 2011). Children with dyslexia are predicted to write less because of their spelling difficulties and thus a correlation to poorer text quality would be expected in comparison to their age-matched peers.

In comparison to the young spelling-ability matches, it would be expected that children with dyslexia would show a similar performance, again relating to the role of spelling being very demanding in a writing task.

2. Children with dyslexia will reflect problems with **phonology and orthography in the spelling errors** made in the written compositions and the dictated spelling task.

It was predicted that the spelling errors made by children with dyslexia would lack phonetic plausibility, given that the phonological deficit hypothesis of dyslexia has received the most support. Further difficulties were predicted in orthography, based on current findings in the literature that demonstrate children and adults with dyslexia produce orthographically unacceptable spellings (Bernstein, 2009; Bourassa & Treiman, 2003) and that phonology provides the foundations to develop orthographic knowledge (Ehri, 1997), which means that the root of development for these children is already impoverished.

Problems with phonology and orthography were predicted for children with dyslexia and the younger spelling-ability group, but the age-matched peers were expected to follow rules of phonology and orthography accordingly.

3. Children with dyslexia will demonstrate a more limited **use of vocabulary in writing** in comparison to their age-matched peers.

It is conceivable that children with dyslexia would try to avoid making spelling errors by limiting their vocabulary choices to those they find easier to spell and perhaps repeating word choices within a text. If words are repeated then calculations of lexical diversity would be lower than those that are able to express a wider range of vocabulary because spelling does not constrain their performance. This last direction was predicted from the age-matched peers, while the younger spelling-ability group was expected to have a low value for lexical diversity too. Furthermore, a link was expected to be found between a limited range of different words in a text to the text quality ratings, as lexical diversity has been found to be associated with a higher graded text (Grobe, 1981; Olinghouse & Leaird, 2009).

Research would benefit from identifying the child's spoken vocabulary level first of all, to pinpoint whether these children have a proficient level of vocabulary to begin with, when the demands of writing are not present. A discrepancy was expected between spoken and written lexical diversity for children with dyslexia, demonstrating a problem that is specific to writing. Conversely, the age-matched peers were predicted to show similar performance across spoken and written tasks assessing vocabulary choice.

4. **Handwriting** production will be affected by the spelling difficulties of children with dyslexia.

Another assumption concerning children with dyslexia is that they are slow at handwriting. In relation to the theories of dyslexia, the phonological deficit theory posits significant difficulties with accurate spelling. The cerebellar/automatisation theory of dyslexia believes that these difficulties with phonology will be more widespread and cause problems in other areas, such as making everyday skills automatic.

In line with both of these theories, it was predicted that poor spelling would influence handwriting production. The first thing to uncover was whether motor difficulties were a characteristic of this population, and then to investigate the relationship spelling has to the handwriting fluency and speed (words produced in a set time). Examining the online execution of handwriting was possible by using a digital writing tablet, which demonstrated if and where disruptions to the flow of writing occurred. It was predicted that poor spelling would consume cognitive resources resulting in sequential processing of information, evident by frequent pausing while writing. In particular, pauses were expected around misspellings and within- and between-words, reflecting a word-level problem. More specific research questions were devised in the relevant empirical chapter (9) in accordance with this technology.

When exploring the last two hypotheses the relationship of these skills (vocabulary and handwriting) to written text quality was considered. This will bridge the gap in the current literature that fails to bring findings in the area of dyslexia and writing towards a model of writing development for this population.

These four strands of research aimed to build upon current theories of dyslexia. The spelling error analysis was devised to test the phonological deficit theory and to categorise any further related difficulties, such as problems with orthography. Measures of working memory were taken to consider that particular hypothesis of dyslexia, and in addition measures of motor control were used to target the cerbellar/automatisation deficit theory.

In addition to theories of dyslexia, there were the models of writing to consider. It was predicted that spelling would be a strong foundation in the model with direct relationships to handwriting fluency, and in turn speed, and a bidirectional relationship to text generation at the word-level (vocabulary). This will highlight the close relationship of the lower-level skills and their predictive value of written compositional quality. These relationships will be accentuated by using a sample of children with dyslexia, but will contribute to typical writing models too. By establishing a model of atypical writing development, a stronger framework is available to understand the psychology of writing, and of dyslexia. This can then link to practical implications, such as how to assess the writing of children with dyslexia and to pinpoint how support in one area could impact on other aspects of writing too.

5

General methodology

5.1 Introduction

The same pool of participants was used in each of the empirical studies and this chapter provides the relevant background information for these participants. The participant selection measures and additional measures of reading, motor performance and working memory depict a detailed background profile of literacy and writing-related performance. Measures that were selected to explore the four research questions are not described here, but are instead discussed in the relevant chapters.

5.2 Participants

5.2.1 Selection criteria for dyslexia

5.2.1.1 Inclusion criteria

One question that has been raised in terms of defining a dyslexic target population is whether children have generalised learning difficulties across a range of skills, or specific learning difficulties with written language (Berninger & May, 2011). Some might argue that all children that struggle with literacy should be included in the diagnosis and should receive support. Current definitions in the research literature classify dyslexia as a specific written language disorder (Berninger & May, 2011; Berninger et al., 2008). The purpose of this thesis was to establish whether and, if so, why children with specific problems in acquiring skills for accurate reading and spelling in the absence of a cognitive deficit, also present with problems in areas of writing. Children with general difficulties may reflect more severe problems in literacy, which could be confounded by weak cognitive ability. For this reason and to ensure tighter control specifically with regards to how spelling affects written performance, children with dyslexia were selected based on the discrepancy definition, used by researchers in this field (Bourassa & Treiman, 2003; Bourassa & Treiman, 2008; Lyon et al., 2003; Snowling, 2000) and to allow for comparisons to the literature.

The inclusion criteria for children with dyslexia was that they performed within the expected range for cognitive ability based on a UK norm referenced test, yet had scores at more than one standard deviation below the age mean on a dictated spelling test. Due to the nature of the research questions that focus on the influence spelling has on the other writing processes, the selection criteria was aimed at this discrepancy in spelling ability (rather than reading ability). Nonverbal cognitive ability was chosen rather than verbal cognitive ability to apply the discrepancy notion because verbal tests might not always accurately reflect intellectual ability in this group (Gallagher, Frith & Snowling, 2000). However, verbal ability was also assessed later to address the separate research question of vocabulary skill.

Another inclusion requirement was that children in this sample were recruited from Key Stage 2 (year groups 4, 5 and 6). This age group was selected for several reasons, the first being related to practise; at this level children will have had many years of explicit teaching of literacy-related skills. Therefore, the reading and spelling difficulties shown by children recognised as having dyslexia could not be attributed to limited educational opportunity. A second reason for this age group relates to the aspiration to investigate these developmental skills at a stage where they are most important to be developed adequately and built upon. Children in the final years of primary education were targeted, as they will soon enter secondary school, which will be a more literacy-demanding environment.

From a practical point of view, this age group was deemed most appropriate in terms of being able to deal with completing a range of writing-related tasks so that a wide profile of abilities could be assessed for the research project. The final reason for this age criterion related to the study design and inclusion of a spelling-ability matched group. The latter would inevitably be a few years younger than the children with dyslexia, yet needed to be old enough to be able to complete the writing tasks.

5.2.1.2 Exclusion criteria

It has been established that dyslexia is often associated with other developmental disorders (DCD, SLI, ADHD, see Ramus et al, 2003). In this research programme children with ADHD, autistic spectrum disorder (ASD), SLI, or any other known impairments/disorders were excluded because these additional difficulties may play a role in the performance on writing tasks. For example, it has been reported that children with ADHD that were receiving medication for their symptoms had a slower handwriting profile than children without ADHD (Tucha & Lange, 2004), and that difficulties with attention in both ADHD and ASD children negatively impacted on writing quality (Mayes & Calhoun, 2007). This exclusion criterion was applied across all groups. In addition, any children that had English as a second language were excluded from the studies.

5.2.1.3 Comparison groups

Chronologically age-matched (CA). This type of control group is often used in the literature to examine whether children with dyslexia differ to their peers on selected tasks. Within the classroom, such comparisons help determine who might require additional support and a profile of strengths as well as weaknesses across different tasks. This is useful in pinpointing which factors might be associated with a writing difficulty. For example, differences in spelling ability could account for performance in vocabulary choices when composing written text.

An important element of the design was to also match children with dyslexia to the CA group on non-verbal cognitive ability, to ensure that any differences found in other areas could not occur as a result of group differences in this factor (Goswami & Bryant, 1989).

Spelling-ability match (SA). Children with dyslexia were matched to younger typically developing children by raw spelling skill on a standardised spelling task. Children in the SA group also had to have a level of non-verbal cognitive ability close to their age expected mean, so that this was not a confounding variable. In the reading literature, a reading-level match design has been used in studies to pinpoint whether performance could be a result of delay in development or different characteristics noted between groups (Snowling, Goulandris, Bowlby, & Howell, 1986). Similarly, studies exploring the spelling patterns of children with dyslexia have used a spelling-level matched design (Bourassa & Treiman, 2003, 2008; Silliman, Bahr, & Peers, 2006). Using this type of design is a powerful way to explore asynchronous development.

However, rather than using a matched-design by 'level', the SA group were matched by 'ability'. In the Bourassa & Treiman (2008) study the spelling level of children with dyslexia was reported based on the grade levels shown in the test manual. Typically developing children from the identified grade were then recruited for the spelling-level matched group. Whereas, ability matching would be based on the proportion (the number) of spellings the participants answered correctly in a standardised task appropriate for each age group. Equating the groups on ability enhances external validity, as the relative difficulty of the task remains constant across each age group – all participants complete a spelling task that is age-appropriate and then are matched on the number of correct items. Furthermore, ability-matched designs have been shown to be popular in other areas of literacy too, notably when working with children with SLI and comparing performance to language matched controls (Dockrell, Messer & George, 2001).

Concerns have been expressed regarding the representative nature of a predetermined selected sample. Jackson & Butterfield (1989) argued that by using reading-level matched designs, the process of selecting the comparison group could reflect a sampling bias and rules out random assignment of participants to groups, which is a key strength of experimental designs. They argue that the direction of causal relationships cannot be inferred from this type of design (a view also supported by Bryant & Goswami, 1986), this point would relate to spelling-level designs too. That is to say that, for example, if children with dyslexia and a younger spelling matched group both reflect poor vocabulary within their written compositions, this finding would indicate a close relationship between spelling ability and vocabulary but it is not possible to firmly determine which skill is influencing (causing) the other level of performance.

An important point relating to both comparison groups is how to interpret these findings. Goswami & Bryant (1989) argue that both a CA, when also matched on IQ, and an ability-matched design are important to pinpoint causal factors that may influence performance. If differences are found between children with dyslexia and the CA group it is possible to infer that performance in the set tasks cannot be attributed to age or cognitive ability. Therefore, another factor is influencing the findings and when considering that the target group struggle with reading and spelling it would be reasonable to predict that these difficulties provide the explanation. However, Bryant & Goswami (1986) and Goswami & Bryant (1989) argue that this result leaves an ambiguous conclusion, which does not suggest the direction of the causal factor (e.g. is poor reading influencing vocabulary development or vice versa?) Conversely, when children with dyslexia are found to perform at the same level as the CA group stronger conclusions are reached, implying that the specific task is not related to reading or spelling ability, or even cognitive ability as this has been equated in the present cases.

On the other hand, if children with dyslexia perform significantly worse than an ability-matched group (in this case an SA match) it is likely that the variable in question has a causal link to spelling ability. In the reading literature, an example of this would be when children with dyslexia score lower on tests of phonological skills in comparison to children matched by reading-level (Goswami & Bryant, 1989), linking poor phonological skills to poor reading performance of children with dyslexia. In contrast, these authors firmly argue that it is impracticable to reach conclusive interpretations of the findings when no differences are evident between the target and ability group. Goswami & Bryant (1989) contend that the variable in discussion cannot be ruled out as a factor influencing reading (or spelling and writing in the present case) because children with dyslexia will inevitably be older than the ability group and, therefore, may have developed coping strategies or metacognitive skills in order to deal with the task demands. While it is possible to see this argument from that angle it is of course also conceivable that this stance is overanalysing the situation and in fact the variable really does not contribute to performance after all.

Finally, it could be questioned whether a written-ability match would be a useful comparison to determine the causal factors influencing writing. However, when considering the cost-benefit of this type of ability match, it would be extremely time consuming to accurately gather a sample that matched this criterion. Thinking back to definitions of dyslexia, characteristics of this condition do not include problems with writing at present. The purpose of this thesis is to explore this possibility further and therefore it would appear presumptive to recruit a written-ability match from the start. Moreover, there are a number of factors that could influence written ability and individuals' ability may change across different genres or depending on how long a child is asked to write for, which would raise an area of concern in terms of defining group selection. As a result a number of more stringent cut off points would need to be set for this group, which would question the representativeness of such a sample within the general population and thus the validity of the design. Furthermore, Jackson & Butterfield (1989) raised the issues of how strict matching criteria and thus bias of selecting participants from several cut off points, results in only drawing implications from the findings and not direct conclusions. Hence, in the present study an SA match was devised as this relied on only one matching criteria (spelling ability) and so reduced the issues just mentioned.

In sum, there are both advantages and disadvantages to using comparison groups and how to interpret findings across them. The design of the comparison groups in the present study reduced possible ‘third-factors’ by matching on cognitive ability and included an ability match to establish where children with dyslexia show different or delayed development.

5.2.3 Recruitment

Ethical approval was granted by the University Research Ethics Committee at Oxford Brookes University (for confirmation letter, see Appendix B). Local authority primary schools in Oxfordshire were then invited to take part. All contacted schools were recognised as achieving within 10 points of the national average (73%) of pupils achieving level 4 in Maths and English for the statutory assessment tests (SATs), using the Oxfordshire local statistics database (DfE, 2011). Information about the aims and nature of this project were sent to the headteachers at these schools (see Appendix C), resulting in six mainstream schools agreeing to participate. The schools’ SATs averages ranged from 69-76 in Maths and English, meeting the criterion. Meetings were arranged with the school special educational needs coordinator (SENco), who assisted with identifying children for the study.

Prior to participant recruitment the inclusion and exclusion criteria were addressed with school SENco’s. It was specifically stressed that no participants across the three groups should have any further difficulties, as discussed previously. For the dyslexic group, the school SENco identified children that were currently on ‘school action’ or ‘school action plus’. In Oxfordshire this is an accepted route that primary schools use to support children that require assistance in literacy, usually on a one-to-one basis with a specialist-teaching assistant. Children on school action plus require explicit teaching and are usually placed on this programme while waiting for a statutory assessment from an external source, such as an educational psychologist. Potential participants were selected from this pool if they had been recognised as showing marked reading and spelling difficulties that could not be attributed to any of the reasons explained in the exclusion criteria.

The CA group was identified by class teachers, choosing those that had adequate reading and spelling skills. Once participants for these two groups had been identified, letters detailing the nature of the study and consent forms were sent to the respective parents/guardians (see Appendix D).

The final SA group had to be recruited after the children with dyslexia had completed their first testing session (details in 5.3). To identify the SA children, teachers of the year groups 1-3 in the participating primary schools administered the predetermined spelling test to the whole class. These were scored and matched to the raw spelling scores of the children with dyslexia. Letters and consent forms were sent to parents/guardians of the appropriate children.

5.2.4 Participant selection

Up to this stage, participants were selected or excluded based on accounts from the class teachers and school SENco's. It was important to confirm that all participants were accurately allocated to the correct group. Therefore, once parental consent was obtained all children were tested on the selection measures to establish their cognitive and spelling ability.

Across all groups the cut off point of 40 was applied on the measure of nonverbal cognitive ability from the British Abilities Scales-II standardised test (BAS-II; Elliott, Smith & McCullouch, 1996). This is one standard deviation below the scaled score for this test.

The final number of participants and details of the groups based on the inclusion and matching criteria for children with dyslexia, the CA peers, and the SA group are as follows:

<u>Children with dyslexia</u>. Thirty-one children (15 boys, 16 girls) aged between 8;4 years and 11;2 years met the discrepancy criteria for dyslexia. While cognitive ability was required to be close to the scaled mean (score of 50; +/- 1SD), a standardised spelling score confirmed there was a discrepancy when the child performed more than 1SD below the age mean (≤85). Two boys from the initial recruitment stage were excluded based on their performance on these measures. Final group scores can be seen in Table 5.1

<u>CA group</u>. Similarly, thirty-one children (15 boys, 16 girls) aged between 8;3 years and 11;2 years were selected for this group. Cognitive ability was in the same range as for children with dyslexia. However, spelling ability was age-appropriate (+/-1SD of the age mean). All children in this group were matched individually to children with dyslexia on age (+/- 3 months), school, and gender.

<u>SA group.</u> The final group consisted of thirty-one children (15 boys, 16 girls) aged between 5;11 years and 7;9 years. This group performed within the expected cognitive

range. They were individually matched to the 31 children with dyslexia by their raw spelling score on the BAS-II standardised test (Elliott et al., 1996); and further matched by school and gender. The raw spelling score was used as a matching variable because it represents absolute spelling skill while taking into consideration the age-appropriate spellings for the participant. These children were matched on their raw score +/- 2 points.

5.2.5 Matching the groups

The results in Table 5.1 illustrate the mean performance scores for the selection measures across the three groups.

Table 5.1. Performance on the selection measures across the three groups.

	D (*n* = 31) Mean (SD)	**CA** (*n* = 31) Mean (SD)	**SA** (*n* = 31) Mean (SD)
Age (years)	9.44 (.90)	9.41 (.84)	6.63 (.78)
Nonverbal ability (Matrices; scaled)	51.00 (3.83)	51.74 (6.21)	54.46 (4.87)
Spelling standard score	79.06 (5.33)	110.68 (13.04)	92.84 (8.58)
Spelling raw score	8.55 (3.15)	25.16 (8.34)	9.26 (2.94)

Note. Nonverbal and spelling ability were measures taken from the BAS-II. Nonverbal scaled score (*M* 50, *SD* 10); Spelling standard score (*M* 100, *SD* 15).

A series of one-way analysis of variance (ANOVA) were applied, first of all revealing a significant difference in age across the three groups, $F(2, 90) = 11.17$, $p < .001$, $\eta^2 = .71$. Post hoc comparisons using the Tukey HSD test revealed no significant differences in age between children with dyslexia and the CA group; both groups with a mean age of 9 years and 4 months. As expected, the SA group were significantly younger with a mean age of 6 years and 6 months. For the measure of nonverbal ability a significant difference was found across groups, $F(2, 90) = 7.92$, $p = .001$, $\eta^2 = .15$. All groups performed within the required range, with the majority scoring above the average. There were no significant differences between children with dyslexia and their CA peers on this measure, although the SA group scored slightly higher.

As required, significant differences were revealed across the groups for both the standardised and raw scores for spelling, $F(2, 90) = 64.28$, $p < .001$, $\eta^2 = .57$; $F(2, 90) = 54.14$, $p < .001$, $\eta^2 = .70$, respectively. The standardised score of the CA group was significantly higher than the children with dyslexia and the younger SA group.

Children with dyslexia were performing below 1SD of the mean, complying with the discrepancy definition. No significant differences were found between children with dyslexia and the younger SA group (p = .64) on the raw spelling score.

In sum, measures from the three groups of participants were in accordance with the predetermined criteria. It should be noted here that two children from the SA group had a mean standard score of 83 on the BAS-II spelling task but remained in the overall analyses because their reading scores were well above average and they were in an older year group (year 3) than the other children in the SA group. A large proportion of the SA group was very young (from Years 1 & 2); therefore, including these two from year 3 rules out the younger ages that would question useful comparisons.

5.3 Measures

Descriptions of the initial selection measures are presented below. Further measures were collected at this stage to provide general background data for the three groups by establishing performance on reading, phonological awareness, motor competence, and working memory tasks.

5.3.1 Selection measures

Nonverbal cognitive ability. All children completed the Matrices subtest from the BAS-II (Elliott et al., 1996). This is a standardised test with UK norms used to assess nonverbal reasoning skills (cognitive ability). Children were presented with a series of pictures with part of the image deleted. There were six possible options provided that could fit the missing pattern. Reasoning skills were needed to identify the pattern and select the correct answer. The scaled score (*M* 50, *SD* 10) was derived from the number of correctly identified answers using the test manual. Internal reliability of this test for the selected age groups of the participants ranges from α = .78 to .90.

Spelling. All children completed the dictated single-word spelling task from the BAS-II, with UK norms (Elliott et al, 1996). A single-word spelling task was chosen to control the level of words attempted by children with dyslexia and their CA peers. A UK spelling task was deemed more appropriate than other standardised tests that have US norms, as variations in age-appropriate words across countries might have been present. The child's age determined the starting point on the list provided from the test. The list was dictated to the children while they wrote their answers with a pencil on the paper provided. They continued through the list until eight or more errors in a block of ten were made. The raw score was the total number of correct spellings. Raw scores were converted to a standard score (*M* 100, *SD* 15) dependent on the child's age. The task shows high internal reliability (α = .84 to .93).

5.3.2 Additional profiling measures

Additional measures were included to reflect the current theories of dyslexia and to consider their relationship to writing performance in the subsequent chapters.

<u>Phoneme segmentation.</u> To assess each child's ability to recognise and manipulate sounds within a word, the phoneme segmentation task was used from the Dyslexia Screening Test- Junior (DST-J; Fawcett & Nicolson, 1996). All children were asked to repeat a word but to omit a specified sound. For example, they were asked to say 'boat' without the 'b'; or 'snail' without the 'l'. A score of 1 was awarded to each correct answer and 0 for incorrect responses. 12 items were administered to each child, giving a total possible raw score of 12. This task was selected to assess phonological awareness, as these are skills that we use when reading new words, pseudo words, and when spelling. This test was appropriate for the age range of the sample and has good internal reliability.

<u>Reading</u>. To assess single-word reading ability, each child completed the single-word reading task from the BAS-II (Elliott et al, 1996). This required reading aloud a series of words printed on a card, starting at the point that corresponded with their age and continuing until the child made 8 or more errors in a block of 10. As the child works through the reading list the words become increasingly harder. Where any children struggled to successfully read 8 words of the initial block of 10 words, the starting point was moved back a block until a base measure was achieved. The overall raw score was converted to a standardised score for all participants (*M* 100, *SD* 15). UK norms were available and internal reliability ranged from α = .88 to .95.

<u>Reading fluency (words and nonwords).</u> The Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999) was used to assess sight word reading and phonemic decoding (nonword) skills. These two tests assess reading fluency with the nonword reading task being another measure of applying phonological skills. Both of these tests were taken from Form A from the TOWRE set. Children were required to read the list of words aloud as quickly and accurately as possible. They were timed for 45 seconds and the total number of words read correctly

was recorded and converted to a standard score (*M* 100, *SD* 15). The test-retest coefficients range from α = .83 to .96.

Motor skill. The 'Manual Dexterity' component of the Movement Assessment Battery for Children – 2nd Edition (MABC-2; Henderson, Sugden, & Barnett, 2007) was used to assess various aspects of fine motor control. Dyslexia is often associated with motor difficulties (Chaix et al., 2007; Ramus et al., 2003). Although often ignored in research, these difficulties may have an impact on aspects of writing, particularly handwriting and it is therefore important to include this aspect in a detailed assessment of writing. Although the whole MABC-2 test assesses general motor competence (including balance and agility), the manual dexterity component was considered most relevant to writing. The test has three age bands for children aged: 3-6, 7-10, and 11-16 years. There are three manual dexterity tasks, which are similar across the age bands but increase in difficulty.

Each age band contains one item to assess the speed and accuracy of both the preferred and non-preferred hand separately (posting coins in a slot, placing pegs in a peg board or turning pegs over in a peg board, depending on age). A second item assesses speed of performance when using both hands together to complete a task (threading beads on a lace, threading a lace through holes in a board, or putting together strips of plastic with nuts and bolts). The third task involves controlling a pen to draw accurately between two boundary lines (with narrower lines for the older children). Completion time for the first two tasks is recorded in seconds. The number of errors for the drawing trail is recorded by noting how many times the pen trace went over the lines or any gaps in the trail. Raw scores from each task were converted to standard scores and combined to provide an overall score for manual dexterity (*M* 10, *SD* 3). The MABC-2 has recent UK norms, was appropriate for the age range tested and acceptable test-retest reliability (r =.77 for the manual component).

Working memory. The short form of the computerised Automated Working Memory Assessment (AWMA; Alloway, 2007) was administered to all children. The two verbal and two visuo-spatial memory tasks were used. Verbal memory was assessed because of the role of the phonological loop. When reading, spelling, and writing the phonological loop is activated to access, encode and retrieve verbal information. Using the verbal short-term memory (STM) and WM tasks enabled an examination of the capacity of these two stores and provide findings that can be related to the theoretical side of dyslexia and to its role in the subsequent studies. Alongside the verbal measures, visuo-spatial STM and WM tasks were included because research has shown that writing also requires visuo-spatial cognition and a representation of text spatial structure (Hayes, 1996; Olive & Passerault, 2012). Therefore, adequate capacity in both of these memory domains is required and ought to be considered.

All children completed the *digit span* task, which is a verbal STM task used in many studies as a measure of verbal memory capacity (Berninger et al., 2008; Connelly et al., 2006; Hatcher et al., 2002). Here, the child listened to a sequence of digits and was then asked to repeat them in the same order that they were presented. The number of digits to recall increased if the child got four out of a possible six chances correct. The demands on memory continued to increase by adding an extra digit onto the sequence in each set until the child made three or more errors in one set, which terminated the task.

The *listening recall* task was a measure of verbal WM. In this task, the child listened to a sentence (such as, ‘dogs have four legs’) and had to identify whether the statement was ‘true’ or ‘false’. They were then asked to recall the last word of the sentence. Children had to answer four correct trials before progressing to the next stage. When they progressed to two sentences, the child had to remember the last two words of the two sentences in the correct order; the same rule applied for three sentences, etc. If the last words of each spoken sentence were recalled in the wrong order, the answer was marked as wrong. This task required mental processing of the sentence and recall of verbal information. In a similar way to the digit span task, when the child made three or more errors in a set the task was terminated. The listening recall task was more cognitively demanding than the previous task and is designed to assess how these children deal with juggling many demands at once, as is expected when composing written text.

The visuo-spatial STM task was a *dot matrix* task. Children were shown the position of a sequence of red dots individually displayed on a 4x4 matrix on the computer screen. The position of these red dots is displayed for 2 seconds and changed in each set. The aim was to remember the order and position of these dots and to tap their location on to an empty grid displayed on the screen after each trial. Attempts were scored as correct if the order of the red dots was reported as shown in the initial viewing. The number of dots increased after each completed set and when three or more errors were made in a set the task was terminated.

The final task was the *spatial recall* visuo-spatial WM test. Children were shown two shapes on the screen. The shape on the right had a red dot attached to it: either on top of it, on the left side, or on the right, while the separate shape on the left had no red dot attached to it. They saw a sequence of two pictures at a time and the location of the red dot changed on each one. Similar to the listening span task, the child's first task was to identify whether the two shapes were pointing in the same or opposite direction (many times the shapes were rotated). At the end of a trial, the child recalled where each red dot was for the sequence of shapes, in the correct order. Once again, the more trials the child answered correctly the number of sets increased. The same termination rules applied as above.

For each of the memory tasks, raw scores were automatically saved and converted to standard scores by the computer programme. Test reliability for the AWMA ranged from $\alpha = .69$ to .90 (Alloway, 2007).

5.4 General test procedure

Children were tested individually and in a quiet room within the school grounds. A wide range of tasks was used initially to confirm the group selection criteria and then to answer the four research questions. These tasks were scheduled across a total of five sessions, each at least a week apart where possible. Session lasted a maximum of 30 minutes and the tasks were arranged so that short breaks were possible before moving on to the next one. It was explained to all children that they could stop at any time and all tasks were self-paced. If at any point a child was hesitant when completing a task, they were encouraged on their performance. None of the children in this study refused to start or complete any of the tasks set.

5.4.1 An outline of the experimental design

Table 5.2 lists all of the assessments, how they matched to the research objectives, and when they were scheduled. The test names that have not already been discussed in this chapter are abbreviated in capitals and clarified in the final row of the table.

Tasks were allocated in the specific order, shown in Table 5.2, because of the time constraints of each session, and so that they would not be too demanding in one timeframe. It was a requirement that the first session would focus on the selection measures so that the children could be allocated to groups or excluded from further study where necessary. All tasks were counterbalanced within each of the testing sessions.

Table 5.2. The measures included in each testing session.

Session	Objective	Measures
1	Chapter 5: Selection & profiling	• Matrices • Spelling • Reading • Reading fluency (words & nonwords) • Phoneme segmentation

2	Chapter 9: Motor & handwriting tasks	• Manual dexterity component
		• DASH tasks
		  ○ Copy best
		  ○ Alphabet task
		  ○ Copy fast
		  ○ Graphic speed

3	Chapter 6: Writing & memory task	• Writing task (WOLD) • Digit span
4	Chapter 8: Vocabulary & memory tasks (for Ch5)	• Receptive vocabulary (BPVS) • Expressive vocabulary (BAS-II) • Dot matrix • Listening recall
5	Vocabulary & memory tasks cont. (for Ch5)	• Verbal compositions task (WOLD) • Fluency • Spatial recall

Note. DASH = Detailed Assessment of Speed of Handwriting; WOLD = Wechsler Objective Language Dimensions; BPVS = British Picture Vocabulary Scale second ed; BAS-II= British Ability Scales second ed.

5.5 Data analysis

Full descriptions of the analysis process for any tasks that were not standardised are provided in the subsequent chapters. Indeed, the majority of the tasks presented in this thesis were standardised.

5.5.1 Standardised scores and standard deviations

When a standardised test was used the manual instructions were closely followed in terms of procedure and scoring. If possible, raw scores were converted to standardised scores. A standardised score provides information on the level at which children are performing compared with their age peers, and norm-referenced scores allow for comparisons to a nationally representative sample.

The majority of standard scores reported in this thesis have a mean of 100 (tests that differ from this will be noted) and a standard deviation of 15. Standard deviations represent the variability of scores. In the case of when the mean is equal to 100, scores between 85 and 115 would represent a standard deviation (SD) of 15 points either side of the mean. This 1SD variation would be considered to be within the average range. In research that concerns learning difficulties SDs often serve as a cut-off point to identify underperforming children (Hanley, 1997; Snowling, 2000). These are useful markers of where groups deviate from the mean when explaining the reported findings. The standardised scores are also crucial to demonstrate whether typically developing groups are performing at the expected level.

5.5.2 Statistical analyses

All collected data was analysed using the statistical programme, SPSS. Initial tests for normality and homogeneity of variance were conducted on the data in the present and subsequent chapters. Normal distribution was tested using the Kolmogorov-Smirnov test, which provided a level of significance and indicated how far the distributions of the scores deviate from normality. The Levene's test for equality of variance was used to establish homogeneity of variance in the population scores. Equal variance is noted when the significance level from this test is greater than .05, meaning that the variances are approximately equal and thus the data meets the assumptions for parametric tests. When this value is significant (less than .05) non-parametric test were used as an alternative.

Descriptive statistics are provided in all of the results tables in this thesis (means and SDs). Inferential statistics are reported to compare the mean scores across the three groups of participants. Analysis of variance tests are the most common to be used in this thesis because they allow easy comparisons across the three groups using post hoc tests. Where a number of related dependent measures are explored a multivariate analysis of variance (MANOVA) or repeated measures design was conducted to reduce Type I error that can occur when performing a series of univariate tests. The

Tukey post hoc test is used for these analyses because there are an equal number of participants in each group. Post hoc tests compared performance between children with dyslexia and their CA peers, and then the SA matches; and also between the two control groups.

The Kruskal- Wallis test was used when data was not normally distributed. This test is a non-parametric equivalent to the one-way ANOVA and allows for comparisons to be made across two or more samples, which is ideal for the analysis of children with dyslexia and the two comparison groups. As this is a non-parametric test, median values are reported rather than means. Furthermore, as a follow up to this test to determine whether two groups differ from one another, a Mann Whitney U test was conducted to analyse specific group differences.

Bonferroni corrections have been applied when multiple correlations have been carried out, in order to counteract an inflated Type I error. The significance (p) value for all other measures is .05 and this value is from where the correction is calculated. When a significant relationship was found between two or more variables of particular importance to the research questions, these were entered into a regression analyses. Separate regression analyses were computed for each group so that clear distinctions could be made with regards to the effect of group membership and because different significant correlations were flagged for each groups and, therefore, different variables were to be entered into the regression analysis. Multiple regression analysis was used when more than one variable was considered to be a predictor. However, this was specifically limited to 3 predictor variables being entered in this type of analysis, as each participant group had 31 children and 10 participants allow one predictor (Field, 2009). Regression analyses are particularly useful in research of writing development as they demonstrate the prominent skills that have a current effect on a groups' performance.

The stages of analyses that have been discussed here relate to each of the analysis sections in the subsequent empirical chapters.

5.6 Results from additional measures

Additional measures relating to theories of dyslexia were administered to all children to further contribute to the background profile of the three groups, reported in Table 5.3.

Table 5.3. Mean scores (standard deviations) from the additional background measures for children with dyslexia, their CA peers, and the SA group.

	D (n = 31) Mean (SD)	**CA** (n = 31) Mean (SD)	**SA** (n = 31) Mean (SD)	**ANOVA results**	**Post hoc**
Reading (BAS-II; SS)	80.87 (10.56)	113.75 (11.68)	98.19 (13.44)	$F(2, 90) = 37.13$, $p < .001$, $\eta^2 = .61$	D < SA < CA
Reading fluency (TOWRE; SS)	81.87 (6.29)	112.68 (11.06)	97.13 (11.12)	$F(2, 90) = 48.18$, $p <.001$, $\eta^2 = .52$	D < SA < CA
Phoneme decoding (TOWRE;SS)	84.19 (8.35)	113.52 (9.88)	100.71 (9.83)	$F(2, 90) = 76.51$, $p < .001$, $\eta^2 = .64$	D < SA < CA
Phoneme seg. (DST; raw)	6.65 (1.47)	11.84 (.63)	9.29 (1.32)	$F(2, 90) = 122.76$, $p <.001$, $\eta^2 = .73$	D < SA < CA
Manual dexterity (MABC-2; SS)	8.00 (2.05)	8.91 (2.33)	9.46 (2.74)	$F(2, 90) = 2.30$, $p =. 10$, $\eta^2 = .05$	D = CA = SA
Digit span (ST; AWMA; SS)	98.61 (12.08)	103.90 (11.14)	102.97 (11.87)	$F(2, 90) = 1.80$, $p = .17$, $\eta^2 = .04$	D = CA= SA
Dot matrix (ST; AWMA; SS)	94.06 (8.79)	102.77 (9.17)	102.09 (12.87)	$F(2, 90) = 6.68$, $p = .01$, $\eta^2 = .14$	D < (CA = SA)
Listening recall (WM; AWMA; SS)	95.87 (10.08)	103.61 (6.90)	99.39 (12.88)	$F(2, 90) = 4.43$, $p = .02$, $\eta^2 = .08$	D < CA,(D=SA)
Spatial recall (WM; AWMA; SS)	99.58 (7.96)	106.52 (6.98)	103.17 (11.47)	$F(2, 90) = 4.15$, $p = .02$, $\eta^2 = .09$	D < (CA = SA)

Note. SS = standard score; DST = Dyslexia Screening Test; BAS-II = British Abilities Scales II (*M* 100, *SD* 15); TOWRE = Test of Word Reading Efficiency (*M* 100, *SD* 15); MABC-2 = Movement ABC-2 (*M* 10, *SD* 3); ST = short-term; WM = working memory; AWMA = Automated Working Memory Assessment (*M* 100, *SD* 15).

On average, children with dyslexia performed more than one standard deviation below the mean on each of the reading measures. This is in comparison to the CA and SA groups who performed close to, or over the expected mean value of 100. Post hoc tests showed that in the measures of reading and phonological awareness (decoding and segmentation tasks) children with dyslexia scored significantly below their CA peers and the SA group, confirming that the typically developing groups did not show signs of dyslexia.

A repeated measures ANOVA was conducted to compare the standard scores of spelling (Table 5.1) and reading performance across the three groups. There was a significant main effect of performance in these literacy tasks, $F(1, 90) = 10.32$, $p = .002$, $\eta^2 = .10$, and a significant effect of group membership, $F(1, 90) = 60.62$, $p < .001$, $\eta^2 = .57$. Contrasts revealed that children with dyslexia scored below the CA groups on both measures, while all groups performed better on the reading task. A non-significant interaction was found, $F(2, 90) = 1.14$, $p = .33$ $\eta^2 = .02$, between task and group performance, which indicates that the pattern of results across the two tasks were similar for the three groups.

No significant differences were found on the manual dexterity component, as children with dyslexia performed similar to their CA peers ($p = .29$) and the SA group ($p = .08$).

Finally, a multivariate analysis of variance (MANOVA) was conducted on the four memory measures. Using the Pillai's trace, a significant effect of group was found, $V = 0.20$, $F(8, 176) = 2.49$, $p = .014$, $\eta^2 = .11$. Separate univariate ANOVAs were then conducted and are reported in the table. No significant differences were found across the three groups for the verbal STM task, digit span. However, performance on the dot matrix, listening recall, and spatial recall tasks revealed that children with dyslexia are significantly worse than their CA peers. In both visuo-spatial STM and WM tasks children with dyslexia scored significantly below the SA group too, who are matched to the CA group in average scores as they both perform close to the mean of 100. In contrast, although children with dyslexia performed worse than the CA group on the listening recall task (verbal WM), a significant difference was not evident between children with dyslexia and the SA group. It should be addressed here that although children with dyslexia performed below the mean on these memory capacity measures, these scores do not reach below 1SD.

5.7 Contextualising the sample

The initial selection measures confirmed the inclusion criteria for the three groups and reliably marked that participants were accurately matched. Bringing together the results from Tables 5.1 and 5.3, it is apparent that these children with dyslexia show a discrepancy when comparing their cognitive ability to spelling and reading ability, which was a requirement of the target sample based on the diagnostic criteria of dyslexia and past research (Bryant et al., 1997; Rose, 2009; Snowling, 2001). It was highlighted that children with dyslexia performed worse in the spelling task, although reading was also more than one standard deviation below the mean. This would comply with the literature that implies that spelling ability develops more slowly than reading in children with dyslexia (Bourassa & Treiman, 2003). This higher performance in reading was echoed in the typically developing groups also.

Of particular importance, was how delayed in development children with dyslexia were in these skills. The spelling-ability matched group were, on average, three years younger than children with dyslexia, demonstrating a large age gap. If, as research has suggested is the case, children with dyslexia struggle to catch up with spelling (Bourassa & Treiman, 2003), it may be that this age gap continues to get larger as they progress in education. As a result these children might fall behind in other areas too and the direct influence on writing ought to be considered. This provides further justification for the direction of this thesis.

The poor performance on the phoneme segmentation and decoding fluency task support the phonological deficit theory of dyslexia and is consistent with other studies in the field of dyslexia and reading (Connelly et al., 2006; Snowling et al., 1997). Thinking back to Goswami & Bryant’s (1989) stance on interpretations, the finding that children with dyslexia performed below their spelling-ability matches on these measures would indicate that phonological skills and reading ability have a causal relationship to spelling performance for the target group.

The Rose (2009) definition of dyslexia included the possibility of co-occurring motor difficulties in this population. A measure of manual dexterity was included because of its relevance to writing. Yet, no difficulties with motor control and coordination were prominent when looking at group averages, suggesting that this group of children with dyslexia did not have DCD too and goes against the theory of general problems with motor control (Nicolson & Fawcett, 1994). However, when investigating individual scores from the manual dexterity component it was found that children with dyslexia had a wider variation of scores than the two comparison groups (a point that is elaborated on in Chapter 9).

Finally, working memory was assessed to contribute to the working memory deficit hypothesis (McLoughlin et al., 2002); although these findings failed to support such a hypothesis. Children with dyslexia were shown to have a smaller working memory capacity than the two comparison groups on the verbal working memory and two visuo-spatial tasks, but not on the verbal short-term memory task. Weaker performance on these measures has been found in primary and secondary school aged children with dyslexia, in comparison to their peers (Jefferies & Everatt, 2004; Reiter et al., 2005). However, when comparing the performance of the present sample to norms of the test their scores were close to the expected mean, indicating that a ‘deficit’ would be too severe to label this group.

To conclude, the present sample of children with dyslexia is representative of those defined in the literature whereby a discrepancy between cognitive and spelling ability is evident (Berninger et al., 2008; Bourassa & Treiman, 2008; Connelly et al., 2006). Moreover, these findings comply with the phonological deficit theory of dyslexia, while covering and thus disputing at this point the cerebellar and working memory deficit hypotheses. This sample was a ‘pure’ group of children with dyslexia with no additional noted difficulties.

5.8 Summary

This chapter has defined and clarified the key characteristics of children with dyslexia, the CA peers, and the SA group. Participants were selected from Oxfordshire primary schools that performed close to the national average in SATs. The measures presented here will be used in the later chapters to determine how literacy ability relates to written performance.

Table 5.4 summarises the findings in this chapter. Children with dyslexia are shown to be equal to (=) the comparison groups or differing in performance.

Table 5.4 Summary of the group comparisons on the background measures

	D	CA	SA
Cognitive ability	=	=	=
Spelling standard	< 1SD & CA & SA	> D, & >SA	> D, & < CA
Reading standard	< 1SD & CA & SA	> D, & >SA	> D, & < CA
Reading fluency	< 1SD & CA & SA	> D, & >SA	> D, & < CA
Phoneme seg.	< CA, & < SA	> D, & >SA	> D, & < CA
Manual dexterity	=	=	=
Verbal STM	=	=	=
Visual STM	< CA, & < SA	> D, (CA=SA)	> D, (CA=SA)
Verbal WM	< CA (D=SA)	> D, & >SA	< CA, (SA = D)
Visual WM	< CA, & < SA	> D, (CA=SA)	> D, (CA=SA)

Note. Reading fluency includes both measures of word and nonword reading; STM = short term memory; WM = working memory.

6

Quality of Written Compositions

6.1 Introduction

Very few studies have explored the written compositional skills of children with dyslexia and although research is still limited the focus has been with university students. University students with dyslexia have reported long standing difficulties with expressing ideas in writing (Mortimore and Crozier, 2006). Moreover, students with dyslexia produce writing that was graded as lower than their peers, with their level of general spelling ability consistently found to correlate with text quality (Coleman et al., 2009; Connelly et al., 2006; Gregg et al., 2007; Sterling et al., 1998). This disregard of research into the writing skill of younger children is amplified when considering the abundance of research into the reading and spelling characteristics of dyslexia: both of which are skills that are actively used when composing and transcribing text.

In one of the very few studies to explore the writing of children with dyslexia, Berninger et al (2008) acknowledged that these children performed more than one standard deviation below the age mean for written expression. However, the authors did not report how and in what areas of writing children with dyslexia were impaired, or even if spelling errors were present in the written compositions by these children. By only reporting a composite mean score, little is known about how these children responded to task demands or whether, for example, the organisation of their writing was weaker than the ideas they produced. It also raises the question of whether spelling difficulties affected the overall marking criteria, or did it affect one of the marking components, such as vocabulary, more? This would have been a fruitful direction to explore especially when considering that the authors note that these children with dyslexia will often avoid writing words they cannot spell. The present thesis aimed to build upon the work of Berninger and colleagues (2008) by acknowledging the many components that formulate the written product.

In line with deliberating over the writing characteristics that contribute to the text, the English school curriculum identifies a number of skills that will be assessed by the time children reach Key Stage 2, such as: vocabulary, structure, punctuation, etc (DfE, 2011). Text will generally be graded as high when it is considered to be coherent and organised clearly into sentences that express sophisticated vocabulary, grammar and punctuation (Bonin, Fayol, & Peereman, 1998; Scott, 2005). These skills are used to express and present knowledge of a topic. It is the written product that shapes a large part of assessments and school examinations. However, there is no universal, confirmed way of scoring written ability. A large part of the scoring method will be subjective to the reader. When examining the national curriculum for writing, components that are to be scored are relatively ambiguous. For example, the DfE (2011) suggests that all children should be capable of demonstrating 'sophisticated vocabulary' within their writing. Yet, it is unclear how to appropriately assess this. Issues with selecting an appropriate writing task and marking criteria were considered before the design of the present study.

The overarching aim of this chapter was to test the first hypothesis:

1. Children with dyslexia will produce **written compositions** that are graded as poorer than their age-matched peers.

6.2 Predictions based on the literature

Based on the literature that marks the development of the writing processes, it would be naïve to think that the difficulties that university students with dyslexia display in writing (Connelly et al., 2006; Gregg et al., 2007), would not have been present at a younger age. Developing writers are expected to utilise a range of newly acquired and continuously evolving writing-related skills. Therefore, a similar pattern is expected for younger children with dyslexia, in comparison to the reviewed literature of adults with dyslexia.

It is conceivable that the demands of phonological processing and accurate spelling would have repercussions for the development and execution of the writing processes. It was hypothesised that because children with dyslexia have poorly developed transcription skills (spelling), the lower level writing processes would not have reached a level of automaticity. Thus, spelling would require more cognitive attention than would be expected from typically developing children of the same age. Accordingly, the orchestration of the higher level writing processes is likely to be jeopardised; and as a result, would yield differences in the quality of writing produced by children with and without dyslexia. Furthermore, a higher proportion of spelling errors were expected in the writing of children with dyslexia.

6.3 Study

The design of this empirical study was to investigate the quality of the written compositions produced by children with dyslexia, their chronologically-age (CA) matched peers, and the spelling-ability (SA) matched group and to consider the scoring procedure in relation to what teachers are looking for when assessing writing in school (DfE, 2011; Rust, 1996).

A writing prompt taken from the Wechsler Objective Language Dimensions standardised tool (WOLD; Rust. 1996) was used to assess written ability and compositions were scored using the WOLD analytical marking criteria. The analytical scoring consisted of six subsections, listed in the data analysis section (6.3.1.5). Additional text characteristics were also identified from the written product, such as: verbosity (productivity) and spelling errors. These measures contributed to later analyses of whether productivity relates to the quality of writing produced, as has been found in studies of typical writing development (Singer & Bashir, 2004). Only measures that can be identified at the surface level were noted for the present study. However, time taken to complete the writing task is also reported because this did vary across groups and, therefore, could have influenced text length and quality. Specific questions were targeted based on the predictions discussed.

Compared to their peers, do children with dyslexia:

a) Have a lower overall analytical scoring (as scored according to the WOLD manual) for their written compositions?
b) Show more variability in performance on the overall quality of writing scores?
c) Reflect a lower performance in each of the six scored WOLD writing components?
d) Write fewer words?
e) Make more spelling errors in their written compositions?

The following research questions were addressed across all groups:

f) Is there a relationship between spelling ability and the overall quality of written text?
g) Which variables predict the quality of the written compositions?
h) How do the working memory capacity measures relate to written quality scores?

6.3.1 Method

6.3.1.1 Participants

31 children with dyslexia, 31 CA peers (mean age 9;4), and 31 SA matches (6;6). Information about participant selection can be found in Chapter 5.

6.3.1.2 Measures

<u>Written composition.</u> All children completed a narrative written compositional task. Prompt A was taken from the WOLD test (Rust, 1996). The prompt was typed above the writing paper and read to the child beforehand. Children were asked to write a letter to someone describing their ideal place to live. A narrative task seemed to be the most appropriate genre to ask the age groups in the present sample to complete, as this should be a genre they are most familiar with when in primary school (DfE, 2011). All children were told they had 15 minutes to complete this task and were encouraged to write as much as possible. Planning time was not allocated. Instead, children were asked to start writing straight away after the full instructions had been given. If anyone stopped writing after only a few minutes, they were encouraged to write more. No help was given with spellings or ideas for this task.

All children wrote on lined paper that was placed on the surface of a digital writing tablet to record performance. Once they had finished their compositions they were asked to read aloud their text so that the experimenter could note down illegible words, this was required to aid later comprehension of the text. Spelling errors and the total number of words written was recorded. The total number of words included any words that were crossed out, so this provided an accurate account of how many words were written per minute and in the time frame. By including all words a fair calculation was given, as children with dyslexia often crossed out words. Following this analysis, compositions were typed and allocated a participant number to retain anonymity across the samples. When typing the handwritten compositions spelling errors were corrected. These steps ensured an experimenter blind procedure to prevent bias when scoring. No other errors, such as punctuation or grammar, were corrected.

The WOLD assessment criteria were used to score the compositions, covering six key areas: ideas and development, sentence structure, organisation/coherence, vocabulary, grammar usage, and capitalisation/punctuation. A mark was given out of 4 for each of these sections. These scores formed the raw score, which was converted to a standardised score (*M* 100, *SD* 15) for children with dyslexia and CA group. The test is standardised from age 8 upwards, therefore, only raw scores can be reported for the younger SA group. However, as this was a narrative task it was deemed appropriate for the younger age group too. The WOLD analytical scoring has a reliability correlation of .89.

6.3.1.3 Materials

All writing was recorded on a digital writing tablet (Wacom, Intuos 4; 100 Hz; Eye & Pen software, version 1). This required the children to write on lined paper (taped on to the tablet) with an inking pen. The writing paper was mounted on several other sheets of paper so that it was similar to writing on a pad and it was possible to move the tablet to an angle that was comfortable for the child to write at. Therefore, the writing materials (pen and paper) were identical to those that could be used in a typical written composition task undertaken in the classroom. Once the child started to write, the tablet surface recorded the XY coordinates of the pen position to a laptop (Alamargot et al., 2006).

6.3.1.4 Procedure

Children were tested individually and in a quiet room when completing the writing task. This was a necessity to ensure that they were not distracted while the tablet was recording. In the classroom, many distractions can occur and this would have influenced the accuracy of the temporal analyses of the text in Chapter 9. The writing task was placed as the third testing session out of the total five.

6.3.1.5 Data analysis

The WOLD marking criteria covers six main topics (Rust, 1996). An analytical template is provided with the manual whereby the lowest score that can be given is 1, and the highest is 4. Table 6.1 illustrates a brief description of the characteristics that are assessed at these two grade levels. For a full description of all four levels, see Appendix E.

Group differences were explored for each of the components in Table 6.1 as well as for the overall raw and standard (where appropriate) scores. Factor analysis was conducted on the six WOLD components to describe the variability of these scores and is reported in section 6. 3.2.1.

The writing tablet software was used to analyse the temporal characteristics of writing (in particular, handwriting) in more detail in Chapter 9 and, therefore, the configurations for those analyses is discussed in the appropriate chapter. For the present study, the writing tablet was only used to identify the exact time that these children were writing for. Using the Eye and Pen software, it was possible to identify the time when the child first put the pen down to start writing and the last point at which the pen was lifted. The total time is then calculated between these two points. This provides a more exact measurement than using a stopwatch to record writing time; nevertheless, both methods were used.

Table 6.1. WOLD analytical scoring criteria: lowest and highest boundaries

	Scoring criteria	
	1	4
Ideas and development	*'Weak idea(s), with little or no extension of details'*	*'Extensive development of ideas. Interest to audience, strong support of main idea'*
Organisation, unity, and coherence	*'Lack of plan, incoherent'*	*'Organised, smooth flow using transitions and sequences. No wandering from the main theme'*
Vocabulary	*'Very simplistic, lacks variety. May be inappropriate'*	*'Precise, accurate, appropriate. Imaginative & appealing to the audience'*
Sentence structure and variety	*'Poor sentence structure. Many errors that interfere with fluency and clarity'*	*'Excellent formation of sentences. Variety of structure and length. Few errors in structure'*
Grammar and usage	*'Poor grammar, frequent errors'*	*'Error free or very few in approximate proportion to text length'*
Capitalisation and punctuation	*'Frequent/serious errors that interfere with communication'*	*'Error free or very few in proportion to text length which do not interfere with clarity'*

6.3.2 Results

6.3.2.1 Group comparisons

The raw and standard scores for the measures from the WOLD assessment are presented first in Table 6.2.

The last half of Table 6.2 provides additional text characteristics from the written compositions. Time taken was an exact measure of the time that each child spent composing text on the writing tablet. The total number of words written includes any crossings out, and writing fluency was calculated as the total number of words written divided by the exact time taken (words written per minute).

Table 6.2. Mean scores from the WOLD assessment and additional text characteristics of children with dyslexia, their CA peers and the SA group.

	D (*n* = 31) Mean (SD)	**CA** (*n* = 31) Mean (SD)	**SA** (*n* = 31) Mean (SD)		**Post hoc**
WOLD SS	82.48 (10.67)	105.00 (15.41)	---a	$t\,(60) = -6.67$, $p < .001$	
WOLD raw score	8.61 (2.72)	13.68 (3.20)	7.52 (1.59)	$F(2, 90) = 49.09$, $p < .001$, $\eta^2_p = .53$	(D = SA) < CA
Ideas & dev.	1.84 (.69)	2.68 (.79)	1.55 (.57)	$F(2, 90) = 22.49$, $p < .001$, $\eta^2_p = .33$	(D = SA) < CA
Organisation	1.39 (.56)	1.94 (.57)	1.16 (.37)	$F(2, 90) = 18.88$, $p < .001$, $\eta^2 = .30$	(D = SA) < CA
Vocabulary	1.48 (.63)	2.48 (.68)	1.52 (.51)	$F(2, 90) = 27.12$, $p < .001$, $\eta^2_p = .38$	(D = SA) < CA
Sentence structure	1.29 (.46)	2.00 (.63)	1.16 (.37)	$F(2, 90) = 25.20$, $p < .001$, $\eta^2_p = .36$	(D = SA) < CA
Grammar	1.35 (.61)	2.42 (.85)	1.03 (.18)	$F(2, 90) = 43.73$, $p < .001$, $\eta^2_p = .49$	(D = SA) < CA
Capitalisation & punct.	1.23 (.43)	2.16 (.86)	1.10 (.30)	$F(2, 90) = 31.05$, $p < .001$, $\eta^2_p = .41$	(D = SA) < CA
Time taken (mins)	8.89 (2.79)	11.32 (2.98)	6.68 (2.37)	$F(2, 90) = 22.47$, $p < .001$, $\eta^2_p = .33$	SA < D < CA
Number of words	74.52 (37.22)	127.61 (51.37)	35.27 (20.98)	$F(2, 90) = 45.17$, $p < .001$, $\eta^2_p = .50$	SA < D < CA
Writing fluency (wpm)	8.19 (3.34)	11.48 (3.56)	5.17 (2.38)	$F(2, 90) = 30.68$, $p < .001$, $\eta^2_p = .41$	SA < D < CA
Spelling errors	15.39 (9.01)	4.87 (4.08)	12.56 (8.78)	$F(2, 90) = 15.74$, $p < .001$, $\eta^2_p = .26$	(D = SA) > CA
Percentage of text	*21%*	*4%*	*39%*	$F(2, 90) = 57.54$, $p < .001$, $\eta^2_p = .56$	---

Note. a = no standard score available, as the WOLD test is standardised from age 8+; SS = standard score M 100, SD 15. Subcomponents score out of 4; mins = minutes; wpm = words per minute (word/mins).

An independent samples t-test indicated that children with dyslexia were significantly underperforming in the quality of their writing when compared to their CA peers ($p < .001$). The mean scores highlighted that children with dyslexia were performing more than one standard deviation below the mean (M = 82.48), whereas the CA group were marked within the expected range for their age (M = 105). A one-way ANOVA was then conducted for the raw scores. A significant effect of group membership was found, demonstrating again that children with dyslexia were graded significantly lower than the CA group. However, Tukey post hoc comparisons revealed no significant differences between children with dyslexia and the SA group for this measure ($p = .224$).

A MANOVA was conducted on the scores for the six subsections of the writing criteria. Using the Pillai's trace, an overall significant effect of group was found, $V = 0.66$, $F(12, 172) = 7.03$, $p < .001$, $\eta^2_p = .33$. Separate univariate ANOVAs were then conducted and are reported in Table 6.2. For all of the six measures, children with dyslexia performed at a similar level to the SA group, and these two groups were significantly poorer in all measures than the CA group. Closer inspection of the mean scores indicated that children with dyslexia did score slightly higher (although not significantly) than the SA matches on all measures except for vocabulary. It would appear that these two groups are generally scoring between 1 and 2, which suggests that they exhibit frequent errors in these areas and the written text is very simplistic with little organisation. In contrast, the CA group generally scored between 2 and 3, which would reflect more sophisticated word, sentence and text structure with fewer grammatical errors. The final point to make is that while all three groups' highest score was for the ideas and development subcomponent, the lowest scores varied. Children with dyslexia scored worse when assessed on capitalisation and punctuation in their free writing, the CA lowest score was for organisation, whereas grammar was the lowest score shown by the SA group.

A factor analysis was computed to establish the pattern of the relationship between the six scoring components. The Kaiser-Meyer-Olkin measure confirmed the sampling adequacy for this analysis, KMO = .87. A value above .7 for the KMO is considered to be adequate (Field, 2009). Bartlett's test of sphericity, $p < .001$, indicated that correlations between items were large enough for a factor analysis. The factor analysis generated a single factor solution, which accounted for 70.11% of the variance. This type of factor analysis was also conducted for each individual group, which lowered the KMO but yielded the same one factor solution. The solution for the groups combined is included to comply with the KMO statistic.

For the final analyses in Table 6.2, a MANOVA was conducted on the text characteristics. Using the Pillai's trace, an overall significant effect of group was found for the measures of time taken, words written, fluency, and the number of spelling errors, $V = 0.87$, $F(8, 176) = 16.20$, $p < .001$, $\eta^2_p = .44$. The univariate ANOVAs are reported for these measures in Table 6.2 to allow for comparisons across the three groups. Post hoc comparisons highlighted that children with dyslexia wrote for a significantly shorter amount of time and produced fewer words overall, and thus per minute, than their CA peers. However, they did write significantly more and for longer than the SA group. Children with dyslexia made a high percentage of spelling errors in their writing, in comparison to the CA group; and for this measure, children with dyslexia were matched to the SA group on spelling ability once again.

6.3.2.2 Within-group variability

Table 6.3 now recognises variability within groups on written performance. For this analysis within-group variability was recorded only for the children with dyslexia and the CA group because a standardised score was not available for the SA group. Table 6.3 illustrates the number of participants and the overall percentages of the specific group that performed at the level of the mean score (100) or above, up to 1SD below the mean (85-100), and those that scored more than 1SD below the mean (less than 85).

Table 6.3. The number (%) of participants performing around the WOLD mean standard score

	D	CA
At or above the mean	3/31 (10%)	17/31 (55%)
Up to -1SD	9/31 (29%)	14/31 (45%)
> -1SD	19/31 (61%)	0/31

The majority of children with dyslexia performed more than one standard deviation below the mean for the WOLD overall quality score. However, subtle differences can be seen by the variability within this group, as a small number were able to score 100 for this measure. In contrast, the majority of children in the CA group achieved a standardised score of 100+. Although, just under half of the CA group score slightly below the average mean score, while none of them scored more than 1SD below the mean. These calculations have demonstrated that in both groups participants' ability can vary but that children with dyslexia largely achieve lower than their CA peers.

6.3.2.3 Correlations

Table 6.4 displays the Pearsons correlations for the WOLD raw score and the dependent measures: number of words written, words per minute, and spelling errors. Reading and spelling ability as collected from the BAS-II standardised test (Elliott et al., 1996, Chapter 5) were also included in the analysis to determine their relationship to written ability. The WOLD raw score was used as the quality measure, rather than the standard score, so that the SA group could be included. Analyses were calculated separately for each group and using one-tailed correlations based on priori predictions from the literature.

Table 6.4. WOLD written compositional quality correlations with text characteristics and the ability measures

	D (*n* = 31)	**CA** (*n* = 31)	**SA** (*n* = 31)
Number of words	.72*	.54*	.72*
Words per minute	.83*	.60*	.43*
Spelling errors in text	- .51*	- .07	- .38
Spelling ability (BAS-II)	.60*	.30	.04
Reading ability (BAS-II)	.57*	.24	.22

Note. * Bonferroni correction $p < .01$ (one-tailed).

For children with dyslexia all of the dependent variables above significantly correlated with the overall written quality score. The strongest correlation for this group was with writing fluency, followed by the total number of words written, spelling and reading ability, and finally a negative correlation with spelling errors within the text. This significant relationship between spelling performance (both within the text and from the standardised measure) and text quality was only found for children with dyslexia. The CA and SA groups revealed positive correlations (medium to large) with the variables related to productivity and written text quality.

Additional correlations were conducted between the number of spelling errors and the number of words written in the text. A significant negative correlation was only found for children with dyslexia (r = -.43), indicating that the higher the number of spelling errors made in the text the fewer words written overall.

The aim of the next set of correlations was to determine the relationship between memory capacity and text quality, shown in Table 6.5. Performance on the memory measures was discussed in the previous chapter, incorporating both verbal and visuo-spatial short-term memory (STM) and working memory (WM).

Table 6.5. WOLD written compositional quality correlations with the memory measures

	D (n = 31)	**CA** (n = 31)	**SA** (n = 31)
Verbal STM	.42	.21	-.13
Visuo-spatial STM	.22	.04	-.12
Verbal WM	.40	.15	.14
Visuo-spatial WM	.35	-.36	-.21

Note. * Bonferroni correction $p < .01$ (two-tailed); memory capacity assessed from the AWMA = Automated Working Memory Assessment.

When the Bonferroni correction was applied to the correlational analyses in Table 6.5, this meant that the significant level was reduced to .01. At this level, no significant correlations were found between the verbal or visuo-spatial memory measures and written text quality of the three groups.

6.3.2.4 Regression analyses

The final stage of analyses uses the correlational results displayed in Table 6.4 to determine which of the variables had a predictive value on the quality of writing produced by the three groups. As a different pattern of results was observed for the correlational analyses across groups, separate regression analyses were conducted for each group. Memory capacity was not included in the following regressions because no significant correlations were found with writing.

Tables 6.6-6.8 display the regression analyses for each of the three groups. For children with dyslexia (6.6), multiple regressions were conducted using the measures of spelling ability, reading ability, and words per minute as predictor variables against the WOLD quality score as the outcome variable. The number of words written was not included as a predictor variable as this loads on the same factor as words per minute.

For both the CA (6.7) and SA (6.8) groups, linear regressions were conducted. The reason behind this was that only the productivity variables were significant in the correlation analyses, and to remain consistent across group the words per minute value was entered as the predictor variable.

Table 6.6. Regression equations predicting the quality of writing produced by children with dyslexia

Dyslexia	β	R^2	R^2 change	*F*	*df*	*p*
Spelling ability	.21	.36	.36	15.96	1, 29	< .001**
Reading ability	.04	.37	.01	.84	1, 28	.37
Words per minute	.68	.69	.32	27.91	1, 27	< .001**

Note. *p < .05, **p < .001

The regression analyses in Table 6.6 indicate that for children with dyslexia spelling ability accounts for 36% of the variance in writing quality, whereas reading ability does not have a significant effect, and productivity (reported as words written per minute) contributes a further 32% of variance. Together spelling ability and productivity constitute a large sum total of 68% that can significantly predict written performance for children with dyslexia.

Table 6.7. Regression equation predicting the quality of writing produced by the CA group

CA	β	R^2	R^2 change	*F*	*df*	*p*
Words per minute	.68	.43	.43	22.03	1, 29	< .001**

Note. *p < .05, **p < .001

In contrast, for the two typically developing comparison groups, words written per minute were significant predictors of writing quality. Table 6.7 demonstrates that for the CA group, the variable (words per minute) accounted for 43% of the quality of written work.

Table 6.8. Regression equation predicting the quality of writing produced by the SA group

SA	β	R^2	R^2 change	*F*	*df*	*p*
Words per minute	.40	.16	.16	5.54	1, 29	.02*

Note. *p < .05, **p < .001

Similarly, Table 6.8 revealed that 16% of the quality of written work produced by the younger SA group is significantly predicted by the number of words written per minute.

6.3.3 Discussion

This study was designed to identify whether the quality of the written compositions produced by children with dyslexia differed to their chronologically age-matched peers. To clearly answer the first research question, yes, children with dyslexia were found to perform significantly below their peers on written ability. It is important to note here that spelling errors in the text were removed when scoring compositions and, therefore, did not influence the quality ratings. When considering the level that would be expected for the age of these participants, children were dyslexia were also identified as scoring significantly below what would be expected based on the general norms of the test.

Within group analyses revealed that both children with dyslexia and their peers showed variation in written ability. This was expected from children with dyslexia as definitions of this disorder stress that symptoms are often observed on a continuum (Rose, 2009), indicating that characteristics may vary. In fact, the quality of the writing produced by 61% of the children with dyslexia was graded as more than one standard deviation below the age mean. This supports the findings of Berninger et al (2008), whereby children with dyslexia were found to perform more than one standard below the mean on tests of written expression. However, the present study provides more detail as children with dyslexia were identified as showing a trend of scoring lower than their age-matched peers in all six analytical categories. Writing difficulties are accentuated for children with dyslexia when considering the analytical scoring. The fact that children with dyslexia differ from their age-matched peers indicates that the poor writing they produce is not a result of age or cognitive ability. Rather, the performance of these children resembled that of the younger spelling-ability matched group and thus the level of writing is proposed as linked to spelling ability.

On average, all three groups received the highest mark for their ability to express ideas and to elaborate on these in writing. This finding confirms that the writing topic did not present difficulties in eliciting ideas and, therefore, proposes that the writing task was set to an appropriate level for this age group. In contrast, all groups differed in the component that was noted to be their weakest. For children with dyslexia, the lowest score was for capitalisation and punctuation, whereas their peers scored worse out of the six measures for the organisation/coherence component, and grammar was marked as lowest in the spelling-ability group. This finding further sets aside the children with dyslexia and the spelling-ability group from the age-matched peers. The latter group displays difficulties with a higher-level process that is required when writing to ensure that the written text is coherent. Whereas, the lower scores shown by children with dyslexia and the spelling-ability group reflect problems with acquiring/demonstrating the lower-level skills of writing.

It was predicted that a factor analysis would reveal two separate factors from the WOLD, as in the Dockrell et al (2007) study a two-factor solution for the WOLD criteria was reported; separating the semantic dimensions (ideas, vocabulary) from the ‘rule based’ factors (grammar, punctuation). In fact, the results from the factor analysis in the present study support a later study by Dockrell and colleagues (2009), finding that a single factor was generated from the subsections from the marking criteria, pointing towards a general coordination of all of these skills rather than dominance in a particular area and may explain why across the marking criteria participants appear to score similarly for each component. Both studies from Dockrell and colleagues (2007; 2009) pinpointed children with SLI, with the study in 2007 focused on children of the same age as the children with dyslexia and their peers in the present study, and the 2009 study represented SLI children at age 16. Similarities between the single factor result on the present WOLD findings and the older SLI age group (2009) may be attributed to developmental level. On the six subcomponents from the WOLD children with dyslexia scored higher than the SLI children in the Dockrell et al (2007) study and thus, in comparison, do not present with difficulties as severe as those with wider language difficulties.

Similar to findings from university students with dyslexia (Connelly et al., 2006; Gregg et al., 2007), children with dyslexia were found to write for a shorter period of time and, thus produce less than their peers, while demonstrating a high proportion of spelling errors. On average, children with dyslexia wrote for only two minutes less than their peers but produced nearly half the amount. As these children scored highly on the measure of ideas presented, it is reasonable to propose that something else other than idea generation is constraining written production, such as spelling whereby errors were of a high proportion to text length. Indeed a higher number of spelling errors within the text were found to relate to a poorer quality of text written by children with dyslexia. Moreover, regression analyses demonstrated that spelling ability accounted for a significantly large portion of variance in text quality, while productivity contributed further to the quality scores. This indicates a close relationship between spelling, productivity, and text quality for children with dyslexia.

A relationship like the one just described could be explained by considering the spelling difficulties children with dyslexia experience. Firstly, awareness of spelling difficulties could influence their motivation to write. Motivation to write has been found to relate to quality of written text and can be a real issue for children with spelling problems (Berninger & Hidi, 2007). If this is the case, children with dyslexia may put little effort into the task, which could explain the shorter writing time and the lower quality score. On the other hand, the spelling difficulties experienced by these children could jeopardise the efficiency of the writing processes. Cognitive resources are being devoted to the lower-level spelling process; meanwhile the higher-level processes have fewer resources to draw upon for self-regulation of planning and organising the written content. As a result, the process of generating text becomes more arduous and a basic level of written text is composed.

Surprisingly though, working memory capacity did not to reveal a large correlation with the quality of the written compositions produced by children with dyslexia. It was initially predicted that a smaller verbal working memory capacity would reflect a weaker piece of written work because of the role of phonology when writing and the use of the phonological system in working memory. While a relationship was present, this was relatively small. Furthermore, no relationship was found between any of the working memory measures and the quality of the writing produced by the typically achieving comparison groups. In the previous chapter it was demonstrated that all three groups performed relatively close to the expected mean value for each of the memory tasks. Therefore, capacity was not considered to be limited, or a deficit in the case of children with dyslexia. However, the role of working memory has been highlighted in typically developing studies (Baddeley et al., 1998; McCuthen, 1996), and the lack of a relationship in the present study might be explained by the chosen working memory tasks not directly drawing from the same cognitive processes used when writing, as they required processing of spoken information.

In contrast, productivity (words per minute) was the strongest predictor for the age-matched and spelling-ability matched groups. This finding of text length predicting text quality is consistently supported in the literature of typically developing studies of children and adults (Beauvais et al., 2011; Christensen, 2004; Graham et al., 1997) and has been found for adults with dyslexia too (Connelly et al., 2006; Gregg et al., 2007). However, in contrast to children with dyslexia spelling did not have a significant relationship to written text quality for the two comparison groups, which may explain why the age-matched group performed much better than children with dyslexia.

Findings that warrant further discussion are those shown by the spelling-ability matched group. This comparison group performed at the same level as children with dyslexia in terms of quality and the number of spelling errors made, although they wrote fewer words overall and for a shorter period of time. In fact, children with dyslexia wrote almost twice as much as the spelling-ability group and, therefore, it is worrying that writing quality remains similar. When looking through the texts written by these two groups it is apparent that children with dyslexia cross out many of their words and select different words or spelling combinations (all written words were included in the word count analyses to gain a profile of how productive these children are). In addition, children with dyslexia tended to list items they would like in their house rather than write a letter about how they would want it to look (the latter being the aim of the task). This was true for a number of participants in the target group. Listing items received lower scores on the subcomponents of the marking criteria; as ideas are not developed, organisation is not evident, a range of descriptive vocabulary is not seen, and sentence structure is lacking. Furthermore, children with dyslexia rarely punctuated their sentences. In comparison, although the spelling-ability matched group produced shorter written compositions, they demonstrated clearly formed sentences.

It is hypothesised that for children with dyslexia spelling acts as a constraint on the writing processes, hindering the expression of ideas. It would appear that this word-level difficulty of processing phonological and orthographic information when spelling extends to problems at a wider level when composing written text. However, for those typically progressing but of the same spelling level spelling is supporting the composing process, albeit less productive, perhaps due to level of experience.

A limitation to this study was the young age of the spelling-ability group. This group will have had less experience of writing in school. If at this stage these children were not familiar with an acceptable length for a piece of written text, this could explain why they wrote less. However, the important thing to keep in mind is that even with less experience these children were matched to older children with dyslexia for overall writing performance.

The data from this study fits the initial predictions that proposed children with dyslexia would perform in a similar manner to the findings in the literature of university students with dyslexia. Predictions of poor spelling to be influencing the quality of the compositions by children with dyslexia were correct too, and correspond with the Berninger et al (2008) study. Possible explanations for these findings have been discussed above. However, an additional explanation could be through the route of reading. Problems with reading can lead to less exposure to print, which in turn could be expected to affect the quality of writing produced, as discussed in Chapter 2 reading develops knowledge not only of vocabulary and spellings but also of writing styles and conventions. Nevertheless, when entered into a regression equation reading ability failed to significantly contribute unique variance on the quality of texts produced by children with dyslexia. Thus, it could be concluded that general reading ability does not have a large impact on the writing of these children, or at least not as large as spelling does.

Of course, it cannot be ruled out that reading does not have an indirect influence on the online execution of the writing processes. The process of re-reading what has already been written has been found to be engaged in parallel while continuing to write (as reported from eye-tracking studies, see Alamargot et al., 2006). However, a question could be posed here with regards to the effect spelling is having on re-reading as well writing. Indeed, a few children with dyslexia that participated in this study expressed that they never check over their written work once finished because they are unable to read what had been written. For these children, their misspellings were illegible. This point further highlighted that poor spelling interferes with the reviewing process and that they were unable to remember what they had previously written. In this sense it is more reasonable to propose that spelling would directly influence the writing of children with dyslexia; and while reading and writing share similar characteristics, they have been shown to be separable processes (Fitzgerald & Shanahan, 2000; Shanahan, 2006).

A final point to make here in support of the influence of spelling on writing is that explicit teaching of spellings has been found to lead to improvement in the quality of written composition (Berninger et al., 2002). Thus, a large part of the difficulty that children with dyslexia have with writing could be partly dealt with through specific spelling interventions that will then have indirect effects through to improved compositional development.

Overall, a great strength of this study is that the analytical scoring of the written compositions is similar to what would be expected by teachers based on the national curriculum with respect to, awareness of the reader (ideas and development), the structure of the text at the word, sentence and discourse level, punctuation, vocabulary level, and grammar (DfE, 2011). Therefore, it is possible to relate the findings to what is expected at that level of schooling. On the other hand the WOLD scoring scale could be criticised, as 1 to 4 is a narrow scale. However, the strength of the defined categories to assess many components of writing outweighs this limitation at this point.

6.4 Overall conclusions

The present study demonstrated that children with dyslexia are significantly underperforming in all of the writing components that assess quality of text. The widespread consequences that poor spelling can have on the written product are emphasised. Furthermore, the similar performance to the younger spelling-ability matched group points towards providing evidence for delayed development of writing skills in children with dyslexia.

The data that was gathered from the written product yields fascinating results that certainly warranted further exploration. The following chapter provides an insight to the nature of the spelling errors made by these children and Chapters 8 and 9 will delve further into the vocabulary and handwriting profile from this writing task and additional tasks, making the connection back to the influence of spelling.

7

Spelling Error Analysis

7.1 Introduction

At this point, it has been established that the present sample of children with dyslexia have difficulty with phonological segmentation, accurate and fluent reading, spelling, and that they produce a poorer quality of written text in comparison to their peers. The purpose of this chapter is to continue to conceptualise the present sample of children with dyslexia, alongside the two comparison groups. Spelling errors provide an indication of the linguistic nature of the child's difficulties. This topic is addressed here as the spelling errors to be analysed were taken from the standardised spelling task and the written compositional task reported in the previous chapters. The hypothesis to test for this chapter:

2. Children with dyslexia will reflect problems with **phonology and orthography in the spelling errors** made in the written compositions and the dictated spelling task.

Accurate spelling relies on a person's ability to identify and segment spoken words into phonemes, and then to convert these phonemes into grapheme codes ready for translation by hand. There is a strong link between early phoneme segmentation skills and its predictive value of spelling attainment years later (Muter, Hulme, Snowling, & Taylor, 1998). Based on the findings in the current literature (Apel et al., 2004; Cassar & Treiman, 2004), and the results reported from the phonological segmentation task in Chapter 5, it could be predicted that the spelling errors produced by children with dyslexia would reflect high levels of phonetic implausibility.

Comparison groups are particularly helpful in this aspect of analyses. Ehri (1997) argues that spellings are produced either by memory, analogy, or invention. Challenging spellings can be difficult due to phoneme-grapheme irregularity, or low frequency because they are new to our vocabulary and therefore will undergo the invention process. Relating this to the functional spelling architecture proposed by Tainturier & Rapp (2003), the invention process depends on the phonology-orthography conversion system. The phonological structure of the target word and the spelling conventions of the language need to be acknowledged. Analysing spelling errors across typical groups as well as children with dyslexia provides an understanding of how typically progressing children invent spellings. The dual comparison allows the question to be asked regarding whether children with dyslexia are able to acknowledge phonology and orthography at a level that is appropriate for their stage of development; it also sheds light on whether a delay or deviance is evident in the development of their spelling knowledge.

7.2 Phonology, orthography, and morphology

Theories of spelling development (Ehri, 1997; Perfetti, 1997) postulate that spoken vocabulary provides a starting point to recognise and produce phonemes in conversation. This knowledge is subsequently developed when mapping graphemes to phonemes when reading and vice versa when producing written spellings. As well as knowledge of phonology, spelling develops with an increase of orthographic knowledge through reading exposure (Cassar & Treiman, 2004; Frith, 1985; Perfetti, 1997), which provides opportunities to process acceptable letter strings and vowel-consonant positions within a word. As orthographic skills develop, children are able to blend phonemic strings to produce a written word, rather than isolating each individually recognised phoneme (Perfetti, 1997). Stage theories take the view that development at the later, more developed, stages are a result of progress made in the earlier stages. Furthermore, they argue that phonology and orthography eventually merge into a single representation and support overall knowledge of spelling conventions (Ehri, 1997; Perfetti, 1997). From this angle the question that could be asked is, how does orthography progress if phonology is poorly developed? Could it be that orthography is also an area of difficulty for children with dyslexia, as Perfetti (1997) did suggest that reading increases orthographic knowledge?

Analyses of errors made by children with dyslexia in a constrained spelling test have revealed noteworthy difficulties with phonology when spelling both words and nonwords (Bernstein, 2009). Errors are typically coded as phonetically accurate when the word is easily recognised by the selected phonemes even though they are not the exact ones in the target word; or phonetically implausible, meaning that the attempt does not represent the phonemes in the target word, phonemes may be omitted or alternatives used inappropriately (Bernstein, 2009; Bruck & Treiman, 1990). Studies that have scored errors in this way have reported little differences for phonetic accuracy between children with dyslexia and younger spelling ability matched children (Bourassa & Treiman, 2003; Nelson, 1980). This finding suggests that these two groups develop in a similar way albeit children with dyslexia are delayed for their age.

Similarly, phonetically implausible spellings have been detected in the errors made by university students with dyslexia from a dictated spelling task and a writing task where word choice was not constrained (Coleman et al., 2009). In comparison to typically developing peers, these students with dyslexia made a high number of phonological and morphological spelling errors, pointing towards inability to develop and use these skills even at an advanced level of education. Furthermore, it was reported that in the writing task, students with dyslexia made many errors on only one-syllable words. Coleman et al (2009) expressed that shorter words, as a general rule are often easier to spell. Therefore, it would appear that the weight of these difficulties with accurate spelling remain even for high-functioning adults with dyslexia.

Considering orthographic spelling ability, Bourassa & Treiman (2003) found that children with dyslexia produced a higher number of orthographically accurate errors in words than nonwords; a pattern that was mirrored by a spelling-ability matched group. The authors suggested that children with dyslexia compensate for phonological difficulties by using orthographic strategies when spelling words. This would suggest a level of dissociation in the final stage of spelling development, which typically is thought to progresses in stages from phonology to orthography (as suggested by spelling stage theorists, Ehri, 1997 and Perfetti, 1997). Olson (1985) discovered that children with dyslexia are able to detect successfully word forms that are orthographically acceptable from a word list compared to those which are not, even though the phonological form of both test items where accurately matched. In Olson’s (1985) study, children with dyslexia performed similarly to reading-matched children; although when reading nonwords that required advanced phonological skills children with dyslexia performed significantly below the comparison group. Together these findings support the idea that the orthographic skills of children with dyslexia are more advanced than their phonological skills. However, it should be noted that this is only really in relation to reading as these children were asked to recognise orthographically acceptable spellings and not to produce them.

In fact, orthographic errors were highly reported from the misspellings of children with dyslexia in the Berninger et al (2008) and Bernstein (2009) studies that used children of the same age as Bourassa & Treiman (2003). In further support of orthographic difficulties, a study of university students with dyslexia noted inconsistent orthographic spelling attempts that points towards a difficulty with memorising acceptable spelling conventions too (Kemp, Parrila, & Kirby, 2009).

Inconsistent findings in this field could be partly attributed to the various methods of analysing errors. Researchers tend to employ different strategies and provide few examples of the way they code for errors. For example, if the target word was ‘cake’ but a child spelled it as ‘ckoke’, this could be coded as an orthographic error because the ‘ck’ at the beginning of a word in English is orthographically unacceptable. However, it could also be classed as a phonetically implausible as the phonemes in ‘ck*o*ke’ are not pronounced as ‘c*a*ke’ and out of context the target word would not have been easily identified. On the other hand, if it was spelt as ‘ck*a*ke’ it could be classed as orthographically inappropriate still but this time it would be phonetically accurate. There is often an overlap between phonology and orthography. For the purpose of the present analyses the definitions and justification of methods used to classify errors is made in section 7.4.1.1.

In addition, morphology has an important role in spelling development. Morphology is a linguistic unit that attaches meaning to a base word. Recognition of morphemes within a word can help to assist phonology when spelling unfamiliar words (Bourassa, Treiman, Kessler, 2006). Henderson (1981) considered the last stages of spelling development (of a total of 5 stages) to reflect the knowledge that syllable junctures lead to an inflexional ending, and that derived forms of a word reflect meaning. At this level phonology, orthography, and morphology are combined to aid spelling.

Composing written text can influence the expression of morphology. Tense (past, present, future) relates to the relevant expression of morphology. As well as recognising the derived forms of words, knowledge of affixes play a crucial part when composing grammatically correct sentences. Nunes, Bryant & Bindman (1997) argued that the more advanced phonology is, the greater the opportunity for acquiring new morphological knowledge. University students with dyslexia were six times more likely to make an error that demonstrated poor morphological awareness than their age matched peers (Coleman et al., 2009). Likewise, university students with dyslexia have been shown to reflect difficulty in processing derived word forms (distinguishing morpheme units) when completing lexical decision tasks (Deacon, Parrila, & Kirby, 2006). These findings would suggest that morphology could be another area of spelling difficulty for younger children with dyslexia.

Aside from stage models of spelling development, connectionist models accentuate the relationship between phonology and orthography as being supported by lexical cues of the word (Tainturier & Rapp, 2003). The role of word frequency has been demonstrated to mediate the mapping of phoneme-grapheme, with high frequency words being more rapidly accessed than low frequency words and emphasising a frequency-regularity interaction (Houghton & Zorzi, 2003). Therefore, varied performance under the category of phonological or orthographic errors may be explained by word frequency effects.

To summarise, although dyslexia research has a tendency to focus on the phonological deficit, research into stages of spelling development (Ehri, 1997; Henderson, 1981; Tainturier & Rapp, 2001) and the spelling performance of children with dyslexia (Berninger et al., 2008; Bernstein, 2009) suggests that orthography and morphology are key components to develop too.

7.3 Predictions based on theories of dyslexia

As children with dyslexia have prominent difficulties with phonological awareness it was hypothesised that the majority of the spelling errors made by children with dyslexia would fail to capture the phonological structure of a word. However, it was noted that the children in the present study are close to the end of Key Stage 2 and phonics has been a very popular teaching method in UK primary schools (DfE, 2011). Therefore, for some of the simpler spellings it could have been expected that children with dyslexia would attempt to spell by sound.

Considering that phonology acts as a foundation for spelling and then children progress to learn orthographic and morphological conventions, it was also predicted that accuracy in these areas would be worse in children with dyslexia than their age-matched peers. Children with dyslexia were expected to perform similarly to the younger spelling-ability group, as this younger sample is still at the initial stages of acquiring spelling knowledge. If similar errors are noted between these two groups this would suggest that children with dyslexia are delayed in their development.

However, it is clear from the connectionist models and from findings that have demonstrated the role of word frequency when spelling (Houghton & Zorzi, 2003; Tainturier & Rapp, 2003), that spellings can be derived from other strategies such as whole word memorisation and analogy. Children may be familiar with certain high frequency words and thus produce appropriate phonology, orthography, and morphology in these words, but not others. Frequency was not measured in the subsequent analyses, as the attempted spellings were from a set standardised spelling task and unconstrained word choices when writing.

However, the role of different spelling strategies to produce a correct spelling may account for times when a varied pattern of performance is observed.

In addition, similar to the findings that university students with dyslexia make a large proportion of spelling errors on short syllable words (mainly one or two syllables; Coleman et al., 2009; Gregg et al., 2007) it is likely that children with dyslexia would limit their vocabulary choices to short words to try and avoid words that they find difficult to spell. Accordingly, it was predicted that a large number of the spelling errors produced by children with dyslexia would be of only one syllable, whereas the errors made by their peers were expected to be words of longer syllables. The syllable length analyses leads on to the following chapter, which explores the link between vocabulary choices and spelling ability.

7.4 Study

Spelling is a language skill that we use to translate our ideas into visible text and as shown by previous research is one that can either benefit or constrain the execution of the writing process (Apel et al., 2004; Berninger et al., 2008; Berninger & Swanson, 1994). For this reason, it is imperative to consider the spelling errors made in a naturalistic writing task. As Apel et al (2004) marked, the nature of these errors represents an "authentic illustration of how students spell when all aspects of written composition are engaged" (p. 651). Undeniably there are limitations with this method because children with dyslexia might limit word choices to those that are considered to be easier to spell. However, the additional analyses from the dictated spelling task are beneficial as children were asked to complete a range of age-appropriate spellings.

This study was conducted to further conceptualise the dyslexia sample and to contribute to current theories of dyslexia. Analyses of the spelling errors made in the narrative writing and the standardised spelling test were explored to answer the following research questions.

Compared to the comparison groups, do children with dyslexia:

a) Show poor phoneme to grapheme correspondence in the spelling errors they produce?
b) Reflect difficulties with orthographic and morphological accuracy too?
c) Produce spelling errors in the narrative writing that are a shorter syllable length?

7.4.1 Method

As this was a follow-up study to analyse the spelling data from Chapter 5 (BAS-II test) and Chapter 6 (WOLD narrative writing), the pool of participants (dyslexia, CA, and SA) and the measures used to collect this data are the same as shown in sections 5.2 - 5.6 and 6.3.1 - 6.3.3.

7.4.1.1 Analysis

Spellings in both tasks were initially scored for correctness (correct or incorrect). Where a spelling was illegible in the written compositions and the child could not remember the target word, these were scored as incorrect and the total numbers of illegible spellings were noted.

The structure of the standardised spelling task meant that all children across the three groups progressed to a level that ought to have been demanding. The administration rules were to continue until the child made eight or more errors within a set of ten words. Even for the typically developing peers, there was an opportunity to analyse errors produced as many reached the more advanced, challenging level of spellings in the last test items.

Similar to Coleman et al (2009), all errors made by participants in the same group were collated together at first to identify where the majority were placed in the error categories. Qualitative descriptions of the linguistic nature of the errors were focused on from the group corpus, a method that was considered to be advantageous by Silliman, Bahr, & Peters (2006). Following this, quantitative analyses were conducted on the average performance of individual children across the three groups.

The first stage of coding errors concerned <u>phonology</u>. Coleman et al (2009) used a 5-point rating scale to identify whether spellings were plausible: ranging from (1) not recognisable in the absence of the context, to (3) spellings are distorted, and (5) when spellings are plausible. However, this is quite a subjective way to assess spelling and the purpose of the present analysis was to clearly establish whether spellings had strong or weak phoneme-grapheme correspondence. Therefore, spellings were either coded as <u>phonetically accurate</u> or <u>phonetically implausible</u>. The phonetically accurate scoring method is the same as used by studies discussed previously in this chapter (Bourassa & Treiman, 2003; Lennox & Siegel, 1996; Nelson, 1980; Silliman et al., 2006), although they chose to call this method the phonologically unconstrained analysis, as it does not take into consideration orthographic spelling rules at this point. Table 7.1 provides examples of these types of errors collected from the written compositions.

Table 7.1. Examples of coding for phonology from the written narrative spelling errors

	D	CA	SA
Phonetically accurate	*'sinamar' 'sofer' 'pritty'*	*'massarge' 'duvay' 'lamboginie'*	*'pinc' 'plasmer' 'banistar'*
Correct spellings	*'cinema' 'sofa' 'pretty'*	*'massage' 'duvet' 'lamborghini'*	*'pink' 'plasma' 'bannister'*
Phonetically Implausible	*'hodrss' 'bule' 'acose'*	*'defersles' 'garge' 'basially'*	*'seecat' 'box' 'blowe'*
Correct spellings	*'hundreds' 'blue' 'across'*	*'defenceless' 'garage' 'basically'*	*'secret' 'books' 'blue'*

After scoring for phonology, all spellings were recoded for inaccuracies in orthography and morphology. The decision of whether spellings were orthographically inaccurate was based on the few examples that are supplied in the current literature. Bourassa & Treiman (2003) demonstrated that 'klmal' or 'tmat' are orthographically inaccurate for the word 'tomato'; whereas 'clen' is acceptable for the word 'clean'. An error where a consonant was not doubled is classed as an orthographic error, likewise so is failing to recognise a silent <e> (Bebout, 1985; Bourassa & Treiman, 2003; Coleman et al., 2009).

Due to the close overlap between defining phonological and orthographic inaccuracies (as shown in the 'ckake' example in section 7.2), orthographic spelling errors were also scored under the two headings of phonetically accurate or phonetically implausible, to ensure that data was appropriately scored. In the present study, the classification of an orthographic error that still abides to phonological rules was grouped as '<u>orthographic error – phonetically accurate'</u> (labelled as phonologically constrained in the papers of Bourassa & Treiman (2003) and Silliman et al., (2006), although this term was not considered to be as clear). Table 7.2 provides examples of these categories.

A number of orthographic errors also lacked appropriate phonology. Therefore another category was created that determined when spelling errors were noted as '<u>orthographic error – phonetically implausible</u>'. Errors in this category were considered to violate both the rules of English orthography and could not be pronounced accurately based on the phonemes used in the attempted spelling.

Table 7.2. Examples of orthographic and morphological errors, either phonetically accurate or phonetically implausible, and homophone mistakes

	D	CA	SA
Orthographic error - PA	*'vyiew'*	*'outher' 'masive'*	*'cklows' 'bedjroom'*
Correct spellings	*'view'*	*'other' 'massive'*	*'clothes' 'bedroom'*
Orthographic error - PI	*'facoo' 'aor'*	*'ivite'*	*'nayd'*
Correct spellings	*'thank you' 'art'*	*'invite'*	*'named'*
Morphological error - PA	*'fancie' 'comfei'*	*'powerd' 'helpfull' 'balconys'*	*'swimmig' 'siten'*
Correct spellings	*fancy' 'comfy'*	*'powered'* 'helpful' *'balconies'*	*'swimming' 'sitting'*
Morphological error - PI	*'sterinke'*	*n/a*	*'hast'*
Correct spellings	*'stinky'*	*n/a*	*'has'*
Homophone mistakes	*'pear'* - *'pair' 'wood' – 'would'*	*'witch' – 'which'*	*'too' – 'to'*
Note. PA = Phonetically Accurate; PI = Phonetically Implausible.			

The same method was used for the morphological spelling errors, whereby they were classified as a morphological error that remained phonologically accurate or phonetically implausible. It is worth noting here that morphological errors were very rare in the narrative writing but this could not be controlled, as it was an unconstrained task. As can be seen in Table 7.2, there are no examples for the CA group producing morphological errors that were phonetically implausible, as they did not make errors of this kind. Another important point to make is that only the number of inaccurate errors for these categories was calculated; as opposed to the phonological scoring that split all errors as accurate or not.

Homophone errors were identified because Coleman et al (2009) reported that university students with dyslexia made a considerable number of homophone substitutions. These errors remain both phonetically and orthographically accurate, but would relate more so to a semantic/linguistic error.

Finally, syllable length of each of the spelling errors made in the narrative writing task was calculated because it would lead on to the direction of the following chapter regarding vocabulary choices when writing. Syllables were counted using the SMOG Trottier's calculator, which uses a dictionary to look up the syllable length of words (McLaughlin, 1969). Errors were grouped as having one syllable, two syllables, or three and more.

7.4.2 Results

Overall considering each group corpus, in the spelling task children with dyslexia made a total of 377 spelling errors, the CA group made 313 errors, and the SA group made 289 errors. The reason for a high number of misspellings by the CA group relates to the procedure of this particular test. The rules of the spelling test were to keep going until children made at least eight errors in a block of ten.

On the other hand, in the writing task as a whole children with dyslexia made a total of 490 spelling errors, the CA group made 151 errors, and the SA group made 391 errors overall. There was an observable increase in the number of errors made by children with dyslexia and the SA group in their narrative writing. However, there was a decrease in the number of errors made by the CA group in the spelling test and the narrative writing.

7.4.2.1 Phonetically accurate or implausible

Table 7.3 presents the phonological analysis of the spelling errors made in the standardised spelling test (BAS-II; Elliott et al., 1996). The brackets represent the percentage of the overall spelling errors in each category, by each group.

Table 7.3. Phonological analyses of the spelling errors in response to the BAS-II spelling test

	D	CA	SA
Phonetically accurate	117 (31%)	249 (80%)	141 (49%)
Phonetically implausible	260 (69%)	64 (20%)	148 (51%)

Note. Percentages in brackets = the overall % of spelling errors that were either phonetically accurate or implausible out of the total number of errors.

A large percentage of the errors made by children with dyslexia (69%) did not conform to the phonetic rules of spelling. In contrast, the majority of errors made by the CA group were phonetically accurate and it must be reiterated here that a large number of the CA group progressed to the end of the spelling test and thus were presented with more difficult spellings than the other two groups. Performing better than children with dyslexia in terms of the number of phonetically accurate misspellings made, the SA group made a roughly equal number in the two error categories.

Next, Table 7.4 displays the phonological analyses of the misspellings produced in the writing task (WOLD; Rust, 1996). 5 out of the 31 children in the CA group made no spelling errors when composing text. Every child with dyslexia and those in the SA group made at least one error, while some made errors that were illegible.

Table 7.4. Phonological analyses of the spelling errors made in the WOLD narrative writing task

	D	CA α	SA
Phonetically accurate	146 (30%)	121 (80%)	205 (52%)
Phonetically implausible	331 (68%)	30 (20%)	161 (47%)
Unidentified	13 (2%)	n/a	5 (1%)

Note. α= 5 participants in this group made no spelling errors in their free writing. Percentages in brackets = the overall % of spelling errors that were either phonetically accurate or implausible out of the total number of errors.

The CA group produced a large percentage of errors that were phonetically accurate. In contrast, two-thirds of the spellings errors made by children with dyslexia were phonetically implausible and, once again, children in the SA group made roughly an equal amount of phonetically accurate and implausible errors. Furthermore, children with dyslexia made a number of spelling attempts that were illegible to both the researcher and the child.

Quantitative analyses are shown in Table 7.5 for the level of phonology in the spelling errors across the two tasks. Mean performance represents individual performance rather than the group corpus. Percentages reflect the proportion of errors that were either phonetically accurate or phonetically implausible relative to the number of errors made overall for each participant. By showing the proportion it controls for the different number of errors that were made across the groups. This time the numbers in brackets represent how many participants in each of the three groups made at least one error or more in this category.

In the standardised spelling task all children with dyslexia and those in the SA group made errors in each phonetic category. Whereas on the same task only 25 of the CA children made an error that was marked as phonetically implausible and 30 made phonetically accurate errors, with 1 child from the CA group making no errors at all. In the narrative writing, all children with dyslexia made phonetically implausible errors whereas 2 of these children made no phonetically accurate spelling errors. 5 of the children in the CA group made no errors at all in the written compositional task and less than half made a phonetically implausible error. Finally, the majority of children in the SA group made errors that were classed as phonetically accurate with one child in this group making only phonetically implausible errors.

Table 7.5 Phonological analyses across both tasks and the number of participants that made these spelling errors

	D (*n* = 31)	**CA** (*n* = 31)	**SA** (*n* = 31)
BAS-II spelling			
Errors per person	12.23	10.06	8.06
Phonetically accurate	32% (31)	77% (30)	51% (31)
Phonetically implausible	68% (31)	23% (25)	49% (31)
Narrative spelling			
Errors per person	15.39	4.87	12.56
Phonetically accurate	33% (29)	84% (24)	43% (30)
Phonetically implausible	67% (31)	16% (13)	57% (13)

Note. % represents the relative proportion of errors made in the category; Brackets = number of children (out of a total of 31 in each group) that made at least 1error within the category

A repeated measures ANOVA was conducted for the results in Table 7.5. There was no significant main effect of the task that the spelling errors were analysed from, $F(1, 90) = 2.03$, $p = .16$, $\eta^2_p = .02$. Contrasts revealed that performance across tasks was similar. However, there was a significant effect of phonetic accuracy from the spelling errors, $F(1, 90) = 10.43$, $p = .002$, $\eta^2_p = .10$. The overall estimated means reflected more phonetically accurate errors than implausible errors. There was also a significant effect of group membership, $F(2, 90) = 7.26$, $p = .001$, $\eta^2_p = .14$, indicating that the three groups generally performed differently across these task analyses. Planned contrasts demonstrated that children with dyslexia were not significantly different to the SA group, however these two groups scored significantly higher overall than the CA group.

There was no significant interaction between the task and group membership $F(2,90) = 1.22$, $p = .30$, $\eta^2_p = .03$, indicating that mean performance across the tasks did not differ in the three groups. To break down this interaction, contrasts revealed that in both the spelling and writing task the pattern of errors were consistent. Children with dyslexia and the SA matches made a similar number of errors in both tasks, whereas the CA made more errors in the standardised spelling task.

There was a significant interaction between accuracy and group, $F(2, 90) = 71.56$, $p = < .000$, $\eta^2_p = .61$. Children with dyslexia made significantly more phonetically implausible errors, whereas the CA and SA groups made more errors that were phonetically accurate. However, there was no significant interaction between task and accuracy, $F(1, 90) = .24$, $p = .63$, $\eta^2_p = .03$, revealing that across the tasks the level of phonological accuracy remained constant. Finally, the task x accuracy x group interaction was revealed as non-significant, $F(2, 90) = .98$, $p = .38$, $\eta^2_p = .02$, suggesting that the groups did not differ in terms of accuracy performance and consistency across the tasks.

7.3.2.2 Orthographic, morphological or homophone mistakes

Table 7.6 and 7.7 present the orthographic and morphological qualitative differences between the groups, and the homophone mistakes. Table 7.6 illustrates these results from the standardised spelling test. The percentage of spelling errors that were orthographically and morphologically accurate is presented on the first row, followed by the inaccuracies.

Table 7.6. Further analysis of the spelling errors from the BAS-II

	D	**CA**	**SA**
Orth. & morph. accurate	*41%*	*72%*	*45.7%*
Orthographically Inaccurate – PA	22 (6%)	19 (6%)	20 (7%)
Orthographically Inaccurate – PI	188 (50%)	39 (12%)	134 (46%)
Morphologically Inaccurate - PA	2 (.5%)	28 (9%)	n/a
Morphologically Inaccurate - PI	2 (.5%)	n/a	3 (1%)
Homophone mistakes	9 (2%)	3 (1%)	1 (.3%)

Note. PA = Phonetically Accurate; PI = Phonetically Implausible. Percentages in brackets = the overall % of spelling errors that were either phonetically accurate or implausible out of the total number of errors.

The results shown above demonstrate that over half of the total spelling errors produced by children with dyslexia were orthographically inaccurate and furthermore were not considered to be PA. A small number of errors made by these children were considered to violate morphological rules and only 2% of the total 377 errors made were homophone mistakes. A similar pattern was seen in the SA group, with a high proportion of errors being orthographically inaccurate and PI.

In contrast, 72% of the errors made by the CA group followed the conventions of orthography and morphology. This group was found to make a higher percentage of morphological errors in comparison to children with dyslexia, although they remained PA.

Table 7.7. Further analysis of the spelling errors from the WOLD narrative writing task

	D	**CA**	**SA**
Orth. & morph. accurate	*52%*	*57%*	*50.13%*
Orthographically Inaccurate – PA	51 (10%)	31 (21%)	51 (13%)
Orthographically Inaccurate – PI	142 (29%)	10 (6%)	104 (27%)
Morphologically Inaccurate - PA	19 (4%)	20 (13%)	10 (2.57%)
Morphologically Inaccurate - PI	9 (2%)	n/a	1 (.3%)
Homophone mistakes	14 (3%)	4 (3%)	28 (7%)

Note. PA = Phonetically Accurate; PI = Phonetically Implausible. Percentages in brackets = the overall % of spelling errors that were either phonetically accurate or implausible out of the total number of errors.

Table 7.7 illustrates the spelling errors made from the writing task. A similar percentage of orthographically and morphologically accurate errors were made across groups when making errors in a narrative writing task. Once again, the majority of errors made by children with dyslexia fell in the orthographic error – PI category, and the same patterns were reflected in the SA group. In contrast, the highest proportion of errors in this task by the CA group was recognised as orthographically inaccurate but still PA. Only a small number of errors were shown to be morphologically inaccurate or homophone mistakes.

Quantitative analyses from Table 7.8 were computed on only the orthographic errors because the morphological and homophone errors were extremely small in numbers; with many participants making no errors in these categories.

Table 7.8. Orthographic analyses across tasks and the number of participants that made these errors

	D (n = 31)	**CA** (n = 31)	**SA** (n = 31)
BAS-II spelling			
Errors per person	12.23	10.06	8.06
Orthographically Inaccurate – PA	7% (16)	5% (11)	7% (15)
Orthographically Inaccurate – PI	52% (26)	10% (19)	37% (30)
Narrative spelling			
Errors per person	15.39	4.87	12.56
Orthographically Inaccurate – PA	8% (18)	10% (11)	13% (21)
Orthographically Inaccurate – PI	35% (31)	6% (7)	27% (27)

Note. PA = Phonetically Accurate; PI = Phonetically Implausible. Percentages in brackets = the overall % of spelling errors that were either phonetically accurate or implausible out of the total number of errors.

Similar to Table 7.5 the numbers in the brackets of Table 7.8 represent the number of participants from each specific group that made at least one error in the determined categories. It can be noted that not all children made errors in each of these categories, although every child with dyslexia made at least one error in the writing task that was coded as orthographically inaccurate and PI.

A repeated measures ANOVA was conducted and revealed a significant main task effect, $F(1, 90) = 8.60$, $p = .004$, $\eta^2_p = .09$. Contrasts revealed a higher number of orthographically inaccurate errors in the standardised spelling task. There was also a significant effect of orthographic inaccuracy from the spelling errors, $F(1, 90) = 129.77$, $p < .001$, $\eta^2_p = .59$. The level of orthographic error (PA or PI) revealed a significantly higher number of errors in the PI category. Furthermore, there was a significant effect of group membership, $F(2, 90) = 47.62$, $p < .001$, $\eta^2_p = .51$, indicating that the three groups generally performed differently across these task analyses. Closer inspection revealed significant differences between children with dyslexia and their CA peers, and between children with dyslexia and their SA matches. Overall, children with dyslexia made more errors than the other two groups and the CA group made the fewest.

There was a significant interaction effect between the task and group membership, $F(2,90) = 3.85$, $p = .03$, $\eta^2_p = .08$. Children with dyslexia made more errors in the standardised spelling task, as did the SA group. However, the CA made roughly the same amount of errors in both tasks: no significant differences were found for this group. There was a significant interaction between accuracy and group, $F(2, 90) = 34.56$, $p = < .000$, $\eta^2_p = .43$. Contrasts revealed children with dyslexia made significantly more errors that were classed as orthographically inaccurate PI, with a similar pattern by the SA group although they did not make as many errors as children with dyslexia. In contrast, an equal number of errors were found across these accuracy categories for the CA group.

To follow this up, there was a significant interaction between task and accuracy, $F(1, 90) = 16.17$, $p < .001$, $\eta^2_p = .15$ revealing that in the standardised spelling task orthographic PI was significantly higher than errors that were scored as PA. A similar pattern was seen for the writing task, although the estimated means were not as exaggerated as shown for the spelling task. Finally, the task x accuracy x group interaction was revealed as non-significant, $F(2, 90) = .67$, $p = .51$, $\eta^2_p = .02$, highlighting that the groups did not differ in terms of accuracy performance and consistency across the tasks.

7.4.2.3 Syllable length in misspellings

The spelling errors made by children with dyslexia and the SA group that could not be identified from the narrative writing were excluded from the following calculations. Therefore, for this analysis the total number of identifiable misspellings made in the writing task by children with dyslexia was 477 words, for the SA group it was 386 words, and the total number remains at 151 for the CA group.

Table 7.9 displays the number of misspellings by each group that consisted of one, two, or three + syllables. Percentages in proportion to the total number of spelling errors are provided also to make a comparison possible across groups that differed in the total number.

Table 7.9. Number of misspellings and percentages for the three syllable categories

	D	CA	SA
1 syllable	279 (58%)	29 (19%)	240 (62%)
2 syllables	160 (34%)	76 (50%)	130 (34%)
3+ syllables	38 (8%)	46 (31%)	16 (4%)

The majority of spelling errors made by children with dyslexia were only one-syllable words, with very few reaching three syllables or more, and similarly the SA group made more errors of only one syllable too. The CA group reflected a different pattern, with the highest number of errors made on words of 2 syllables or more. This will be followed up in the following chapter by considering average syllable length of all words written in the narrative task.

7.4.3. Discussion

Consistent with the literature (Bourassa & Treiman, 2003; Coleman et al., 2009; Nelson, 1980), children with dyslexia largely demonstrated phonological difficulties in the spelling errors made from the spelling task and the narrative writing task. This finding lends support to the phonological deficit theory of dyslexia. By way of contrast, the spelling errors made by their age-matched peers were largely phonetically accurate. Qualitative analyses revealed a very small number of the errors by this comparison group were classified as phonetically implausible, although this proportion could be explained by the more challenging spellings this group completed in comparison to children with dyslexia and the spelling-ability matches.

In terms of the proportion of total spelling errors, children with dyslexia made more phonetically implausible errors in the spelling task than the spelling-ability group did, but in the narrative writing task they showed a similar pattern of making a higher number of phonetically implausible than phonetically accurate errors. This finding from the spelling task differs to the Bourassa & Treiman (2003) study that demonstrated a matched performance across these two defined groups. In the present study, children with dyslexia were able to select word choices in the narrative writing task and, therefore, it is possible that they avoided writing words that are difficult to spell, which is hinted at by the findings of one-syllable words being largely misspelt by this group. The error analysis from the writing task could be masking underlying difficulties because these children are able to select word usage; yet, the forced choice spelling task reveals these difficulties in phonology and orthography.

It must be reiterated here that children with dyslexia performed consistently worse than the younger spelling-ability matches in tasks that assessed phonological skills in Chapter 5 (phoneme segmentation, reading, non-word reading). Therefore, differences in phonological accuracy when producing spellings was expected because they are developmentally different, even though these two groups were matched by performance (correct/incorrect) on a spelling task in the participant selection stages. Conflicting results to Bourassa & Treiman (2003) on the spelling task analyses could be attributed to the different word lists used or due to individual differences of the participants. Children with dyslexia in the present study may have exhibited more severe difficulties with phonology. On the other hand, the standardised task used in the present study began with age-appropriate spellings. Words such as ‘do, play, back’ were first administered to the younger spelling-ability group and it was common to see misspellings like ‘doo, plae, bac’, all of which are incorrect but correspond to the phonological structure of the target word. At this younger age, the spellings were at a more basic level and may have been easier to segment using phonology. Frequency could have played a role in why this younger group performed better than children with dyslexia and those in the Bourassa & Treiman (2003) study.

The question of whether children with dyslexia can develop orthographic skills, when phonology is impaired, was assessed through the number of orthographic inaccuracies made. Bourassa & Treiman (2003) reported that children with dyslexia performed equally as well as a younger spelling-ability matched group when scoring spellings on orthographic structure. Using this same measure to decide when errors were orthographically inaccurate, but also adding in the factor of whether this type of error remained phonetically accurate or not, the present results contrast with previous findings (Bourassa & Treiman, 2003; Nelson, 1980). In comparison to the age-matched group, children with dyslexia and the spelling-ability group made a large proportion of errors that went against orthographic rules of spelling and a large number of these hindered phonetic plausibility. However, the mean average of orthographic errors was higher in children with dyslexia than both comparison groups, concluding that this population do not progress in orthography when phonology is poorly developed.

Although the classification of orthographic errors followed the same identification method as in the previous studies discussed, there was a difference in terms of what items were scored. The purpose of the present analyses was to analyse only the errors made. Whereas, Bourassa & Treiman (2003) considered orthographic acceptability across all spelling attempts (those correct and incorrect) and this formed the total score. In their study, on average, children with dyslexia made 9 spelling attempts that were orthographically acceptable and the correct spelling mean score was 5 items. In this case, it is granted that 5 of the 9 spellings would be orthographically acceptable and therefore the mean scores they present do not only consider where children with dyslexia struggle. In addition, a point should be made about the short list they used consisting of only 10 words. A short test battery raises questions about the reliability of these findings and if they can be generalised to a larger sample. An additional criticism is that an age-matched group was not used in the Bourassa & Treiman (2003) study and therefore it is difficult to infer whether children with dyslexia were underperforming in this area when accounting for age.

In this sense, the tasks used in the present study have an advantage because in the spelling task each child completed at the very least 20 words and attempted to spell many more words in the narrative writing task, thus offering a broader analysis of errors which has raised problems with orthography in children with dyslexia.

Problems with accurate morphology were not stressed for any of the three groups. The age-matched peers demonstrated a higher number of morphological errors than the other two groups, although these errors remained, more often than not, phonetically accurate. To some extent, this result was expected since the age-matched peers completed more challenging spellings that included more opportunities to attempt morphology (e.g. words such as ‘beginning’ and ‘measured’). A limitation in this aspect is that children with dyslexia were not appropriately challenged in this area. Further work using a spelling list that taps into each of the spelling components would be beneficial to contribute to profiling the spelling difficulties of this group.

Homophone mistake were also recorded because a number of children did make these mistakes across the two tasks. The finding that children with dyslexia and the younger spelling-ability matched group made this type of errors more frequently than the age-matched group represents a semantic difficulty. In relation to the connectionist models of spelling it may be that the lexical route of spelling is less advanced for children with dyslexia and the spelling matches, in comparison to their peers (Houghton & Zorzi, 2003) and differentiating between the two meanings and their same-sound spellings is difficult. Again, problems with phonology are demonstrated to extend to wider aspects of processing, in this case semantics.

In compliance with previous studies (Coleman et al., 2009; Sterling et al., 1998) and to consider the role of vocabulary when spelling, the final research question revealed that the majority of errors made by the age-matched peers consisted of two syllables or more, whereas children with dyslexia and the spelling matches produced a higher number of errors in words of only one syllable. Two issues are raised from this finding. The first is that children with dyslexia reflect a difficulty with spelling words that are shorter and these could be considered to be easier to spell because they do not require analysis of several word constituents. The second issue is that the word choices made by children with dyslexia in their narrative writing appears to be more constrained than their peers. This point is explored in more detail in the subsequent vocabulary chapter.

To summarise, a main strength of this study is the large corpus of misspelled words available from the two types of tasks. Children with dyslexia were hypothesised to demonstrate poor phoneme-grapheme ability in their spelling errors and that this weakness would influence the expression of orthography too, as phonology and orthography have been shown to overlap in development (Ehri, 1997; Henderson, 1981). This hypothesis was confirmed and in comparison to their peers, children with dyslexia were found to be significantly underperforming in each aspect.

7.5 Overall conclusions

Children with dyslexia have impaired phonological analysis skills (Hansen & Bowey, 1994). A weakness in phonology means that the spelling foundations are initially poorly developed, which has negative consequences for the development of orthographic knowledge; a finding that complies with stage theories of spelling development (Ehri, 1997; Perfetti, 1997).

The difference between the errors made in the set spelling task and the writing task emphasise the role of spelling ability when selecting words (vocabulary). The syllable analysis of misspellings in the writing task demonstrated that children with dyslexia are selecting words of short syllables in comparison to their more advanced peers. Furthermore, by selecting their own word choices spelling difficulties are being masked in comparison to the more orthographic errors made in the forced choice spelling test. At this point it is difficult to firmly establish which direction spelling and vocabulary influence one another, this is addressed in the following chapter.

8

Vocabulary Choices in Writing

8.1 Introduction

Vocabulary is used to articulate ideas in writing and to aid the readers' comprehension of the text. Surprisingly, models of writing fail to include vocabulary and language as either a resource or an active component required when composing a written text. The limitations of such models were addressed in the introductory chapters that emphasised the importance of bridging the gap to incorporate the influence of language on written language production (Chapter 2). The present chapter aimed to clarify the role of vocabulary when writing and its relation to the spelling process.

When reviewing the literature it was apparent that although very few studies have explored vocabulary performance in the written compositions by children with dyslexia, assumptions exist that these children will avoid writing words they find difficult to spell (Berninger et al., 2008). Both spelling and vocabulary are interacting language acts processed largely at the word-level. However, this avoidance of more complex words does remain as speculation; albeit one that had a formative influence on the research questions and the design of the study in this chapter. The hypothesis was:

3. Children with dyslexia will demonstrate a more limited **use of vocabulary in writing** in comparison to their age-matched peers.

Indeed, this question has been partly acknowledged by the findings in Chapters 6 and 7. First of all, it was demonstrated that children with dyslexia scored below their peers on a general assessment measure of vocabulary from their written compositions. However that was a rather general, and possibly subjective, measure of vocabulary skill. Chapter 7 shed new light on the topic of vocabulary choice by pinpointing children with dyslexia as making spelling errors on words of shorter syllables in comparison to their peers; hinting at more simplistic vocabulary, yet this requires more thorough analyses. The subsequent sections that lead up to the empirical study of this chapter discuss more specific measures to assess vocabulary.

8.2 Assessment of vocabulary in writing

In the literature, vocabulary is often referred to using derivations of the word ‘lexicon’, meaning an individuals’ mental vocabulary. Forms of the words ‘vocabulary’ and ‘lexical’ are used interchangeably within this chapter. The focus will mainly be on two key terms that researchers in this field use to assess vocabulary: lexical diversity and lexical density. These two measures are used largely in research of spontaneous speech data (Thordardottir & Weismer, 2001; Vermeer, 2000); although writing researchers have successfully applied these to written text too (Johansson, 2008; Wengelin, 2007), as the underlying assessment is that it explores how verbose a sample is.

First of all, lexical diversity refers to how varied vocabulary is. A text with high lexical diversity would be indicative of a range of different words, reflecting a skilled level of written language production, as lexical diversity has been found to correlate with written text quality (McNamara et al., 2010). In contrast, low lexical diversity would point towards limited vocabulary usage and frequent repetition.

There are a number of calculations used to assess lexical diversity. The most commonly cited measure is the type-token ratio (TTR), which divides the number of different words produced (types) by the total number of words (tokens) in the spoken/written sample (McCarthy & Jarvis, 2010; Watkins, Kelly, Harbers, & Hollis, 1995). However, this calculation can be problematic as it is heavily dependent on text length. As text length increases the negative gradient of TTR will inevitably decrease. Function words (for instance, pronouns and conjunctions) tend to be repeated in spoken and written communication and, therefore, when a word such as ‘the’ is used numerous times the denominator (tokens) will outnumber the numerator (types). Thus, in large samples of text, TTR can mask how diverse vocabulary is. Nevertheless, although this weakness is widely acknowledged in the literature, it still remains as a popular method of vocabulary assessment.

Notably, papers that report TTR often supply additional indices. Researchers generally record the number of different words produced (types) as an indication of lexical diversity (Scott & Windsor, 2000; Thordardottir & Weismer, 2001; Watkins et al., 1995; have used this measure to compare between groups with and without language difficulties). However, the number of ‘types’ in a text is only useful in providing accurate comparisons across participants or other samples if the text length is similar, which is often not the case in groups that differ in ability. It has been suggested that equating the size of texts to a set length would counteract this (McCarthy & Jarvis, 2010) but, by doing so, data is lost/disregarded in the process and the altered text can no longer be seen as representative of the participants' ability.

Alternatively, McKee, Malvern & Richards (2000) proposed a probability calculation of lexical diversity that tries to control for text length, named *vocd*. This calculation is based on the probability of new vocabulary being introduced into the text. A minimum of 50 tokens is required to plot a curvilinear relationship between text length and the vocabulary used (an empirical TTR curve) and a theoretical curve based on randomly selected tokens (35-50) in the sample. The value of *D* that provides the best fit to the empirical curve is recorded as the level of lexical diversity. This approach has its strengths because it accounts for text length and has proven to be popular in adult studies of vocabulary usage (Johansson, 2008; Wengelin, 2007). However, trying to employ this for children with written language difficulties would be problematic, as many children struggle to write as much as 50 tokens.

Furthermore, *vocd* has been criticised because the end value of random sampling will be different each time the analysis is run (McCarthy & Jarvis, 2010); although the authors do suggest conducting the analysis three times and averaging across these trials (McKee et al., 2000). Finally, the method of random sampling is believed to lose the essence of the text (McCarthy & Scott, 2007; Tweedie & Baayen, 1998). There is a structure to the way ideas and thus vocabulary is presented in writing. By using a random selection of words this structure is not preserved and, therefore, it is questionable whether this measure of diversity is a true account to what was available. Despite these criticisms, *vocd* is one of the more developed methods of mathematically transforming TTR.

Other mathematical calculations of lexical diversity that are recommended for text samples below 3000 words are the Guiraud and Uber indexes (Guiraud calculation (1954), Uber index (1966): as reported in Vermeer, 2000). The Guiraud index divides the number of different words by the square root of the total number of words, implying that vocabulary size is proportional to the square root of the text length, whereas the Uber index proposes a log transformation of the types and tokens. Exact calculations are provided later in section 8.6.1.4. To validate these measures, global measures of receptive and expressive vocabulary performance were conducted from which, Vermeer (2000) demonstrated that the Guiraud index gave a strong indication of lexical diversity between first and second language learners and had a positive correlation with the global tasks too. The usefulness of the Guiraud index in distinguishing between lexical diversity abilities and correlations to other vocabulary measures has been supported by a number of studies (Daller, 2010; Daller & Phelan, 2007; Van Hout & Vermeer, 2007).

Currently, there is no consistent measure of lexical diversity in the literature. For this reason, there is a need to consider that various measurements may have been used when comparing findings across studies. The Guiraud and Uber indexes appear to be more suitable for analysing lexical diversity in children with dyslexia that struggle to write a large amount of text.

The other method to assess vocabulary is through lexical density. Lexical density refers to the proportion of content words (verbs, nouns, adjectives, and adverbs derived from adjectives) to the total number of words (Johansson, 2008). This measurement excludes function words (e.g. pronouns, conjunctions etc.), so that only the words with lexical properties are assessed (Wengelin, 2007). A ratio is calculated and the higher the value the more dense the text is, meaning that a high proportion of the words were descriptive and carried meaning, which is thought to show a more sophisticated level of lexicality (Johansson, 2008; Wengelin, 2007). Similar to the TTR measure, a criticism of this lexical density assessment is that there is a dependency on text length. A longer text evidently reduces the value by increasing the possibility of more function words being introduced. However, other density calculations to control for this have not been formulated.

Lexical diversity and density provide a quantitative assessment of vocabulary, which allows for an expansion to more objective conclusions than those in Chapter 6. Additional assessments of vocabulary could consider word frequency or syllable length. Identification of word frequency requires an accessible database of frequency counts and, thus is rarely reported in studies of vocabulary choices in writing. However, syllable length is explored in more detail, as composing a text with words of longer syllables would be expected to reflect a more sophisticated vocabulary (Coleman et al., 2009; Ollinghouse & Leaird, 2009). The aim of using the listed vocabulary measures (diversity, density, and syllable length) was to identify an expected level of vocabulary performance in writing, determined by the age-matched peers, and to examine whether children with dyslexia are able to achieve in the same way.

8.3 The contribution of vocabulary to writing

In models of typical writing development vocabulary tends to have the least focus, in comparison to the transcription processes and the planning/reviewing strategies (Berninger

& Swanson, 1994; Hayes & Flower, 1980). Although not explicitly labelled, vocabulary should be placed under the text generation component in Berninger & Swanson's (1994) model of writing development.

It could be theorised that vocabulary choices have close ties with both the transcription component and the higher-level writing processes. Vocabulary is produced at the word level and is directly related to spelling, as the phonological properties of a word are encoded and retrieved while writing. Fluency in identifying and accessing items from the lexicon would be expected to increase fluency in the transcription component, which would reduce the cognitive load in working memory. In this case, for typically developing children and adults spelling has a mediating role. In contrast for children with dyslexia who have poorly developed spelling skills, this fluent transaction between generating and transcribing vocabulary may be expected to be affected.

On the other hand, semantic characteristics are activated when selecting appropriate words for a text. Vocabulary further impacts on writing at the sentence and discourse level and has a more global effect on the cohesion of the text. Thus, the influence of spelling on vocabulary choice could have wider consequences for the quality of the text produced. Research has shown that writers review their text to ensure that it meets the task demands and that in younger writers many revisions focus on the surface characteristics, such as spelling and word choice, rather than changing the content presented (Chanquoy, 2001). Vocabulary has an important role for the efficiency of the writing processes and for the written product and this component deserves more credit or elaboration in current models of writing development than is currently provided. At present, theories of writing development direct attention to the need to automatise the transcription component to free resources to devote to generating text (Berninger & Swanson, 1994; McCutcheon, 1996).

Assessments of the quality of writing, such as the WOLD marking criteria (Rust, 1996), express the requirement to demonstrate a range of vocabulary in written compositions. In a scoring system like the WOLD, when vocabulary is marked as high this will have a positive influence on the overall quality score. In a similar way, measures of lexical diversity using mathematical transformation of the TTR and syllable length have been shown to significantly correlate with writing quality for typically developing children and adults (McNamara et al., 2010; Ollinghouse & Leaird, 2009; Wagner et al., 2011). This measure of lexical diversity taken from narrative compositions produced by typically developing children aged between 7-10 years was found to be a unique predictor of writing quality, beyond what was contributed by spelling performance in the text (Olligh ouse & Leaird, 2009). The relationship between vocabulary and text quality may be expected, as quality ratings of written compositions will be judged largely on how clear the writing was to comprehend.

Although this area has been relatively under researched in comparison to the other writing processes, it is clear that the mental lexicon drives writing as it does in verbal conversation. However, generating language verbally is different to written production. While spoken language undergoes the process of conceptualising a conversation through to articulation (Treiman, Clifton, Meyer, & Wurm, 2003), written vocabulary production does the same but also links semantics to the phonological, orthographic, and morphological rules of written language. A question for the dyslexic population remains about how problems with acquiring phonological and orthographical awareness will influence the expression of written vocabulary.

8.4 Written vocabulary performance in dyslexia

There has been much speculation about the overlap between dyslexia and oral language difficulties (Catts, 1996; Hulme & Snowling, 2009; Rose, 2009). Children with dyslexia and those with specific language impairment (SLI) portray difficulties with reading and phonological processing. However, research has shown that children with SLI have more severe difficulties with comprehending and using oral language (Catts, Adlof, Hogan, & Weismer, 2005; Larkin & Snowling, 2008; Rice, Oetting, Marquis, & Bode, 1994), which is supported by a number of thorough reviews that have made a clear claim that children with dyslexia are distinct from those with wider language problems (Bishop & Snowling, 2004; Catts et al., 2005; Pennington & Bishop, 2009).

Aside from possible co-occurring language difficulties, it is reasonable to propose that children with dyslexia would, to some extent, show a weaker performance in vocabulary than their peers. While we use vocabulary to aid reading comprehension (Wise et al., 2007) this route feedbacks too, as reading is an important source for vocabulary acquisition (Steele & Mills, 2011): supported by the finding that good readers have larger vocabularies at their disposal (Nagy, 2007). Reading can help to cement semantic knowledge of a word in the mental lexicon. Reduced reading exposure in children with dyslexia could limit the opportunities to acquire new vocabulary in comparison to those children that do not find reading difficult. When presented with a new word, numerous levels of processing occur that require the "integration of phonological, semantic, and morpho-syntactic knowledge with cognitive and social processes" (Dockrell & Messer, 2004, pp. 35). Research with typically developing readers has found that performance on nonword repetition tasks (assessing phonological awareness and memory) was significantly associated to receptive vocabulary skills and reading ability (Gathercole & Baddeley, 1989; Gathercole, Willis, & Baddeley, 1991). Therefore, poor phonological analysis skills in children with dyslexia might be expected to hinder vocabulary development.

Verbal fluency tasks are another way of assessing conceptual knowledge. On semantic and phonetic (naming words with a particular starting sound) fluency tasks, children with dyslexia have been found to retrieve fewer items than age-matched controls, with a more significant drop shown in the phonetic fluency condition (Cohen, Morgan, Vaughn, Riccio & Hall, 1999; Reiter et al., 2005; Wolf & Bowers, 1999). The fast retrieval of words from specified categories relies on verbal memory, semantic knowledge, and the processing of phonological codes. Here, another route is demonstrated whereby poor phonology may hinder the acquisition of vocabulary, storage, and rapid retrieval of items from the lexicon.

However if additional oral language difficulties are not present, children with dyslexia should be able to develop vocabulary through spoken media. Acquisition through this route may contribute to an explanation for the findings of Puranik et al (2007), whereby individuals with dyslexia were equal to their age-matched controls on the number of different words produced (lexical diversity) in written compositions. In fact, these two groups had a higher lexical diversity than those with a language impairment.

Two reasons could explain why spelling did not appear to constrain written lexical diversity for those with dyslexia in the Puranik et al (2007) study. The first being that a wide age range (11-21 years) was used for this small sample and, as a developmental skill, vocabulary could have been compensated for and acquired through proficient oral language abilities. The second explanation could be related to the nature of the writing task, which asked the participants to retell a story in writing. With this design, it is reasonable to propose that students could have merely retrieved the vocabulary that was first presented to them in the verbal story and used these same word choices in their written compositions. This possibility was not explored in the paper. Perhaps different results might be expected if these participants composed text independent of external cues.

Notably, this was true for university students with dyslexia when composing an expository text (Coleman et al., 2006; Gregg et al., 2007) and, furthermore, the idea of spelling influencing vocabulary choices was demonstrated from writing samples produced by Swedish university students. Wengelin (2007) assessed lexical density and diversity (*vocd*) across compositions produced verbally and in writing, by university students with and without dyslexia. No differences were reported across groups for either of these measures on the scoring of the verbal compositions. However, students with dyslexia evidenced lower lexical diversity and density in their written compositions, alongside a high proportion of spelling errors; whereas, students without dyslexia scored significantly higher on these vocabulary measures.

Wengelin (2007) concluded that university students with dyslexia do not have difficulty with expressing language per se, however when the demands of spelling whilst composing were introduced, the diversity of available vocabulary is reduced. At present, this is the only study in the literature that has compared vocabulary in spoken and written compositions of students with dyslexia. While the findings are useful to illustrate that difficulties with vocabulary production are specific to writing for this population, the small sample size (11 students) means it should be treated as exploratory rather than conclusive. Furthermore, additional general measures of receptive or expressive vocabulary would have strengthened findings to further set aside this group from those with specific language difficulties.

It is apparent from the literature review that studies use a range of lexical diversity measures and that the majority of research in this area has focused on an older sample of university students with dyslexia. This emphasises the need to examine a younger sample and to determine the role of vocabulary in models of the writing processes.

8.5 Predictions based on the literature

Based on the phonological deficit theory of dyslexia it could be predicted that difficulties with phonology and reading would influence vocabulary acquisition. It was expected that children with dyslexia would perform below their peers on global measures of vocabulary, although still within a range that does not highlight oral language difficulties. However, on measures of lexical diversity and density in a verbal composition task the difference between children with and without dyslexia was not predicted to be as large. The reason being that children with dyslexia are not characterised as showing impairments with oral language production or expression.

When considering the complexity of the writing processes and the cognitive demand of spelling for children with dyslexia, it was hypothesised that vocabulary choices in writing would be vulnerable to spelling capabilities. Models of writing development emphasise the limited capacity of working memory and its important role for overseeing the fluent orchestration of the lower and higher level processes (Berninger & Swanson, 1994; Hayes & Flower, 1980). Children with dyslexia made a high proportion of spelling errors in their written compositions (Chapter 6) and therefore it is likely that these children found the writing task cognitively demanding. Consequently, it is reasonable to propose that they would avoid difficult spellings or repeat words that were already been used in the text to alleviate the cognitive load.

The measure of lexical density was expected to be higher in the written rather than verbal compositions, as repetitions of functions words were expected in verbal conversation where visual feedback of the text is absent. This was expected across all three groups. Additionally, it was predicted that overall mean syllable length will be smaller for children with dyslexia than their age-matched peers, based on the findings from Chapter 7.

Finally, Berninger and colleagues showed that word recognition has a direct path to spelling ability in the connecting models of language by ear and language by hand (Berninger et al., 2002). Significant correlations were expected between reading and spelling ability and written lexical diversity for children with dyslexia. It was predicted that lexical diversity would relate to the overall quality of the written compositions produced by each of the three groups, as research with typically developing children and adults has demonstrated a close relationship between vocabulary and text quality ((McNamara et al., 2010; Ollinghouse & Leaird, 2009; Wagner et al., 2011) and work on adults with dyslexia (Gregg et al., 2007).

8.6 Study

The idea of children with dyslexia avoiding spelling certain words instigated the exploration of three areas. The assumption of avoiding words implies that these children have an adequate level of vocabulary in their lexicon from which they can select or reconsider vocabulary choices. Therefore, the first step was to address general vocabulary knowledge. Next, was the investigation of vocabulary choices made when generating verbal compositions whereby they had free reign with regards to word choice, and the final area to explore was the written vocabulary choices made. Comparisons across these three areas were predicted to provide greater insight into whether spelling acts as a constraint on vocabulary choices for children with dyslexia. The specific research questions are listed below.

Compared to their peers, do children with dyslexia:

a. Reflect oral language difficulties, as measured using standardised tests of receptive and expressive vocabulary?
b. Reflect difficulties with semantic and phonetic verbal and written fluency tasks?

c. Perform better in the verbal compositions than the written compositions in terms of text quality?
d. Have a greater lexical diversity and syllable length in the verbal compositions as opposed to the written compositions?

The following research questions were addressed across all groups:

e. Is lexical density lower in the verbal compositions?
f. Do the general measures of receptive and expressive vocabulary correlate with the measure of written lexical diversity?
g. Do general literacy and working memory measures correlate with written lexical diversity?
h. Do the measures of lexical diversity correlate with written text quality?

8.6.1 Method

8.6.1.1 Participants

31 children with dyslexia, 31 CA peers (mean age 9;4), and 31 SA matches (6;6). Details about participant selection can be found in Chapter 5.

It is important to reiterate here that the selection criteria for participants clearly specified that any children with known speech or language difficulties were excluded from the recruitment phase. School SENcos only identified children that were on 'school action plus' because of difficulties with reading and spelling.

8.6.1.2 Measures

<u>Receptive vocabulary.</u> All children took part in a task assessing receptive vocabulary, using the British Picture Vocabulary Scale – second edition (BPVS-II; Dunn, Dunn, Whetton, & Burley, 1997). This test has been used in the literature to assess vocabulary level (Hatcher et al., 2002). The picture test book is printed on an easel. A word was read aloud to the child and they were asked to point to or say the number of the picture that they believed corresponded to the word. The procedure for administering and scoring this test was carried out as presented in the manual. All responses were recorded and the test ended when the child reached their ceiling item (making 8 or more errors in one set). Raw scores were converted to standard scores (*M* 100, *SD* 15). The median split-half reliability coefficient is .86.

<u>Expressive vocabulary.</u> The word definitions task was administered to all participants, from the BAS-II (Elliott et al., 1997). This task can be used to assess verbal ability, as it makes up

one of the components in the composite measure of general cognitive ability in the BAS-II. However, here it was used as a measure of expressive vocabulary. Children were required to convey explicit knowledge about the semantic attributes of a specified word from the test battery. Each word was read aloud to the child and they were asked to explain the meaning of the word. All descriptions were recorded and, like the previous task, the words increased in difficulty each time. The task ended when the child made five consecutive mistakes. All answers were scored using the criteria in the manual. Raw scores were converted to a scaled score (*M* 50, *SD* 10). The internal reliability for this task, across the age band, ranges from $\alpha = .83$ to .92.

Verbal fluency. To assess how readily these children can access and report words, verbal fluency tasks were used. These tasks are thought to assess conceptual knowledge (Dockrell & Messer, 2004). The first was a semantic task, where children were required to name as many different animals as possible in 60 seconds. All responses were audio recorded and typed at a later date. Correct responses received 1 mark, if an answer was repeated it was not counted and neither were variations of the same animal (for example, cat and kitten).

The phonemic verbal fluency task asked children to report as many words that began with the letter ‘H’ in the 60 seconds timeframe. The raw score for each category is the number of eligible responses in 1 minute.

Written fluency. Based on the method of the verbal fluency task, this time the semantic category required children to write as many different types of food in 60 seconds. A study by Hatcher et al (2002) used both of these semantic categories (animals and food) for verbal fluency tasks.

The phonemic written fluency task required the child to write as many words as they could think of that began with the letter ‘S’ in 60 seconds. Scoring rules, as above, were applied.

Written composition. Children completed the free writing task that was described in Chapter 5 (WOLD; Rust, 1996). Analyses were conducted to explore lexical diversity, density, and mean syllable length of the words produced (including misspellings, but excluding illegible words).

Verbal composition. Verbal compositional skills were also assessed using the same narrative prompt as the writing task (WOLD; Rust, 1996), asking each child to describe their perfect place to live. No time constraints were imposed and no help was given with ideas for their compositions. An audio recorder was used so that all compositions could be later transcribed. Verbal compositions were scored (1-4) using the three subsections of the WOLD marking criteria: ideas and development, organisation and coherence, and vocabulary. The remaining sections from the WOLD analytical scoring were excluded because they were not considered to be appropriate for verbal compositions (e.g punctuation). The scripts were then analysed on the vocabulary measures. Spoken words that were clearly the child thinking aloud (such as ‘umm’, ‘ahh’, and ‘what’s the word?’) were excluded from the total word count and the vocabulary assessment, as they did not contribute to the compositions.

8.6.1.3 Procedure

The composition task was presented first in the written modality. Verbal compositions were deliberately conducted at least two weeks after, to prevent the same narrative being reported.

8.6.1.4 Data analysis

Table 8.1 lists the chosen measures to assess vocabulary, and clarifies terminology and formulas for these calculations. These calculations were conducted on Excel, after marking tokens and types from each individual composition.

Table 8.1. Descriptions and formulas for the measures of lexical diversity

Label	Description	Formula
Tokens	Number of words	N
Types	Number of different words	V
TTR	Type/token ratio	V/N
R	Guiraud index	$V/\sqrt{N}$
U	Uber index	$(\log N)^2 / (\log N - \log V)$

Although TTR is flawed because of its dependency on text length, this will still be measured to demonstrate this case. Guiraud (*R*) and Uber (*U*) indexes were favoured over the *vocd* measure, as they have been shown to be more reliable for short texts (Vermeer, 2000). In addition, lexical density was calculated as the number of content words divided by the total number of words. Content words and density was calculated using Compleat Lexical Tutor ‘vocabprofile’ (http://www.lextutor.ca/).

Finally, texts were analysed for syllable length, which was calculated using the SMOG Trottier’s calculator, as in Chapter 7 (McLaughlin, 1969). This package has been recommended as an accurate tool to assess written texts (Fitzsimmons, Michael, Hulley, & Scott, 2010).

8.6.2 Results

8.6.2.1 Global measures of vocabulary

Table 8.2 compares performance across the groups on the standardised receptive and expressive vocabulary tasks.

Table 8.2. Mean scores (and standard deviations) on the global measures of vocabulary

	D (*n* = 31) Mean (SD)	**CA** (*n* = 31) Mean (SD)	**SA** (*n* = 31) Mean (SD)	**Post hoc**
Receptive vocabulary	92.71 (7.21)	104.29 (5.10)	100.68 (8.48)	**D < (CA = SA)**
Expressive vocabulary	40.68 (8.42)	54.94 (11.40)	49.65 (6.23)	**D < (CA = SA)**

Note. Receptive vocabulary = BPVS-II, standard score *M* 100, *SD* 15. Expressive vocabulary = word definitions task from the BAS-II, scaled score *M* 50, *SD* 10.

One-way ANOVAs revealed a significant effect of group on the receptive, $F(2, 90) = 21.80$, $p < .001$, $\eta^2_p = .41$, and expressive vocabulary tasks, $F(2, 90) = 20.15$, $p < .001$, $\eta^2_p = .31$. Post hoc comparisons distinguished children with dyslexia as significantly underperforming on both measures of vocabulary when compared to the CA and SA groups. However, the mean score of children with dyslexia was not more than 1SD below the mean.

Table 8.3 illustrates semantic and phonetic performance on the verbal and written fluency tasks. Raw scores and standard deviations are presented, with post hoc comparisons in the right hand column.

Table 8.3. Raw scores and standard deviations for the verbal and written fluency tasks

	D (*n* = 31) Mean (SD)	**CA** (*n* = 31) Mean (SD)	**SA** (*n* = 31) Mean (SD)	**Post hoc**
Verbal – semantic	15.81 (5.10)	16.87 (4.61)	10.77 (3.89)	SA < (D = CA)
Verbal – phonemic	7.74 (3.59)	8.68 (3.33)	5.23 (2.51)	SA < (D = CA)
Written – semantic	5.87 (2.76)	9.81 (2.12)	3.87 (1.61)	SA < D < CA
Written – phonemic	5.65 (2.56)	8.61 (2.69)	3.32 (1.80)	SA < D < CA

Note. Verbal: semantic = animals, phonetic = /h/; Written = semantic = food, phonetic = /s/.

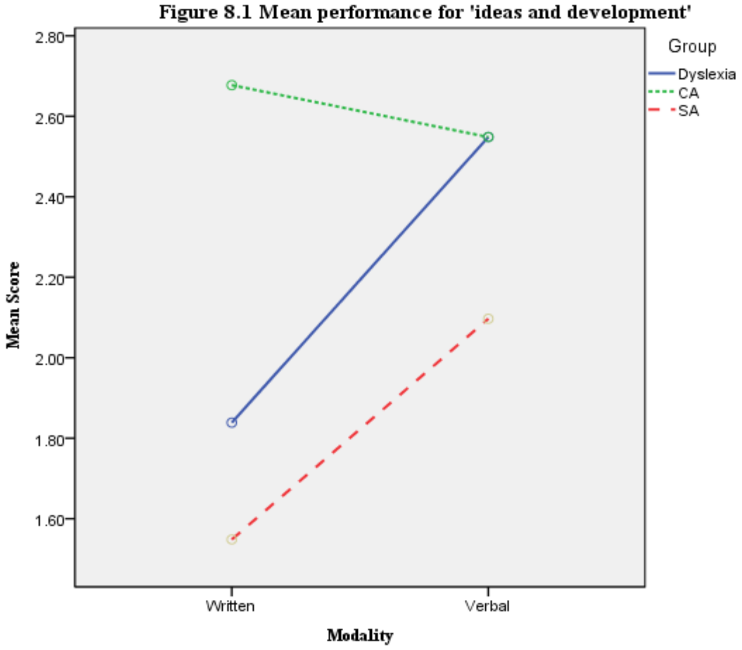
A MANOVA was conducted on all fluency measures. Using the Pillai's trace, there was a significant main effect of group on performance in these tasks, $V = 0.71$, $F(8, 176) = 12.01$, $p < .001$, $\eta^2_p = .35$. Separate ANOVAs revealed significant differences for each of these measures: verbal semantic, $F(2,90) = 15.82$, $p < .001$, $\eta^2_p = .26$; verbal phonetic, $F(2,90) = 9.77$, $p < .001$, $\eta^2_p = .18$; written semantic, $F(2,90) = 57.59$, $p < .001$, $\eta^2_p = .56$; and written phoentic, $F(2,90) = 38.38$, $p < .001$, $\eta^2_p = .46$. Children with dyslexia were able to verbally name as many different animals and words beginning with /h/ as those children in the CA group. These two groups named significantly more in these categories than the SA group. In the verbal fluency tasks, performance decreased in the phonetic condition for all groups.

In contrast, although children with dyslexia were able to write more than the SA group in both the semantic and phonetic conditions, they were significantly worse than the CA group. It can also be reported that over 50% of the written reponses made by children with dyslexia consisted of spelling errors. A similar pattern but slightly lower percentage were made by the younger SA group (40%), whereas misspellings were very rare for the CA group.

8.6.2.2 Written versus verbal compositions

To begin with, Figures 8.1-8.3 show the mean scores for the WOLD quality ratings for: ideas and development, the organisation, and vocabulary; comparing both written and verbal performance. A mixed ANOVA was conducted for each component.

Figure 8.1 Mean performance for 'ideas and development'



There was a significant main effect of the performance scores for ideas and development (Figure 8.1), $F(1, 90) = 19.26$, $p < .001$, $\eta^2_p = .18$. Contrasts revealed that overall the ideas component was scored significantly higher for verbal compositions. A significant effect of group indicated that the scores differed across the three groups, $F(2, 90) = 12.84$, $p < .001$, $\eta^2_p = .22$ and there was a significant interaction effect between ideas and group membership, $F(2,90) = 8.98$, $p < .001$, $\eta^2_p = .17$. Children with dyslexia and the SA group produced ideas that were more strongly developed in the verbal compositions, whereas an opposite pattern was evident for the CA controls. A decrease in the CA ideas scores from written (*M* 2.68) to verbal (*M* 2.55) means that the level of performance meets that of the children with dyslexia in the verbal compositions. These two groups scored higher than the younger SA group on the verbal ideas measure.

Figure 8.2 Mean performance for 'organisation'

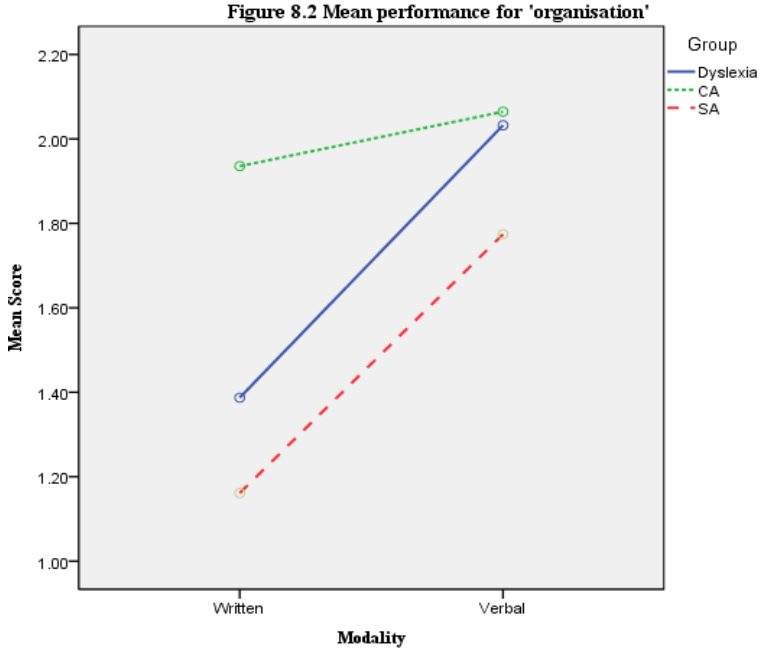
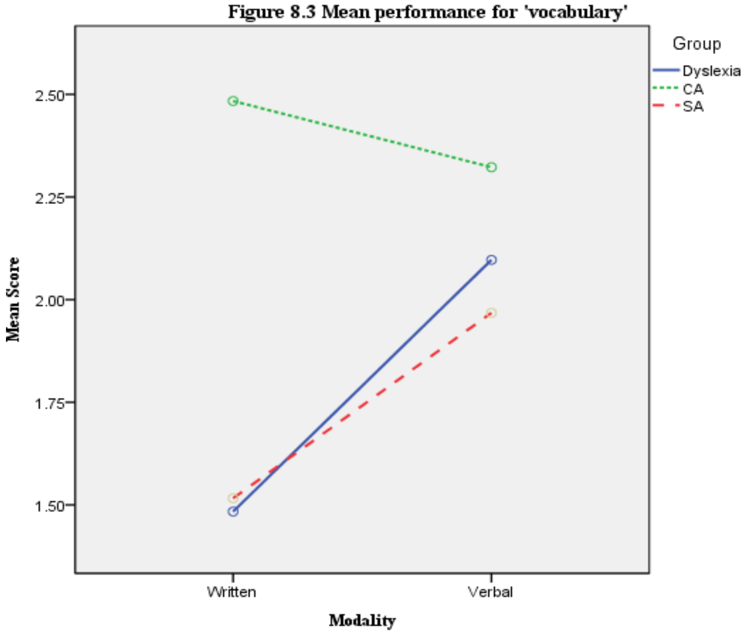


Figure 8.2 displays the results for the organisation component. A significant effect was found for this scoring, $F(1, 90) = 42.67$, $p < .001$, $\eta^2_p = .32$, whereby overall organisation was scored significantly higher in the verbal condition. There was a significant effect of group, $F(2,90) = 9.28$, $p < .001$, $\eta^2_p = .17$ and a significant interaction between the score for organisation and group $F(2, 90) = 5.56$, $p = .005$, $\eta^2_p = .11$. Children with dyslexia were not significantly different to the SA group in the written modality although they differed in the verbal compositions, as the gap between their mean scores reached significance. On the other hand, children with dyslexia scored below the CA group for the organisation of the written compositions, but no significant differences were observed between these groups on this measure from the verbal compositions. Figure 8.2 illustrates that all groups increased in

the level of organisation when composing text verbally, although this is only slight for the CA group.

Figure 8.3 Mean performance for 'vocabulary'



Finally, vocabulary scores are shown in Figure 8.3. A significant main effect was found, $F(1, 90) = 12.00$, $p = .001$, $\eta^2_p = .12$, portraying vocabulary as significantly higher in the verbal compositions. There was a significant effect of group $F(2,90) = 18.03$, $p < .001$, $\eta^2_p = .29$ and a significant interaction between vocabulary and group membership $F(2, 90) = 7.36$, $p = .001$, $\eta^2_p = .14$. Contrasts revealed no significant differences between children with dyslexia and the SA matches for vocabulary scores in both conditions. However, there was a significant difference between performance of children with dyslexia and the CA group, with the CA scoring higher in both modalities. Interestingly, the vocabulary scores increased for children with dyslexia and the SA group when composing text verbally.

8.6.2.3 Quantitative analyses of lexical diversity and density

Table 8.4 presents the mean scores and standard deviations for the measures of lexical diversity, density and syllable length from the written and verbal compositions. Descriptions of the measures can be seen in the last row. The mean number of words above the syllable boundaries is presented in the table; however percentages of the total text for these measures are discussed later in the text.

A mixed ANOVA was conducted on each of these variables to compare performance in the written and verbal compositions and also across groups. The right hand column in Table 8.4 shows the comparisons across the three groups for the written and then verbal compositions.

Table 8.4. Vocabulary characteristics from the written and verbal compositions of the three groups.

	D (n = 31) M (SD)	CA (n = 31) M (SD)	SA (n = 31) M (SD)	
Tokens				
Written	70.19 (35.79)	126.52 (48.64)	35.19 (20.31)	SA < D < CA
Verbal	144.42 (108.32)	122.52 (70.27)	64.35 (50.68)	SA < (D = CA)
Types				
Written	41.79 (18.25)	72.52 (22.91)	22.13 (9.64)	SA < D < CA
Verbal	67.13 (37.63)	60.65 (28.12)	36.55 (23.85	SA < (D = CA)
TTR				
Written	.62 (.09)	.60 (.09)	.69 (.16)	(D = CA) < SA
Verbal	.53 (.12)	.58 (.28)	.63 (.12)	D = CA = SA
R				
Written	4.93 (1.02)	6.44 (.96)	3.75 (.75)	SA < D < CA
Verbal	5.57 (1.23)	5.90 (3.01)	4.45 (1.29)	SA < (D = CA)
U				
Written	14.98 (5.09)	21.44 (5.78)	10.99 (5.74)	SA < D < CA
Verbal	17.78 (6.33)	15.80 (4.93)	14.14 (5.81)	(D = CA), SA< D
>2 syllables				
Written	11.38 (7.34)	26.06 (12.91)	6.19 (3.49)	SA < D < CA
Verbal	24.87 (18.22)	22.48 (13.87)	13.13 (9.75)	SA < (D = CA)
>3 syllables				
Written	1.68 (2.07)	4.55 (3.53)	.77 (.96)	SA < D < CA
Verbal	4.29 (4.52)	4.29 (4.83)	1.84 (2.19)	SA < (D = CA)
Lexical density				
Written	.52 (.08)	.52 (.09)	.57 (.15)	(D = CA) < SA
Verbal	.48 (.10)	.45 (.08)	.53 (.12)	(D = CA), CA< SA

Note. Tokens = number of words; Types = number of different words; TTR = type-token ratio; R = Guiraud index of diversity; U = Uber index of diversity; Lexical density = content words / total number of words; >2 syllables = the number of words above 2 syllables per text; >3 = the number of words above 3 syllables.

To begin with, there was a significant effect of modality, $F(1,90) = 16.43$, $p < .001$, $\eta^2_p = .15$, which highlighted that more tokens (words) were produced in the verbal modality. A significant effect of group was found, $F(2,90) = 20.39$, $p < .001$, $\eta^2_p = .31$, along with a significant interaction between modality and group, $F(2, 90) = 7.69$, $p = .001$, $\eta^2_p = .15$. This indicated that the number of words written in these conditions differs across groups. Contrasts revealed children with dyslexia and the SA group wrote significantly fewer words in the written compositions in comparison to the verbal task. However, children with dyslexia composed significantly more than the SA group in the verbal condition but were not found to be significantly different to the CA group for this measure.

Similarly, for the measure of different types of words, significant effects were found for modality, $F(1,90) = 8.99$, $p = .004$, $\eta^2_p = .09$; group, $F(2,90) = 28.25$, $p < .001$, $\eta^2_p = .38$, and the interaction between modality and group, $F(2, 90) = 12.62$, $p < .001$, $\eta^2_p = .22$. Overall, the mean estimates demonstrated a higher number of different types of words in the verbal compositions. Planned contrasts revealed significant differences between children with dyslexia and the CA controls and the SA group too for the types counted in the written compositions. In this modality, the SA group scored the lowest, then children with dyslexia, and the CA group wrote a higher number of types. However, there was a non-significant difference between children with dyslexia and the CA group for the types in the verbal compositions, while both of these groups scored higher than the SA group.

The TTR value revealed a significant effect for modality, $F(1,90) = 5.83$, $p = .02$, $\eta^2_p = .06$, and group membership, $F(2,90) = 4.30$, $p = .02$, $\eta^2_p = .09$. Contrasts revealed that the TTR score was higher for written compositions than verbal. However, the interaction was not significant $F(2, 90) = .84$, $p = .44$, $\eta^2_p = .02$. Children with dyslexia did not differ to the CA group for the TTR written scores, although both of these groups scored below the SA group. The same pattern was found for the TTR from the verbal compositions, suggesting that children in the SA group had a higher score for lexical diversity. However, this would conflict with the mean scores for the number of types (different words) presented in the row above. Thus, the reliability of the TTR values is questionable, hence why the Guiraud and Uber indexes were used too.

Mean scores for the Guiraud index (*R*) revealed no significant differences between modality, $F(1,90) = 2.01$, $p = .16$, $\eta^2_p = .02$. Yet, a significant effect of group membership was found, $F(2,90) = 20.63$, $p < .001$, $\eta^2_p = .31$ and for the interaction between modality and group, $F(2, 90) = 4.56$, $p = .01$, $\eta^2_p = .09$. Lexical diversity (*R*) was lowest for children with dyslexia in the written condition; instead they showed a more diverse range of vocabulary in the verbal compositions. This pattern was similar for the SA group, although they were significantly worse as seen by their overall mean score. Whereas for the CA group, the lowest *R* score was in the verbal condition.

Similarly, for the Uber index (*U*), no significant differences between modality were found, $F(1,90) = .20$, $p = .90$, $\eta^2_p = .00$. However, a significant effect of group, $F(2,90) = 16.46$, $p <$

.001, η^2_p = .27 and an interaction between modality and group, $F(2, 90) = 13.63$, $p < .001$, η^2_p = .23 was demonstrated. In the same way as for the Guiraud index, this type of lexical diversity (*U*) was scored as lower in the written compositions of children with dyslexia and the SA group, whereas it was lowest in the verbal compositions for the CA group. Children with dyslexia were able to match vocabulary performance of the CA group when composing text verbally.

The number of words produced above 2 syllables revealed a significant effect of modality, $F(1,90) = 13.60$, $p < .001$, η^2_p = .13; and group membership, $F(2,90) = 18.93$, $p < .001$, η^2_p = .30. A significant effect was also found for the interaction, $F(2, 90) = 10.66$, $p < .001$, η^2_p = .19. Children with dyslexia and the SA group scored better on this measure in the verbal condition; where a vice versa pattern is reflected by the CA group. In the written condition, children with dyslexia write more words of two syllables or more than the SA group, but they are significantly below the CA group. A percentage calculation of the total text was made, revealing that 16% of the text written by children with dyslexia consists of words of 2 syllables or more, compared to 21% of the text composed verbally. This is in comparison to 21% shown for this measure in the writing of the CA group and 18% of the verbal composition, whereas for the SA group 21% of the words in the written condition are above 2 syllables, with an increase to 24% in the verbal text.

Similarly, when the boundary is increased to the number of words of 3 syllables or more, a significant effect is found for modality, group, and the interaction, $F(1,90) = 7.55$, $p = .007$, η^2_p = .08, $F(2,90) = 10.69$, $p < .001$, η^2_p = .19, $F(2, 90) = 3.99$, $p = .02$, η^2_p = .08, respectively. Mean estimates revealed that overall 3 syllable words are higher in the verbal compositions. At this boundary, children with dyslexia scored below the CA group on the written compositions; however, these two groups were matched on the verbal condition. The difference in the mean score of words above 3 syllables written by the children with dyslexia and spoken by these children is particularly large, which suggests that they avoid writing longer words.

Finally, for the measure of lexical density a significant effect of modality was found, $F(1,90) = 12.47$, $p = .001$, η^2_p = .12; and for group membership, $F(2,90) = 6.65$, $p = .002$, η^2_p = .13. All groups scored higher for lexical density in the written compositions and the mean score was the same for children with dyslexia and the CA group, although they scored lower than the SA group. However, there was a non-significant interaction between modality and group, $F(2, 90) = .87$, $p = .42$, η^2_p = .02, indicating that all groups performed in the same way across these conditions: with a higher score demonstrated in the written compositions. In comparison to verbal texts, written compositions were made up of more content words that supply information.

8.6.2.4 Predictors of written lexical diversity

The general measures of vocabulary (receptive and expressive tests) were examined in relation to written lexical diversity. The correlations computed in Table 8.5 used the Guiraud index as the main variable because it took into consideration text length. Spelling and reading performance were also included in the analyses to determine their relationship to vocabulary choices in writing. The working memory measures were not found to significantly correlate with Guiraud written performance for any of the groups and are therefore not included in the table below.

Table 8.5. Written Guiraud (R) diversity correlations with vocabulary and literacy measures.

	D (*n* = 31)	**CA** (*n* = 31)	**SA** (*n* = 31)
Receptive vocabulary - BPVS	.52*	.02	.01
Expressive vocabulary – BAS-II	.49*	.12	.14
Verbal Guiraud - *R*	.19	.64*	.28
Spelling ability – BAS-II	.64*	.24	-.13
Reading ability – BAS-II	.64*	.28	.18

Note. * Bonferroni correction $p < .01$ (two-tailed); BPVS = British Picture Vocabulary Scale; BAS-II = British Abilities Scales 2nd edition.

Table 8.5 shows that for children with dyslexia there were medium significant correlations between the receptive and expressive vocabulary measures and the Guiraud lexical diversity measure. Furthermore for these children, spelling and reading ability were significantly correlated with this lexical diversity measure, suggesting that the higher the global literacy performance the higher the level of written lexical diversity for children with dyslexia. Interestingly, the only measure that did not show a significant correlation for children with dyslexia was the verbal Guiraud score, whereas this was the only significant correlation for the CA group. A medium significant correlation in this area suggests that the children in the CA group demonstrate a close link between vocabulary, whether expressed verbally or in writing. No significant correlations for the SA group were established in Table 8.5.

For children with dyslexia, stepwise regression analyses were computed for the strongest correlations reported in the previous table: meaning that spelling ability was the first criterion variable to be entered, then receptive, and expressive vocabulary. The results from the multiple regression analyses for children with dyslexia can be seen in Table 8.6.

Table 8.6 Regression equation predicting the Guiraud written lexical diversity performance for children with dyslexia

Dyslexic	β	R^2	R^2 change	*F*	*df*	*p*
Spelling – BAS-II	.49	.42	.42	18.40	1, 25	< .001**
Receptive vocabulary	.14	.47	.05	2.31	1, 24	.14
Expressive vocabulary	.24	.51	.04	1.77	1, 23	.20

Note. **p* < .05, ***p* < .001

Table 8.6 demonstrates that spelling ability accounted for 42% of unique variance in the written lexical diversity performance of children with dyslexia. Reading ability was initially included in this analysis but was not found to significantly predict any additional variance after controlling for spelling ability; and, therefore, was removed from the equation. Interestingly, neither receptive nor expressive vocabulary contributed any additional variance in this circumstance.

Table 8.7 illustrates the results for the CA group. For this group, the verbal Guiraud variable was included as a predictor variable because of its significant correlation with written lexical diversity. Verbal lexical diversity was found to be a unique predictor of written lexical diversity in the CA group, accounting for 40% of the variance in performance.

Table 8.7 Regression equation predicting the Guiraud written lexical diversity performance for the CA group

CA	β	R^2	R^2 change	*F*	*df*	*p*
Verbal Guiraud	.64	.41	.40	20.26	1, 29	< .001**

Note. **p* < .05, ***p* < .001

Finally, although no significant correlations were found for the SA group, both the spelling ability and verbal Guiraud variable were entered into the regression equation as they cover the variables that were associated to children with dyslexia and the CA group. Table 8.8 lists this final regression analysis for the SA group.

Table 8.8 Regression equation predicting the Guiraud written lexical diversity performance for the SA group

SA	β	R^2	R^2 change	*F*	*df*	*p*
Spelling – BAS-II	-.25	.02	.02	.53	1, 29	.47
Verbal Guriaud	.36	.13	.11	3.68	1, 28	.03*

Note. *$p < .05$, **$p < .001$

As expected, spelling ability did not contribute any significant variance to the written lexical diversity shown by children in the SA group; whereas, verbal lexical diversity contributed 11% of variance in written lexical diversity. In this respect, the two typically developing comparison groups show a similar pattern.

8.6.2.5 Lexical diversity and text quality

The Guiraud and Uber indexes were used to establish the relationship of written lexical diversity to written text quality, as shown in Table 8.9. TTR, lexical density and syllable length were not included in this analysis, as these measures were influenced by text length.

Table 8.9. WOLD written compositional quality correlations with lexical diversity measures

	D (*n* = 31)	**CA** (*n* = 31)	**SA** (*n* = 31)
Types	.72*	.50*	.51*
Guiraud index (*R*)	.60*	.36*	.29
Uber index (*U*)	.32	.02	.05

Note. * Bonferroni correction $p < .02$ (two-tailed).

Significant positive correlations were established across all groups for the relationship between the number of different words (types) written and the quality of the text produced, although the strongest correlation here was evident for children with dyslexia. A significant correlation was revealed with the Guiraud index and written text quality for both children with dyslexia and the CA group. The more diverse vocabulary was in the written compositions of these groups, the higher these compositions were graded. However, this relationship was not found to be significant for the younger SA group. Moreover, the Uber index was not found to correlate significantly with text quality for any of the three groups.

Regression analyses were computed to determine which of the lexical measures predicted written text quality for the three groups, shown in Table 8.10-8.12. In the cases of children with dyslexia and the CA group, the Guiraud index and types were entered into the regression because of their high correlations with text quality. However, for the SA group only the types value was added to the regression.

Table 8.10. Regression equations predicting WOLD text quality for children with dyslexia

Dyslexic	β	R^2	R^2 change	*F*	*df*	*p*
Guiraud	.60	.36	.36	16.33	1, 29	< .001**
Types	.12	.55	.19	12.16	1, 28	.002*

Note. *p < .05, **p < .001

Table 8.10 demonstrates that for children with dyslexia, the Guiraud value of lexical diversity accounted for 36% of the variance in text quality, with a further 19% being accounted for by the number of different words (types) used in the written composition. However, it is important to note that after controlling for spelling ability these percentages decrease, to 8% for the Guiraud predictive value to text quality, and a further 17% for types.

Table 8.11. Regression equations predicting WOLD text quality for the CA group

CA	β	R^2	R^2 change	*F*	*df*	*p*
Guiraud	.36	.13	.13	4.36	1, 29	.04*
Types	.89	.29	.16	6.41	1, 28	.02*

Note. *p < .05, **p < .001

Similar to the children with dyslexia, both the Guiraud and types variables had a significant effect on written text quality of the CA group. Table 8.11 shows that the Guiraud value predicts 13%, and the types an additional 16%, of text quality for the CA group.

Table 8.12. Regression equation predicting WOLD text quality for the SA group

SA	β	R^2	R^2 change	*F*	*df*	*p*
Types	.51	.26	.26	10.28	1, 29	.003*

Note. *p < .05, **p < .001

Finally, Table 8.12 displays the results for the SA group. Only the types value accounted for unique variance, 26%, in the quality of written text produced by the SA group. Thus, for the SA group it would suggest that text length (types did not control for text length) is having a strong influence on text quality for these younger children, a finding addressed previously in Chapter 6.

8.6.3 Discussion

The overall aim of this study was to investigate the vocabulary choices made in the written compositions of children with and without dyslexia. Vocabulary was assessed from many different angles to answer the specific research questions. Global measures of receptive and expressive vocabulary confirmed that the two comparison groups did not have language difficulties. However, children with dyslexia scored significantly below both comparison groups on these vocabulary measures, yet their performance did not reach more than one standard deviation below the test average, which is a typical cut off point used to represent significant problems (Hanley, 1997; Snowling, 2000).

It can be argued that this sample of children with dyslexia did not exhibit characteristics of SLI, as their performance on the verbal fluency task and verbal compositions matched their age-matched peers. Thinking back to the predictions, it was expected that children with dyslexia would show a weaker performance on the phonetic fluency tasks in comparison to their peers: though, the findings reflect that this was only evident in the written modality. Surprisingly, children with dyslexia performed equally well in semantic and phonemic fluency tasks, and the explanation for this may lie with the letter /s/ that was the phonetic category. This starting letter consistently received the same answers from participants, which were short to write, such as: so, see, saw, she, etc. It is possible that this task was too easy for the higher age group and as a result ceiling effects mask possible difficulties with identifying and accessing words with a particular starting sound. At this level these findings do not provide support for the double deficit hypothesis of dyslexia.

The younger spelling-ability matched group appeared to find these fluency tasks more challenging, as they consistently scored below children with dyslexia and their peers. The literature clearly reports that performance on fluency tasks reflects a developmental pattern and improves with age (Cohen et al., 1999), providing an explanation for why the youngest group scored the lowest out of the three groups, in the absence of notable phonological difficulties. A final point to make about these tasks is that all three groups named fewer items in the written condition, emphasising the added cognitive effort of translating and transcribing answers in writing.

Moving on to the comparisons between the written and verbal compositions, the findings demonstrated that children with dyslexia and the spelling-ability group improve on their ability to express ideas, the organisation of the text, and the vocabulary used when composing a narrative verbally. Again, the demands of writing are highlighted as affecting the expression of composing skills in children that experience problems with accurate spelling.

Bereiter & Scardamalia (1982) argue that conversation and composition are two different things. When composing written text, the reader is absent and, therefore, writing needs to be clear and this can be achieved by redrafting work. In contrast, generating text through talking (dictating) reduces motor demands but could result in information being repeated, as the composition is not visible to work on. Bereiter & Scardamalia (1987) asked children to compose a narrative text in three conditions: writing, dictation, and slow dictation (speaking as the experimenter transcribes). Productivity was lowest in the written condition, as children composed more in the dictation tasks. The present findings support this earlier work, especially for children with dyslexia who dictated twice the amount of words than when writing.

In addition, MacArthur & Graham (1987) and Graham (1990) found that composing a text verbally resulted in a better quality of text for students with learning disabilities than when writing. Again, this corresponds with the findings of children with dyslexia in the present study and points towards the mechanics of writing interfering with quantity and quality. Linking this back to theories of writing and language production, language develops from an early age and at a faster rate (Treiman et al., 2003) than writing which is first formally introduced in the primary grades. Therefore, it would generally be expected that children would be better talkers than they are writers, especially for those children with dyslexia who have spelling difficulties.

However, while on the one hand dictating text could be a solution for children with dyslexia, there are weaknesses of this method too. Dictation can influence the way a text is generated. Graham et al (1991) found that many repetitions are evident in verbal text and there is little discourse structure. Ideas might be introduced as remembered rather than shaped into the text. The method of dictation could be seen as less formal and as a result vocabulary could change to more of a conversationalist tone. For these reasons, in the present study comments such as “um, I can’t remember what it’s called” were deleted from the transcripts when later typed, even though they were rare, because it did not contribute to the overall meaning of the text. Finally, although dictation may benefit a child with writing difficulties in many ways, it is only a short-term solution and in practical terms will not always be available.

Vocabulary in writing was analysed at the word-level. Measuring lexical diversity using the total number of different words meant that ability was somewhat masked because of the dependency on text length. Similarly, the type-token ratio (TTR) can be criticised for masking performance, even though it acknowledges text length. Findings from the TTR calculation emphasise how unreliable this measure is, as it would lead to the conclusion that all three groups demonstrated a similar range of vocabulary in their written and verbal composition; contradicting the number of different words reported. At this point, the validity of lexical diversity measures could be questioned. A strength of the present study was that more appropriate measures were computed to gain a better understanding of lexical performance.

The Guiraurd (*R*) and Uber (*U*) mathematical transformations of the TTR provided a more accurate representation by revealing that children with dyslexia and the spelling-ability matches composed more, with a more diverse range of vocabulary in the verbal condition; although, children with dyslexia performed significantly better. Interestingly, the age-controls composed the same number of words in both conditions, but produced a higher number of different words for the written compositions. The same pattern of results is revealed in the syllable analysis, with children with dyslexia further separated from their peers in writing, but matching in the verbal condition. Theoretically, these findings suggest that the age-matched peers have reached a writing level whereby they are able to transfer their knowledge proficiently in this medium. In contrast, children with dyslexia and the spelling-ability matches are unable to perform at the same level in writing as they can in spoken production. This raises the question of what is constraining written lexical diversity for children with dyslexia.

In a similar way to the Wengelin (2007) study, lexical diversity was specifically constrained in the writing of children with dyslexia. Similarities are also seen between the lexical diversity results for the age-matched peers and the findings from a small study of typically developing children of the same age, that demonstrated a higher lexical diversity (*vocd*) in written, rather than spoken modalities (Johansson, 2008). The more diverse range of vocabulary used by the older typically developing group was associated to a better quality of text overall, which would be expected if meaning is clearly communicated and they are reaching a knowledge transforming stage of writing (Scardamalia & Bereiter, 1987).

On the measure of lexical density it is probably no surprise that all three groups presented similar scores, as this calculation remains dependent on text length. In fact, the younger spelling ability group scored significantly higher as they composed significantly less overall.

It was predicted that this score would be higher in the written compositions, because when verbally composing a text a high number of function words (and, the, because) are used, as sentences are not as clearly punctuated as when writing; and this was found to be true. Johansson (2008) also found this pattern in typically developing children. Due to the influence of text length, it is best to only consider the results of the chronologically-age matched group because on average they produced the same amount of words in both modalities. Therefore, for this group, lexical density is a reliable measure to convey that when writing, more ‘information packing’ content words are used (Johansson, 2008), reflecting a more sophisticated level of text overall (Johansson, 2008; Wengelin, 2007).

Spelling ability was predicted to constrain written vocabulary choices. Phonology has an important role in reading, spelling, and vocabulary development (Gathercole et al., 1991). Its embedded role in writing is more complex. Vocabulary choices activate phonology and the additional orthographic and morphological characteristics of a word to orchestrate the motor processes to transcribe spellings. If children with dyslexia struggle to spell a certain word, they might search their lexicon for an alternative. The alternative word should still correspond to the rest of the sentence, in the same way as the original would have done. This intricate relationship between spelling and vocabulary choices in writing is discernible. It is likely that spelling places a higher cognitive load on written vocabulary choices by children with dyslexia. If this were to be true it might be expected that the execution of the text would be constrained in some way also, perhaps by taking longer to complete words or pausing more frequently (explored in the following handwriting execution chapter).

A higher level of general vocabulary (receptive and expressive) was found to correlate with more diverse vocabulary usage in writing for children with dyslexia. However, spelling ability predicted the largest proportion of written lexical diversity for this target group, confirming the link between spelling and vocabulary. Moreover, these two skills significantly impact on text quality too. Models of writing development (Berninger & Swanson, 1994) are lacking in this area, while the present findings have established an important bidirectional relationship between these two skills.

In contrast, for the age-matched peers, verbal lexical diversity was highly predictive of written vocabulary performance and text quality, supporting previous studies that have demonstrated the role of vocabulary when grading writing (Ollinghouse & Leaird, 2009). It was initially surprising that no significant correlations were found for the influence of literacy measures on written lexical diversity in the spelling ability group. A possible explanation could be due to the short texts that were composed by this comparison group.

However, a similar pattern to children with dyslexia was seen through the increase in lexical diversity from the written to the verbal compositions. The weaker diversity performance in the writing of the spelling-ability group may be partly due to lower spelling ability or to the younger age of this group having less experience with writing and thus producing shorter texts overall.

A limitation to this study could be that the same narrative task was used for both the written and verbal conditions. The same topic was chosen so that accurate comparisons could be made; different topics could have elicited different vocabulary choices. A gap of at least two weeks between these sessions was scheduled to prevent repetition and it can be qualitatively reported that each child reported something new and different in the second (verbal) task.

Finally, on a positive note, the array of vocabulary measures used is a key strength to this study. This study provides a novel contribution to the literature, as no published research has focused on the vocabulary choices made by children with dyslexia when writing. While Wengelin (2007) considered a similar direction in university students, the sample size was much smaller and the measures were more restricted. Together, the findings answer the research hypothesis by emphasising that individuals with dyslexia reflect problems with expressing a wide range of vocabulary that is specific to writing.

8.7 Overall conclusions

Children with dyslexia did not present with additional oral language difficulties that is often suggested in the literature (Rose, 2009). Regression analyses concluded that lexical choice is largely predicted by spelling capabilities and that these two skills influence text quality for children with dyslexia. The present study accentuated the link between spelling and vocabulary choices when writing and stresses the need for more attention to be targeted on the bidirectional relationship of these processes than is currently shown in models of writing development. The following chapter will determine how spelling ability impacts on another closely linked writing process: handwriting.

9

Handwriting execution

9.1 Introduction

Berninger & Swanson (1994) categorise spelling and handwriting together as the transcription component in the model of typical writing development. Spelling is also identified as a processing unit in Van Galen's (1991) hierarchy of handwriting production, with spelling activating the cognitive/linguistic processes that feed into motor processing. The cognitive and motor processes required when producing written text form an intricate relationship and it could be predicted from the models just mentioned that difficulties in one area would have consequences for the other. Certainly, general measures of these two lower-level processes have been shown to constrain written compositional length and quality in typically developing beginning writers (Chapter 2). Yet, little research has considered the direct interaction of spelling and handwriting and, in turn, their relation to the act of composing a written text.

Children with dyslexia provide an opportunity to determine the relationship between these two skills; if spelling is impaired, does handwriting execution suffer? This chapter presents work that has explored the transcription component in great detail. First of all, with the aim of defining the handwriting profile of children with dyslexia, addressing issues of motor difficulties; and then investigating the influence of spelling on handwriting execution. The hypothesis was:

4. **Handwriting** production will be affected by the spelling difficulties of children with dyslexia.

A review of the literature that contributed to the development of the two studies presented in this chapter will follow. A section of the findings reported here in Study 1 (9.7) formed part of a published paper (Sumner, Connelly, & Barnett, 2012, see Appendix F). General conclusions from both empirical studies (9.7 and 9.8) are addressed at the end of this chapter (9.9).

9.2 Assessment of handwriting performance

Handwriting is a skill that requires motor control and coordination to convert thoughts and ideas into written language. Styles of handwriting will differ between individuals and will change and develop over time (Graham & Harris, 2000; Van Galen, 1991). In the early years of education, the aim for all children is to master this intricate form of motor control using a pencil/pen to produce legible text. During these first years of school, legibility is an important element and children must ensure that letter formation is consistent and words are clearly spaced (DfE, 2011).

With practice children must try to make handwriting an automatic skill, one that requires little attention. The importance of handwriting automaticity relates back to models of writing (Berninger & Swanson, 1994; Hayes & Flower, 1980; Kellogg et al., 2007; McCutcheon, 1996), which argue that the lower level processes need to be sufficiently learned so that working memory resources can be devoted to the higher level processes of writing. Dual-task methods have been particularly insightful in adult studies investigating the engagement of the lower- or higher-level processes while writing, with longer response times to a secondary probe demonstrating the demands of handwriting when composing text (Kellogg, 1996; Olive & Piolat, 2002). However, for a more practical assessment of handwriting, 'speed' of production is often taken as a proxy measure of the degree of automaticity. The English school curriculum emphasises that handwriting should be legible in both joined and printed styles with increasing speed by Key Stage 2 (DfE, 2011). Learning to write quickly is crucial in education, especially in time-constrained examinations and when note-taking in lectures in higher education (Connelly, Dockrell, Barnett, 2005). A faster handwriting speed is thought to represent lower cognitive effort and, therefore, resources can be targeted at generating text.

In the literature there are a number of measures that are used to assess handwriting production. While some measures seem similar, there can be important differences in task requirements that should be noted. First to be considered is the alphabet task, which has been used extensively in writing research (Berninger et al., 2008; Connelly et al., 2006; Graham et al., 1997; Puranik & Alotabia, 2011), primarily as a predictor of aspects of composition. This task is quick and easy to administer and involves writing out lower case letters of the alphabet in the correct sequence from memory, within a given timeframe. However, this task has been used in two different ways in research. Berninger and colleagues have argued that handwriting automaticity can be measured by asking children to write the alphabet in 15 seconds, and then scoring the correctly sequenced letters (Berninger, Mizokawa, & Bragg, 1991; Berninger et al., 2008; Berninger et al., 1997). They believe that this task assesses orthographic-motor integration, the level of automaticity in retrieving letters from memory and producing them with a pen. With this task, Berninger and colleagues recognise that handwriting is not just a motor act but it requires the encoding, retrieval, and speed of producing orthographic information too. The 15-second time limit may be considered to provide an appropriate representation of automaticity, as the initial letters of the alphabet should be most readily available. However, it could be argued that this does not allow sufficient information to be captured and if fewer letter shapes are produced in this short timeframe, this may relate poorly to text writing when all letters should be incorporated. The accuracy or justification of using a 15 seconds cut-off has yet to be explicitly tested. A further limitation of using this task is that there is no normative data available from the UK.

Moving away from the term ‘automaticity’ and its connotations, the alphabet task has been used to assess ‘speed’ of handwriting production over a longer period of time in the Detailed Assessment of Speed of Handwriting (DASH; Barnett, Henderson, Scheib & Schulz, 2007). Here, speed refers to how productive a person is (letters per minute). An alphabet task forms one of the five components of the DASH. Children are required to write the lowercase letters of the alphabet as many times as possible in one minute. Speed is then calculated as the number of correctly sequenced letters produced in that minute. Using the one-minute timeframe has been a popular method of assessing speed of handwriting (Connelly et al., 2006; Olive et al., 2009; Wagner et al., 2011) as it is assumed to require little cognitive cost or conceptual and linguistic processing (Alves, Castro, de Sousa, & Stromqvist, 2007). The longer timeframe that is used here, compared to Berninger’s work, provides a greater opportunity for children to write all of the letters of the alphabet, and in some cases more than once. Thus, it is a more accurate representation of speed of forming all letter shapes. However, a limitation of both alphabet tasks is that they presume that all children will know the full sequence of the alphabet and, in fact, if they make any errors on letter ordering they will be scored as producing fewer letters (slower speed) within the timeframe.

Speed of handwriting can also be assessed from copying tasks. Single-word copying tasks have been used in just two studies exploring the handwriting of children with dyslexia (Martlew, 1992; Sovik & Arntzen, 1986). Sentence-copying tasks are more common (DASH; Barnett et al., 2007; Hatcher et al., 2002), from which speed is calculated by words written per minute. An advantage to using sentence tasks is that children are required to use letters to form complete words and, therefore, the findings are more applicable to everyday writing tasks. However, the role of spelling (orthographic awareness) in these tasks is rarely acknowledged. While Berninger and colleagues claim that the alphabet automaticity task (15 seconds) explores orthographic-motor integration, it could be argued that sentence-copying tasks would actually provide a better representation.

There are precautions to consider when children with dyslexia are asked to complete these tasks. It is possible that the poor spelling knowledge of these children will influence how fast they are able to retrieve orthographic information. In a sentence-copying task, children with dyslexia might frequently look back to the prompt for spelling information and thus a reduction in the rate of transcription could be evident. Furthermore, when comparing the findings across studies it should be noted where different stimuli have been presented. For example, Hatcher et al. (2002) chose to present participants with a sentence consisting of 12 words (sentence not reported in the paper) and asked them to write for one minute; whereas, the sentence-copying task from the DASH has a two minute timeframe and consists of 9 words, which use each letter of the alphabet. Asking participants to write different letter shapes could influence speed of handwriting performance across studies.

Speed of handwriting can also be taken from a written compositional task if measured in the same way as discussed above – words written per minute (Alamargot et al., 2009). It should be noted that ‘speed’ in all of these tasks does not refer to the actual speed of the pen movement but is taken from the total time taken to produce the letters/words. In a writing task, there is the added cognitive load of spelling and text generation. There may be times when a writer needs to pause to consider a spelling, or what to write next. Poor phonological skills and weaker knowledge of orthographic conventions might result in more frequent pausing, a disruption in the transcription process. A words per minute measurement would mask this performance, and is therefore a very general measure across all three tasks discussed. However, using this type of writing task provides a more naturalistic observation of the speed of composing text: which is, after all, the main purpose of handwriting.

Consequently, the best method to employ would be to use a range of these tasks to either demonstrate where handwriting profiles vary or are consistent across different task demands. Notably, this critique of the various tasks used to measure speed of handwriting has pushed forward the question of, when is a handwriting task measuring only handwriting (only the motor act)? The close relationship of spelling and handwriting makes this difficult to assess independently and, therefore, it is possible that children with dyslexia might demonstrate a slower speed (words per minute) due to poor spelling (phonological and orthographic awareness).

Fortunately, technological advances have supplied a new method of recording handwriting on a digital writing tablet, and using the Eye and Pen analysis software a more accurate measurement of movement speed can be obtained - called 'execution speed' (Alamargot et al., 2006). Execution speed is calculated as the distance covered by the pen trace on the paper divided by the actual time spent writing on paper, and excludes all pauses made when engaged in the writing task. Pauses are recognised by the software programme depending on the set sampling rate and are marked as a period of inactivity above the set threshold, which can be altered depending on the research question. Therefore, using a writing tablet gives a precise measurement of the execution of orthographic-motor processes and, for this reason, is a measure that was included to illustrate the handwriting profile of the three groups of participants examined.

Finally consideration is given to the definition of 'fluency', another term often used in the literature to refer to speed/words per minute (Alves et al., 2007; Olive et al., 2009). However, the formal definition of fluency is slightly different to speed. Fluency refers to undisrupted, free flowing movement. Thus, it refers to more than just speed and speed will not always relate to how fluent/flowing handwriting is. Handwriting may accelerate as an idea is retrieved from memory and it may decelerate as we consider what to write next. In support of this, research on handwriting has found that writing is frequently interrupted by pauses, which is often attributed to cognitive constraints (Rosenblum, 2008; Stromqvist, 2007). Explaining handwriting in terms of fluency needs to be justified with more detailed analyses of the temporal characteristics of handwriting execution. By using technology digital writing tablet, 'fluency' of handwriting can be analysed by detecting where an individual pauses when writing and the duration of these pauses. For the purpose of this chapter, fluency in Study 1 (9.7) refers to how often a child pauses overall in the task, with longer and more frequent pauses reflecting a less fluent profile.

Overall, measurements of handwriting performance can range from producing single letters, to whole words and sentences. From this point on, when 'automaticity' is used to describe findings from previous studies this will refer only to when the criteria of the 15 seconds cut-off point from the alphabet task has been employed (Berninger et al., 2008; Berninger & Rutberg, 1992). As 'speed' (words per minute) is a popular method of assessing handwriting speed (Barnett et al., 2007) and has been frequently reported as being related to text quantity and quality (Connelly et al., 2006; Graham et al., 1997; Wagner et al., 2011) this assessment was incorporated into the present direction of work. Issues concerning what 'speed' actually measures and the strength of conclusions that use this measurement to demonstrate a relationship between the motor act of handwriting and text quality are discussed later. The use of a digital writing tablet adds to typical handwriting measures by determining the 'execution speed' of the pen moving over the paper when writing, and has provided a representation of 'fluency' from the pattern of pausing shown. To date, a digital writing tablet has not been used to assess the handwriting of children with dyslexia.

9.3 The contribution of transcription skills to the written product

The literature from typically developing populations can help to inform predictions for children with dyslexia. The relationship between spelling and handwriting deserves to be addressed in more detail before moving on to their combined contribution to the quality of the written product.

9.3.1 Handwriting and spelling

Writing encompasses cognitive, linguistic, and motor processes. Handwriting has also been illustrated as using these levels of processing hierarchically (as listed) in the only existing model of handwriting in the literature (Van Galen, 1991). Proposed from findings in the psycholinguistic literature, Van Galen's model demonstrates that handwriting is produced by a combination of real-time strokes, motivated by concurrent processing of the forthcoming intentions. Van Galen (1991) identifies three routes that are believed to communicate and interact with one another: the processing module, the size of the processing unit, and the mediating buffer/memory store that correspond with these processes. For example, the first processing module to be encountered is labelled as the 'activation of intentions'; the size of this unit is the 'ideas' produced; and they draw upon 'episodic memory'. As the ideas become more established, the writer is thought to consider the semantic and syntactic characteristics of the text, using the mental lexicon and short-term memory as an aid, before leading up to the spelling of the word, which is assisted by the orthographic buffer.

It is only at this point in the handwriting model, after the internal structuring of the text, that the complexity of the spelling process is acknowledged. Albeit only briefly, Van Galen (1991) recognises that there is a dual-route theory of spelling production; whereby the orthographic buffer or reference back to the verbal lexicon is considered to aid spelling. Here, parallels can be drawn to Tainturier and Rapp's (2001) dual-route model of the spelling system. However, "for reasons of simplicity" the spelling module is not differentiated in any detail (Van Galen, 1991, p. 184). Although the relationship between handwriting and spelling production is indeed a complex one, it needs to be examined in more detail to distinguish the effect of children with a strong spelling deficit.

Van Galen (1991) does not address whether hesitating around spelling would hinder the real-time production of handwriting, yet it is reasonable to propose that it would. As an outline, Van Galen suggests that the direction of the spelling processing modules is broken down into allographs (letters) based on graphemic representations in the orthographic buffer. The final step before production concerns the size control and muscular adjustment that is supported by motor memory, and subsequently performs the writing patterns. This model is useful in showing that cognitive and linguistic variables concurrently influence the real-time movements of the pen. Moreover, it pinpoints the role of motor control as ensuring that the size of the letters and spatial arrangement is legible when executing each stroke, which in turn relates to speed of production.

One criticism of Van Galen's (1991) model is that it does not shed light on whether these hierarchically structured units feedback to the top of the chain. Chapter 7 and 8 demonstrated that spelling capabilities may influence word choices when writing. However, in this model there is no recognition of this type of relationship. Similarly, spelling is placed above the activation of the motor processes. However, it is possible that the execution of handwriting feeds back (Kandel et al., 2011) and supports the spelling of a word. For example, pausing at the stem of a written word and reassessing the morphological counterpart, or pausing while writing to edit a spelling.

The need for handwriting to become an automatic skill (produced at speed) is frequently cited in the literature (Berninger et al., 1997; Graham & Harris, 2000; Graham et al., 1997; Medwell, Strand, & Wray, 2007); although it really should refer to the need for the transcription component to become co-ordinated and automatic, as both spelling and handwriting have independently been shown to influence written text length and quality (Berninger et al., 2008; Graham et al., 1997; Wagner et al., 2011).

For children with dyslexia, one half of transcription (spelling) is initially impaired and therefore they have a weaker start in comparison to those children without spelling difficulties. When spelling is a considerably high cognitive cost it would be expected to impact on the execution of the hierarchical steps pinpointed by Van Galen (1991). In particular, deliberation over spellings would interrupt the free flowing movement of the pen as the activation of the motor processes has been shown to depend on the cognitive and linguistic variables. Problems with spelling are likely to result in sequential processing of accessing spelling knowledge and then transcribing this step-by-step (Maggio, Lete, Chenu, Jisa, & Fayol, 2012). Thus, if spelling disrupts parallel processing, the activation of the processing units identified by Van Galen could be cyclical across lexical retrieval and spelling, and then between spelling (phonology, orthography, etc) and motor activation, rather than linear as originally suggested.

The idea of parallel versus sequential processing when spelling demands are high was recently explored in typically developing French undergraduate students. Similar to English, the French language has a deep orthography and consists of many irregular spellings. Lambert, Alamargot, Larocque & Caprossi (2011) manipulated the third word in a sentence to be either high or low in word frequency, and to have either a regular or irregular phoneme-grapheme conversion. Students were asked to copy these sentences using a writing tablet and eye-tracker to mark performance. Lambert and colleagues (2011) found that both frequency and regularity of the third word played a role in whether spelling or motor execution was conducted sequentially or in parallel. These students were able to execute these processes in parallel (meaning writing and reading the word at the same time, no pauses) when it was a high frequency target word, or regular in phoneme-grapheme consistency. Breakdown in performance did, however, occur for low frequency words and in particular for irregular spellings. Here, sequential processing was noted by more frequent looks back and long fixations on the stimuli, resulting in long pauses from transcription. These findings highlight the constraint that spelling can impose on the execution of handwriting, even for experienced writers.

Theoretically, and considering ability, it could be suggested that children with dyslexia would demonstrate sequential processing of the two transcription skills at particular stages of writing when the spelling demands are too cognitively costly. This will be investigated in Study 2 through an analysis of pausing (terminating execution) around misspellings in the text.

9.3.2 The influence of transcription on written quality

The weight of different constraints on written production will vary with age and experience (Berninger & Swanson, 1994). Puranik and Alotaiba (2011) highlighted speed of handwriting (alphabet task) and spelling ability (items from a dictated list) as contributing significantly to written expression for beginning writers, children aged between 5-7 years. Corresponding to these findings, handwriting speed (from an alphabet task and a sentence-copying task) of slightly older children aged 6-9 years, was found to correlate with the quality of written compositions, with large effect sizes also shown for their relation to the number of words written (Wagner et al., 2011). Together these findings and those by Graham et al (1997) highlight the dominant influence of transcription skills when composing a written text in the primary grades of education. Table 9.1 displays this relationship, as discussed in Berninger's (1999) report exploring the combined contribution of handwriting (alphabet, 15 seconds task) and general spelling ability to written text length and quality at three grades in America. The three grade levels (primary, intermediate, junior) have been converted to age groups in the table for easier comparison to later results.

Table 9.1. The amount of variance in compositional length and quality accounted for by transcription, based on results from Berninger (1999).

	Transcription
Ages 6-9yrs (*n*=300)	
Compositional text length	66%
Compositional quality	25%
Ages 9-12yrs (*n*=300)	
Compositional text length	41%
Compositional quality	42%
Ages 12-15yrs (*n*=288)	
Compositional text length	16%
Compositional quality	18%

Numerous studies by Berninger and colleagues support the findings above (Abbott & Berninger, 1993; Berninger, Vaughan, Abbott, Abbott, Rogan et al., 1997; Berninger et al., 1993). As typically developing children progress through education, the percentage of variance explained by transcription decreases. The contribution of verbal working memory was instead found to increase through the grades and contributed unique variance to compositional length and quality in the higher grades (Berninger, Cartwright, Yates, Swanson, & Abbott, 1994). In relation to the model of writing development, it could be hypothesised that this switch occurs when the lower level skills become more automatised and free resources for the higher-level skills.

The findings in Table 9.1 are based on the alphabet automaticity measurement of handwriting (15 seconds). However, consistent findings of this relationship of transcription to text quality have still been found when the alphabet task was used over a longer time period (1 minute) (Puranik & Alotaiba, 2011) and also when using sentence-copying tasks (Wagner et al., 2011).

Detailed case studies of female writers using a digital writing tablet marked the increase of execution speed at various levels of expertise (Alamargot et al., 2009), ranging from children to adults. In a written narrative task younger and less experienced writers produced fewer ideas, had longer mean pause durations, and a higher pause frequency in words (calculated by dividing the number of pauses by the number of words) than older participants (Alamargot, et al., 2009). A relationship was identified between execution speed, pausing, and the ideas produced and, furthermore, this study revealed a developmental trajectory whereby as execution speed and the number of ideas increased, the mean pause duration decreased. While this study was insightful in mapping developmental progression of execution speed, it was an exploratory study and the conclusions relating execution speed to the expression of ideas could be largely confounded by topic knowledge. Despite this criticism, when comparing across samples of the same age but splitting participants into those that have a fast or slow speed of handwriting (dependent on the number of letters written in a minute from the alphabet), a link between handwriting speed and productivity has been found in children (Olive et al., 2009) and older students when typing compositions (Alves et al., 2007).

In the Olive et al (2009) study, the faster the handwriting speed (alphabet task, letters in one minute), fewer pauses were made when composing a narrative text, and more words were written following each pause when compared to children that were identified with slower handwriting. Moreover, the quality of the text produced by those with a faster speed of handwriting was rated higher than the slower group. Study 1 (9.7) demonstrates the relationship between handwriting speed, using this same measure, and the quality of written texts produced by children with and without dyslexia. Furthermore, in a similar way pause time while writing and text quality was considered.

Up to this point, predictions have been based on the influence of spelling on handwriting execution. The debate about whether children with dyslexia have additional motor difficulties is investigated below.

9.4 Handwriting performance in dyslexia

The British Dyslexia Association (BDA) website describes how children with dyslexia “frequently fail to develop the automatic flow of writing which will help them to express themselves clearly and easily in writing” (BDA “Help with Handwriting,” para.1). It is possible to be a slow writer, meaning slow to compose and transcribe a written text as a whole, but to have adequate motor skills to produce a fast speed of handwriting execution. Yet, few studies have attempted to investigate the handwriting profile of individuals with dyslexia. Are motor difficulties present, or are children with dyslexia slow at writing because of additional demands?

Research findings examining the handwriting performance of individuals with dyslexia have already been reported in Chapter 4, and for this reason a critique of the methodologies used is presented here. Berninger et al (2008) administered the 15-second alphabet task to 122 children with dyslexia. These children with dyslexia scored more than one standard deviation below the mean, leading the authors to conclude that orthographic-motor integration was impaired for these children. Similarly, university students with dyslexia produced fewer letters than their peers on the one-minute alphabet task (Connelly et al., 2006). However, no additional regression analyses were conducted to determine what was accounting for performance on the alphabet task. A confounding variable to consider as an explanation for these findings is this reliance on letter knowledge when completing the alphabet. Letter knowledge is highly predictive of spelling ability in the early years of schooling (Muter, et al., 2004), which may point towards an explanation for the lower performance shown by individuals with dyslexia. In support of this, Berninger et al (2008) did report that children with dyslexia had difficulty accessing letters from memory in a rapid automatic naming task; and it was performance in this task, as well as spelling, that predicted written compositional skills.

Conflicting findings have been reported from copying tasks in the dyslexia literature, but these may partly be explained by the fact that different sentences have been used. Sovik & Arntzen (1986), Sovik, Arntzen & Thygesen (1987), and Martlew (1992) reported that although children with dyslexia took longer than their peers to copy single words and sentences, this difference did not reach significance. In contrast, when university students with dyslexia were asked to write a sentence as many times as possible in two minutes they were found to be significantly slower (in words per minute) than age-matched controls (Hatcher et al., 2002). Direct comparisons are hard to make across these studies, as different sentences and time constraints were used. Furthermore, tests of motor skill were not used to verify the findings of speed of handwriting. These issues need to be tackled, as it is unclear why children with dyslexia would perform worse than their peers on an alphabet task (Berninger et al., 2008) but not on copying tasks.

A study by Wengelin (2007) provided a detailed description of typing performance using a keystroke-logging programme. Although a measure of tying speed was not taken beforehand, Wengelin examined the fluency of the compositions produced by university students with and without dyslexia. Students with dyslexia exhibited a high percentage of within-word pauses, which often led to editing the spellings of that particular word. As this was an analysis of typing it was possible to observe when a student paused around, deleted, or rewrote a misspelling. The latter was common for students with dyslexia. A high number of pauses were seen between words for this group too, which could be attributed to thinking of the spelling of the next word. These findings pinpointed spelling as hindering the fluency of written compositions. Moreover, the finding that pausing and editing behaviour related to spelling links back to the idea that individuals' with dyslexia will avoid writing words they find difficult to spell. The number of times students with dyslexia revisited spelling errors (corrected misspellings) and the number of within word pauses together predicted 55% of the variance in written lexical diversity, cementing the link between spelling, fluency in writing and vocabulary choices when writing. This analysis of the link between vocabulary and pausing was explored in the present chapter (Study 2; 9.8).

In sum, more in-depth research is required to determine the handwriting profile of children with dyslexia and the role of spelling when producing handwriting. It is still unclear whether the actual motor act is slower for these children or if slowness is a consequence of poor spelling.

9.5 Dyslexia and possible co-occurring motor difficulties

At this point, discussions have tended to lean towards the influence of spelling on handwriting, but it is possible that the motor component is difficult for children as well as problems with spelling. Handwriting requires fine motor control to execute each letter stroke (Van Galen, 1991). A finger succession task is popular in the literature published by Berninger and colleagues, to assess fine motor control and planning (Berninger et al., 2008; Berninger & Rutberg, 1992; Berninger et al., 1992). This task requires tapping the thumb with each finger in succession and performance on this task has been found to significantly predict handwriting automaticity (15-second alphabet task) and writing in typically developing children (Berninger et al., 1992); but interestingly not for children with dyslexia, where spelling was the unique predictor (Berninger et al., 2008). While this finger succession task has been shown to correlate to handwriting in typically developing populations the exactness of what this task measures is unclear. It does not require using a pen to produce writing so it could be questioned whether the motor skills used in the finger succession tasks are the same as those used when writing.

Definitions of dyslexia have recognised the possibility of co-occurring motor difficulties (Rose, 2009). In support of this, studies have reported incidences of movement difficulties in dyslexia and co-morbidity with developmental co-ordination disorder (DCD) (Chaix et al., 2007). It may be that children with dyslexia show signs of slow handwriting because of a general difficulty with poor motor control and coordination.

Children with DCD have been shown to have a slow handwriting speed and difficulties with producing legible text and consistent spatial arrangement of the letters (Rosenblum & Livneh-Zirinski, 2008). The letters produced by these children often vary in shape and height, showing many inconsistencies even across the same letters, which is thought to reflect difficulties with controlling the pen (Rosenblum, 2008). However, in the few studies that assess handwriting skill of individuals with dyslexia, it is rare for motor performance to be separately assessed or for DCD to be considered. Research needs to include tests to assess motor performance specifically related to handwriting when working with individuals with dyslexia to fully explain what may be constraining speed. Van Galen (1991) specifically shows the influence of cognitive and motor processes when producing handwriting; therefore, an assessment of motor skill should be included in order to gain a full understanding of the complexities of writing and possible constraints on performance.

9.6 Predictions based on previous research and models of the writing processes

If children with dyslexia have a general motor difficulty then they should have a slower handwriting execution speed (excluding pauses) compared to an age-matched control group. Furthermore, this would be expected to be evident across all measures of handwriting: the alphabet, sentence-copying tasks, and the written compositional task.

However, it is possible that a general motor difficulty is not present in these children with dyslexia. In this case, execution speed should match the age-controls. Yet, children with dyslexia were predicted to pause more than their peers to consider spelling, perhaps showing a profile of pausing behaviour similar to the spelling-ability matched group. This would tie into the idea that spelling has a strong influence on handwriting production and would dispute claims of poor motor execution in this sample. Rather, pausing more frequently would result in text being written more slowly than those who are more fluent when writing. Thus, fewer letter/words would be written in a set time because they are slower writers overall.

A compositional writing task was predicted to demonstrate more frequent pausing by children with dyslexia, rather than alphabet or copying tasks when the compositional and spelling demands are reduced. These predictions are explored first in Study 1 (9.7). It was addressed how the handwriting tasks used in the literature may largely depend on spelling capabilities, as they all require a level of orthographic processing. Therefore, it is predicted that for children with dyslexia, spelling will account for a large proportion of variance in handwriting speed even when decisions about spelling per se are not required (as in the sentence copying tasks). Furthermore, it was expected that both speed of handwriting (letters written per minute in the alphabet task) and spelling would play a large role in the written text quality of these children.

In addition, using Berninger and Swanson's model of typical writing development (1994) and the Van Galen (1991) model of handwriting as a template, it was hypothesised that difficulties with spelling will affect the execution of text. Fluency may be interrupted by difficulties with identifying correct spellings. Children with dyslexia were expected to pause more frequently and for a longer period of time around misspellings than their peers. It was predicted that children with dyslexia would make a large proportion of pauses within and between words, again as a result of problems with spelling. Therefore, if spelling is a cause of the pause behaviour, it was expected that children with dyslexia would perform similarly to the spelling-ability matched group for these measures too. Finally, linking this study back to vocabulary choices when writing, and especially considering how Van Galen (1991) included lexical choice above the spelling processing unit, it was predicted that within-word pauses would be associated with lexical diversity, as reported by Wengelin (2007). These particular predictions are explored in Study 2 (9.8).

9.7 Study 1

The main aim of this study was to establish whether handwriting performance of children with dyslexia was slower than their age-matched peers and its relation to text quality. Using real-time analysis of the production of text, it was possible to explore this question in more depth and thus to address the specific research questions below.

Compared to their peers, do children with dyslexia:

a) Write fewer words per minute than their peers in timed writing tasks?
b) Have a slower writing execution speed?
c) Pause more frequently while writing?

The following questions were addressed across all groups:

d) Is handwriting performance consistent across different task demands?
e) Do any of the children have co-morbid motor problems, as tested using the MABC-2 and graphic speed task?
f) Does motor competence, as measured by the manual dexterity component of the MABC-2, relate to handwriting production?
g) Does handwriting speed, as measured by the alphabet task, predict written compositional quality?

h) Does spelling performance influence the speed of handwriting as measured by the alphabet (letters per minute) and copying task (words per minute)?

9.7.1 Method

9.7.1.1 Participants

31 children with dyslexia, 31 CA peers (mean age 9;4), and 31 SA matches (6;6). Details about participant selection can be found in Chapter 5.

It is important to reiterate that initial tests of manual dexterity were administered to all children (MABC-2; Henderson et al., 2007), to assess fine motor skill and coordination. The manual dexterity component required children to complete three fine motor assessments, such as: placing pegs in a pegboard, threading lace, and completing a drawing trail. No significant group differences were reported for these measures of fine motor control (see Table 5.3). The motor skills of the three groups were within the expected range for their age. However, it was noted that the individual scores by children with dyslexia were more varied, in comparison to the other two groups. Therefore, motor performance was also analysed using a graphic speed task to enable a more thorough analysis, reported in the measures section below.

9.7.1.2 Measures

Handwriting assessment. Sentence copying tasks, the alphabet task and a graphic speed task were administered from the DASH (Barnett et al., 2007). This test is standardised from the age of 9 years to 16 years and 11 months. The younger spelling-ability matched controls fell under this age group. However, the task was deemed appropriate and raw scores were used from each task. The order of administering the tasks was as specified in the DASH manual and is shown below. The copy best, alphabet task, and copy fast tasks have very high inter-rater reliability (r = .99; Barnett et al., 2007). These three tasks were selected because of their popular use in the current literature that investigates speed of handwriting production and were taken from the DASH because UK norms were available for reference, with this test often used by specialist teachers and occupational therapists to assess handwriting:

<u>Copy best.</u> The first copying task required each child to write the following typed sentence: ‘The quick brown fox jumps over the lazy dog’ in their best handwriting as many times as possible in 2 minutes. This sentence covers all of the letters of the alphabet and therefore is a good sentence to use to counteract the argument presented in section 9.2 about the 15 second alphabet task limiting how many different letter forms children might attempt. It was

explained to all children that 'best' handwriting meant their neatest handwriting and it was confirmed that all children understood. During this task they were asked to make this mark // on the paper when told that 1 minute had passed. The total number of words written was divided by two (minutes), giving a final score for the number of words written per minute.

Alphabet task. Children were asked to write the alphabet in the correct sequence from memory as many times as possible in 1 minute. They were asked to write this using lower case letters. The total number of correctly sequenced letters within the minute was recorded.

Copy fast. This second copying task asked the child to write the same sentence as in the copy best condition (with the typed prompt provided again), however, this time in their fastest handwriting. This followed the same procedure as the copy best condition and the number of words written per minute was recorded in the same way.

Graphic speed. The final task used from the DASH was the graphic speed task, which assesses speed and accuracy of controlling a pen. This is considered to provide a 'pure' measure of the type of perceptual motor control required for handwriting, without the confound of language, as it does not involve writing letters and words. It was included to provide an additional measure of motor control relating more specifically to the task of handwriting than any of the manual dexterity items in the MABC-2. Each child was asked to put an 'X' in the circles printed on the A4 page. They were shown how to do this correctly so that the lines were long enough to at least touch the inner circle but not so long that they went over the outer circle and they were given the chance to practice on five unmarked circles. They had 1 minute to mark as many X's as possible. The number of correctly marked X's was recorded as suggested in the test manual. This measure reflects both speed and accuracy of performance, as any errors are deducted. In order to include a pure measure of speed; the total number of attempts (including those with errors) was also recorded. The inter-rater reliability of scoring the graphic speed task is r = .85, as reported in the manual.

Writing task. All children completed the writing task from Chapter 6 (WOLD; Rust, 1996). It was explained that they had 15 minutes to complete this task, but many children stopped writing before this time. Writing speed was recorded as the number of words written per minute, including crossed out words.

9.7.1.3 Materials

All writing tasks were conducted on paper placed over a digital writing tablet (Wacom, Intuos 4, 100Hz) and samples were recorded to a laptop for later analysis using Eye & Pen software (version 1). Lined paper was taped on top of the writing tablet and the child used an inking pen to write. Children were able to adjust the positioning of the tablet if necessary and did not need to worry about leaning on or applying pressure to the tablet. The tablet surface records the XY coordinates of the pen position to the attached laptop and the recording demonstrates handwriting rates and pause locations/durations (Alamargot et al., 2006).

9.7.1.4 Procedure

The handwriting assessment (measures from the DASH) and the writing task were administered a week apart, to alleviate the possibility of fatigue. In particular for these recorded writing tasks on the tablet, it was important that the testing occurred in a quiet room with no one else present. This was kept as a strict procedure so that pauses could not be attributed to distractions in the room, which is often typical in a busy classroom.

9.7.1.5 Online analyses

The Eye and Pen software enables analysis of the writing processes behind the product, recording both pausing patterns and the execution of the text. A pause is an interruption to the flow of handwriting and is defined as when the inking pen is no longer writing on the paper, meaning a period of inactivity (Olive, 2010). All writing pauses above the threshold of 30 milliseconds were included for analysis to gain a clear picture of total time spent pausing and writing. This is the baseline threshold fixed by the Eye and Pen software (a pause is at least equivalent to three successive digital samples). The authors of Eye & Pen use the baseline threshold to identify all pauses within a written sample (Alamargot et al, 2006; Alamargot et al, 2009).

The aim was to identify temporal characteristics of handwriting, by considering the total time spent on the task and how this was split between time that that was spent physically writing on the paper versus time spent pausing. This allowed for the following variables to be calculated:

<u>Execution speed</u> (cm/s) was calculated by the software as the physical <u>distance</u> (cm) covered by the pen divided by the actual writing time when the pen was moving across the tablet. This calculation excludes all pauses when writing and gives an indication of handwriting skill and the level of automatisation of the motor processes which make up the segments of each letter (Alamargot et al, 2009). <u>Pause time</u> was calculated as the proportion of the total time that was spent when the pen was not moving (either off the tablet or stationary on top of the surface), and <u>writing time</u> reflects the time spent physically writing on paper, when the pen was moving. Finally, <u>mean pause duration</u> was also recorded by the software

programme and is a measure used in research of handwriting (Alamargot et al., 2006; Alamargot et al., 2009) and typing (Alves et al., 2009; Wengelin, 2007). This measure is the average sum of the length of all of the pauses made and was considered along with the other temporal variables to show pause profiles of the three groups.

9.7.2 Results

This section is divided into three parts. The first considers group analyses from the handwriting tasks; the second focuses on the narrative writing task, and finally regression analyses are presented to examine the relationship between handwriting performance and written text quality, and the role of spelling when handwriting.

9.7.2.1 Handwriting performance

Table 9.2 presents the results for the four measures administered from the DASH. The score for the alphabet task reflects the number of letters written per minute, whereas the copying tasks represent words written per minute. The graphic speed results indicate the number of correctly marked X's per minute and the total number of attempts made.

Table 9.2. Mean scores (and standard deviations) of all three groups for the DASH measures

	D (*n* = 31) Mean (SD)	**CA** (*n* = 31) Mean (SD)	**SA** (*n* = 31) Mean (SD)	**Post hoc**
Alphabet task	30.87 (14.98)	37.87 (10.51)	17.87 (11.95)	(D = CA) > SA
Copy best	8.71 (3.57)	11.65 (3.36)	5.84 (2.82)	SA < D < CA
Copy fast	13.16 (4.93)	19.73 (3.27)	7.29 (3.72)	SA < D < CA
Graphic speed	23.77 (10.97)	30.87 (10.24)	15.97 (11.83)	SA < D < CA
Graphic speed: all	36.77 (14.98)	37.87 (10.51)	17.87 (11.95)	(D = CA) > SA

Note. Alphabet task = number of correctly sequenced letters in one minute; copy best and fast = number of words written per minute; graphic speed = number of correct Xs marked in one minute and total number of attempts made.

One-way ANOVAs were conducted to investigate group differences on all of the DASH measures. There was a significant effect of group on the score for alphabet task F (2,90) = 20.03, $p < .001$, $\eta^2_p = 31$. Post hoc comparisons revealed that children with dyslexia performed at a similar level to their CA peers ($p = .095$); and that these two groups wrote significantly more than the spelling-ability matches ($p < .001$). These scores were initially checked for outliers, which revealed none. A significant effect of group was also found for the copy best and copy fast tasks, F (2,90) = 24.51, $p < .001$, $\eta^2_p = .35$; F (2,90) = 73.78, $p < .001$, $\eta^2_p = .62$, respectively. Children with dyslexia wrote more than the SA matches but fewer words per minute than the CA group.

Similarly, the two recorded measures of graphic speed showed a significant effect of group membership, both for the number of correctly marked, $F(2,90) = 16.46$, $p < .001$, $\eta^2_p = .27$, and the total number of attempts made, $F(2,90) = 4.27$, $p = .02$, $\eta^2_p = .09$. However, it was found that children with dyslexia made fewer correct responses than the CA peers, but no significant differences were found between these two groups when considering all of the attempts made. Both of these groups were able to mark the same number of circles in one minute, which was more than the SA group.

Table 9.3 illustrates the online analysis of the written DASH tasks. The writing tablet provides information of the written temporal characteristics for the three groups.

Table 9.3. Temporal characteristics from the DASH handwriting tasks for children with dyslexia, their CA peers and the SA matches

	D (n = 31) Mean (SD)	**CA** (n = 31) Mean (SD)	**SA** (n = 31) Mean (SD)	ANOVAs	Post hoc
Alphabet task					
Execution speed	2.32 (.59)	2.23 (.53)	1.75 (.47)	$F(2, 90) = 10.47$, $p < .001$, $\eta^2_p = .19$	(D = CA) > SA
Distance (cm)	44.39 (18.08)	52.46 (15.79)	33.95 (16.20)	$F(2, 90) = 9.55$, $p < .001$, $\eta^2_p = .18$	(D = CA) > SA
Pause time (secs)	40.41 (5.94)	36.75 (5.56)	39.45 (4.57)	$F(2, 90) = 3.80$, $p = .03$, $\eta^2_p = .08$	CA < (D = SA)
Writing time (secs)	19.25 (5.59)	22.95 (5.37)	20.04 (5.10)	$F(2, 90) = 4.10$, $p = .02$, $\eta^2_p = .08$	CA > (D = SA)
Mean P duration (ms)	1057.71 (726.60)	722.25 (261.33)	1213.74 (666.74)	$F(2, 90) = 5.64$, $p = .01$, $\eta^2_p = .11$	(D = SA) > CA
Copy best					
Execution speed	1.93 (.50)	1.84 (.53)	1.66 (.47)	$F(2, 90) = 2.21$, $p = .116$, $\eta^2_p = .05$	D = CA = SA
Distance (cm)	95.05 (30.83)	115.03 (33.24)	67.74 (32.74)	$F(2, 90) =16.76$, $p < .001$, $\eta^2_p = .27$	SA < D < CA
Pause time (secs)	68.98 (11.49)	56.49 (7.07)	81.99 (12.69)	$F(2, 90) = 44.08$, $p < .001$, $\eta^2_p = .50$	CA < D < SA
Writing time (secs)	49.54 (15.25)	63.64 (7.15)	39.98 (13.24)	$F(2, 90) = 28.70$, $p < .001$, $\eta^2_p = .40$	SA < D < CA
Mean P duration (ms)	906.11 (423.69)	698.81 (303.79)	1307.17 (528.72)	$F(2, 90) = 16.14$, $p < .001$, $\eta^2_p = .26$	(D = CA) < SA
Copy fast					
Execution speed	3.27 (1.07)	3.22 (.63)	2.58 (.93)	$F(2, 90) = 5.70$, $p = .005$, $\eta^2_p = .11$	(D = CA) > SA
Distance (cm)	162.08 (66.20)	209.14 (51.19)	108.34 (54.65)	$F(2, 90) = 23.68$, $p < .001$, $\eta^2_p = .35$	SA < D < CA
Pause time (secs)	69.81 (12.26)	54.01 (9.99)	79.44 (13.01)	$F(2, 90) = 36.55$, $p < . 001$, $\eta^2_p = .45$	CA < D < SA
Writing time (secs)	50.06 (12.34)	67.43 (10.92)	41.44 (13.09)	$F(2, 90) = 36.84$, $p < .001$, $\eta^2_p = .45$	SA < D < CA
Mean P duration (ms)	637.98 (294.09)	393.01 (135.54)	1068.45 (603.24)	$F(2, 90) = 23.20$, $p < .001$, $\eta^2_p = .34$	CA < D < SA

Note . Execution speed = cm/s (excluding pauses); ms = milliseconds. Mean P duration = mean pause duration.

As can be seen in Table 9.3 children with dyslexia were able to execute handwriting (execution speed) at the same speed as their CA peers. These two groups were significantly faster than the younger SA matches and covered a larger distance when writing. This is a consistent finding across all three tasks, although the mean scores for execution speed show changes for the different task demands.

In contrast, when exploring the temporal characteristics of pausing while writing, children with dyslexia showed a similar pattern to the spelling-ability matches. Children with dyslexia paused for a slightly shorter amount of time than the SA matches on both the copy best and copy fast tasks, although for the alphabet task there is no significant difference between these two groups on pause versus writing time.

For the copy best task significant differences were found for pausing and writing time across the three groups. The younger spelling matches paused for longer (68% of total time) than children with dyslexia (57%), who in turn paused for longer than their CA peers (47%) whose actual writing time is significantly longer.

A similar pattern is seen in the copy fast condition. Once again, the post hoc comparisons revealed that both children with dyslexia and the SA matches paused for significantly longer than writing (58% pause time vs. 42% writing time; 66% pause time vs. 34% writing time respectively) when compared to the CA group (45% pause vs. 55% writing). Furthermore, the mean pause duration for each of these tasks reflects how children with dyslexia paused for almost double the time shown by their CA peers.

Children with dyslexia were in fact no slower at executing handwriting movements than their CA peers. However, they did tend to pause more frequently while writing which provides an explanation for the slower output measured by the words per minute shown in table 9.2.

9.7.2.2 Writing task

Chapter 6 presented the text characteristics from the narrative compositions of the three groups. Notably, children with dyslexia wrote for a significantly shorter amount of time, and thus produce less text than their CA peers. Children with dyslexia made a high proportion of spelling errors when writing, a pattern that was found to be similar to the SA matched group. Table 9.4 reports the temporal characteristics of their compositions.

Table 9.4. Temporal characteristics from the narrative writing task for children with dyslexia, their CA peers and the SA matches

	D (*n* = 31) Mean (SD)	**CA** (*n* = 31) Mean (SD)	**SA** (*n* = 31) Mean (SD)	ANOVAs	Post hoc
Execution speed	2.11 (.69)	2.19 (.64)	1.59 (.44)	$F(2,90) = 9.41$), $p < .001$, $\eta^2_p = .17$	(D = CA) > SA
Distance (cm)	341.53 (169.03)	585.97 (226.45)	170.59 (89.42)	$F(2,90) = 40.75$, $p < .001$, $\eta^2_p = .48$	SA < D < CA
Pause time (mins)	6.48 (2.11)	7.03 (2.15)	4.61 (1.40)	$F(2,90) = 12.12$, $p < .001$, $\eta^2_p = .16$	
Of total time	*73%*	*62%*	*73%*	$F(2, 90) = 12.87$, $p < .001$, $\eta^2_p = .24$	(D=SA) > CA
Writing time (mins)	2.41 (.99)	4.29 (1.91)	1.97 (1.95)	$F(2,90) = 12.17$, $p < .001$, $\eta^2_p = .40$	
Of total time	*27%*	*38%*	*27%*	$F(2, 90) = 12.77$, $p < .001$, $\eta^2_p = .24$	(D = SA) < CA
Mean pause duration	1681.74 (948.98)	1252.74 (570.59)	2065.64 (1183.7)	$F(2, 90) = 5.85$, $p < .001$, $\eta^2_p = .12$	CA < D < SA

Note. Execution speed = cm/s (excluding pauses)

A MANOVA using Pillai's trace, revealed there was a significant effect of group on all of the measures in Table 9.4, $V = 0.61$, $F(10,174) = 7.68$, $p < .001$, $\eta^2_p = .31$. No significant differences were found between children with dyslexia and the CA peers on the measure of handwriting execution speed ($p = .98$) from the writing task. Once again, post hoc tests illustrate that the percentage of pause time taken by the children with dyslexia was more than for the children of the same age ($p < .001$) but the same as children of the same spelling ability ($p = .99$). Children with dyslexia and the SA group spent 73% of the task time pausing (not writing) and their overall mean pause duration was much higher than the CA group. These results explain the fewer words produced per minute for these two groups, and eliminate assumptions of slow handwriting execution for children with dyslexia.

9.7.2.3 Relationship between motor skill and written ability

Manual dexterity was initially assessed to determine the influence of motor control on the production and quality of writing. An analysis of covariance (ANCOVA) was conducted to determine whether the scores of the dependent variables: quality of writing (WOLD raw score), words per minute, execution speed, and pause time, differed after adjustments for manual dexterity performance; given the trend towards the children with dyslexia having more varied performance on this measure. Group was the between-subjects factor and manual dexterity was the covariate. For the measure of writing quality, manual dexterity, showed a significant effect $F(1, 89) = 4.10$, $p = .046$, $\eta^2_p = .04$, and so did group $F(2, 89) = 51.96$, $p < .001$, $\eta^2_p = .54$. There was no interaction between group and manual dexterity, suggesting that both of these factors affect the quality of writing produced.

For the measures of words per minute and execution speed, there was no significant effect of manual dexterity $F(1, 89) = .92$, $p = .341$, $\eta^2_p = .015$; and $F(1, 89) = 1.33$, $p = .25$, $\eta^2_p = .01$ respectively. Although, these two measures still reflected a significant effect of group, $F(2, 89) = 33.77$, $p < .001$, $\eta^2_p = .43$; and $F(2, 89) = 9.93$, $p < .001$, $\eta^2_p = .18$ respectively. Pairwise comparisons confirmed that children with dyslexia write fewer words than their CA peers but execute handwriting at the same speed even when controlling for manual dexterity. However, when pause time was analysed there was a significant effect of manual dexterity $F(1, 89) = 11.84$, $p = .001$, $\eta^2_p = .12$, and group $F(2, 89) = 13.29$ $p < .001$, $\eta^2_p = .23$. Comparisons revealed that children with dyslexia paused for the same percentage as the SA matches; pausing for longer than the CA controls.

Bivariate correlations were also conducted to examine the relationship between manual dexterity and writing. For children with dyslexia, the manual dexterity scores showed a significant positive correlation ($p < .05$) with the quality of writing produced ($r = .62$) and words per minute ($r = .53$), a significant negative correlation with pause time ($r = -.48$) but no correlation was found with handwriting execution speed. These correlations were not significant for the CA or SA group. However, when the graphic speed task was used rather than the manual dexterity component, no significant correlations were found with the quality of writing produced by any of the three groups.

9.7.2.4 Relationship between handwriting skill and written ability

Table 9.5 illustrates how the handwriting variables correlate with the quality of the written text produced by the three groups. The alphabet task (letters per minute) was included in this analysis. Execution speed (as measured by the writing tablet) was taken from the writing task as this was the most naturalistic, as opposed to the instruction for the copy best and copy fast conditions, and a similar value was seen for the writing task and the execution speed from the alphabet task.

Table 9.5. WOLD written compositional quality correlations with handwriting measures

	D (*n* = 31)	**CA** (*n* = 31)	**SA** (*n* = 31)
Alphabet task (DASH)	.71**	.15	.47**
Execution speed (writing task)	.30	.19	.02
Pause % from writing task	-.59**	-.37*	-.33

Note. *$p < .05$ **Bonferroni correction $p < .02$ (two-tailed). DASH = Detailed Assessment of Speed of Handwriting.

As can be seen from Table 9.5, for children with dyslexia and the younger SA group handwriting speed (as measured by the number of letters of the alphabet written in one minute) is significantly correlated to the quality of the written text. However, this relationship was not found to be significant for the CA group. In addition, for children with dyslexia, a significant positive relationship was found between the number of letters written in the alphabet task and text length in the written compositions produced ($r = .67$).

Interestingly, the measure of execution speed (excluding pause time, thus looking at only the motor execution) revealed no significant correlations across groups. Whereas, when the percentage of pause time was inputted, significant correlations were found with the quality of the writing produced by children with dyslexia and their CA peers.

Table 9.6 shows the regression analyses that were computed for children with dyslexia. Spelling ability was included because of its close relationship to handwriting (transcription). Age was not entered into this regression analysis because the participants in each of the three groups were very close in age and so developmental differences were not present. This was originally checked within a regression analysis before reporting the results in this way.

Table 9.6. Regression equation predicting the quality of writing produced by children with dyslexia

Dyslexic	ß	R^2	R^2 change	*F*	*df*	*p*
Spelling ability (BAS)	.14	.36	.30	13.22	1, 29	< .001**
Alphabet task (DASH)	.49	.55	.19	16.84	1, 28	< .001**
Pause % from writing task	-.26	.59	.04	12.75	1, 27	< .001**

Note. *p < .05, **p < .001. BAS = British Abilities Scales-II; DASH = Detailed Assessment of Speed of Handwriting.

Spelling ability was found to uniquely account for 30% of the variance in the quality of the written text produced by children with dyslexia, with the performance on the alphabet letter writing task explaining an additional 19% of the variance, and pause time while writing accounting for a smaller 4%. This means that for children with dyslexia 53% of the variance in WOLD quality scores is accounted for by the lower-level transcription skills of spelling and handwriting speed.

Regression analyses were also computed for the CA and SA groups, shown in Tables 9.7 and 9.8. The correlations in Table 9.5 revealed no significant relationship between the alphabet task and quality of the writing produced by the CA group, however pause time did reach significance and thus was entered into the regression.

Table 9.7 Regression equation predicting the quality of writing produced by the CA group

CA	ß	R^2	R^2 change	*F*	*df*	*p*
Spelling ability	.29	.09	.09	2.95	1, 29	.10
Pause %	-.35	.22	.13	4.42	1, 28	.03*

Note. *p < .05, **p < .001

The alphabet task revealed a significant relationship with the quality of the writing for the SA group and so this variable was entered as a predictor variable after spelling ability in Table 9.8.

Table 9.8. Regression equation predicting the quality of writing produced by the SA group

SA	ß	R^2	R^2 change	*F*	*df*	*p*
Spelling ability	-.09	.02	.02	.05	1, 29	.82
Alphabet task	.49	.22	.20	4.01	1, 28	.009*

Note. $*p < .05$, $**p < .001$

For the CA and SA groups, spelling ability did not contribute a significant proportion of variance towards the quality of the written product. However, for the CA group the percentage of time spent pausing predicted 13% of the outcome variable, and for the SA group it was the alphabet task that made a significant contribution to the quality of the written text, accounting for 20% of the variance in scores.

The results from the multiple regression analyses in Table 9.6 illustrated that performance on the alphabet task accounts for a large proportion of the variance in written ability and as suspicions were raised in the introductory sections as to what the alphabet task actually measures, further regressions were conducted to establish influences on alphabet task performance. The regression results reported in Table 9.9 concern the predictive value of spelling ability (BAS-II) and phoneme segmentation skills (DST-J) towards performance on the alphabet task by children with dyslexia. Manual dexterity was included to determine the role of motor skills.

Table 9.9. Regression equation predicting the alphabet task performance of children with dyslexia.

	ß	R^2	R^2 change	*F*	*df*	*p*
Spelling ability (BAS)	.61	.38	.38	17.46	1, 29	< .001**
Phoneme seg (DST-J)	.30	.43	.05	10.31	1, 28	< .001**
Manual dexterity (MABC)	.36	.53	.10	10.06	1, 27	.02*

Note. $*p < .05$, $**p < .001$. BAS = British Abilities Scales II; DST-J = Dyslexia Screening Test – Junior; M-ABC = Movement Assessment Battery for Children 2nd ed.

The results in Table 9.9 demonstrate that spelling ability accounted for 38% of unique variance in the handwriting speed (letters produced in the alphabet task) of children with dyslexia. A further 5% of variance was accounted for by phonological segmentation skills, and above that a further 10% was explained by manual dexterity performance. Overall nearly half of the variance in performance for this measure can be attributed to spelling and phonological ability, with these two skills accounting for a larger proportion than motor skills. This regression analyses was then conducted with the sentence-copying task (copy fast) as the outcome variable. The copy fast condition was used rather than the copy best because the fast condition is similar in instructions to the alphabet task, whereby children had to write as quickly as possible in the time allowed, and neatness was not discussed. Table 9.10 shows these results.

Table 9.10. Regression equation predicting the 'copy fast' performance of children with dyslexia.

	ß	R^2	R^2 change	*F*	*df*	*p*
Spelling ability	.69	.53	.53	33.04	1, 29	< .001**
Phoneme seg.	.18	.59	.05	3.62	1, 28	< .001**
Manual dexterity	.33	.64	.10	6.65	1, 27	.01*

Note. *$p < .05$, **$p < .001$. BAS = British Abilities Scales II; DST-J = Dyslexia Screening Test – Junior; M-ABC = Movement Assessment Battery for Children 2nd ed.

In a similar way to the findings in Table 9.10, spelling ability predicts a large proportion of unique variance (53%) of performance on the sentence-copying task. Once more, 5% of additional variance is accounted for by phonological skills, and a further 10% is explained by manual dexterity. The predictive relationship between spelling ability and performance on the copying task is slightly stronger than observed for the alphabet task, which could have been expected considering that the copying task requires producing full words rather than letters.

This regression analyses with the copying task as the outcome variable was also conducted for the CA and SA groups. However, neither spelling ability, phoneme segmentation skills, nor manual dexterity significantly predicted variance in this measure for the CA group, $R^2 = .09$, $F(1, 29) = 3.12$, $p = .09$; $R^2 = .10$, $F(1, 28) = 1.58$, $p = .22$; and $R^2 = .10$, $F(1, 27) = 1.02$, $p = .40$; and the SA group, $R^2 = .01$, $F(1, 29) = .23$, $p = .64$; $R^2 = .03$, $F(1, 28) = .50$, $p = .70$ and $R^2 = .06$, $F(1, 27) = .50$, $p = .59$, respectively.

9.7.3 Discussion

Practitioners often believe that poor motor skill development causes slow handwriting in children with dyslexia (Goldup, 2000; Rose, 2009), despite the lack of research to support this stance. Thus, there is a danger that much effort in teaching children with dyslexia may be wasted on focusing on the development of motor skills related to handwriting that are not actually impaired.

Motor skill was considered in this study, providing credibility above those studies in the present literature that have ignored the role of motor control when writing. Motor control was carefully assessed through general aspects of manual dexterity, using the MABC-2, and a very specific examination of control of a pen, using the graphic speed task. At a group level there were no differences in speed, suggesting that no additional motor difficulties were present. Some difficulties with accuracy in motor output (graphic speed task) were noted for children with dyslexia but as problems with motor execution were not apparent this was not considered a problem.

The first research question concerned whether children with dyslexia wrote less than their peers in time constrained tasks. Interestingly, the number of letters of the alphabet written in one minute was not significantly different to their peers, which suggests that speeded access of letters from memory and the ability to produce these in writing was not impaired. These results challenge the findings of the Berninger et al (2008) study, which described children as having slower handwriting automaticity (alphabet task, 15 seconds) when compared to age expected norms. However different time constraints were used and, therefore, different instructions were given across these two studies, making comparisons difficult.

In contrast to the findings from the alphabet task, children with dyslexia were shown to have a significantly slower handwriting speed (words per minute) than the age-matched group in the two sentence-copying tasks and the narrative writing task. This is a finding that has been shown in university students with dyslexia (Hatcher et al., 2002), although the sentence was different to the one used here. Yet, in comparison to the younger spelling-ability group, children with dyslexia wrote more. This time the tasks used were more relevant to children's ability to write text, as they required forming whole words and sentences. These findings would usually be taken as support for a slow handwriting speed in children with dyslexia and do confirm that children with dyslexia composed written text more slowly. However, with the use of a digital writing tablet it was possible to investigate task performance in more detail.

The Eye & Pen software was used to investigate execution speed. The software programme analysed if the real-time movement of the pen when executing orthographic-motor patterns illustrated differences across groups. Perhaps the most interesting and encouraging findings are that children with dyslexia were able to execute handwriting at an equal speed to their age-matched peers. This was a consistent finding across all four writing tasks. These two groups were significantly faster than the younger spelling-ability matched group, whose performance could be attribute to less experience with writing (Graham, Berninger, & Weintraub, 1998; Graham & Harris, 2000). The execution speed does vary across tasks slightly, with all groups writing quicker in the copy fast sentence-copying condition and slower in the copy best condition: demonstrating that the instructions for the tasks were followed. It would seem that the natural execution speed for children with dyslexia and their peers is between 2.11-2.32 cm/s because for the alphabet and writing task execution speed was found within this range, and no instructions were given for these tasks with regards to how to execute handwriting. Moreover, these findings support the results from the graphic speed task when considering just speed (not accuracy) of performance, and provide a strong argument that speed of motor execution is not an area of difficulty for children with dyslexia.

So far, we have a disjointed picture as children with dyslexia write less than their age peers but are able to execute handwriting at the same speed. Temporal characteristics of the text contributed to the research question regarding fluency. Children with dyslexia were found to pause for longer within their text and to subsequently spend a larger proportion of the task time pausing rather than writing. Notably, their peers paused less while writing, and were able to split pausing and writing time relatively equally. For these measures the crucial finding is the similarity between children with dyslexia and the spelling-ability matches. As well as for pausing for the same percentage of time, these two groups have larger mean pause durations than the age-matched controls.

These patterns confirm that children with dyslexia are slower at composing texts than their peers due to less time spent writing, and that the amount of time pausing when composing text is linked to spelling ability. This finding supports current theories that narrowly define dyslexia as a specific language problem with written language (Bishop & Snowling, 2004) and not a motor execution problem as often suggested in the literature (Nicolson & Fawcett, 1994).

Similarly, in the copying tasks children with dyslexia portrayed a pattern of pausing for longer than writing, once more reflecting the opposite pattern to their peers. It was initially discussed that sentence copying tasks would require a certain level of orthographic processing, and for this reason it was predicted that children with dyslexia would perform badly in these tasks. Regression analyses that were conducted to explore the influence of spelling in such tasks demonstrated that for children with dyslexia, spelling ability accounted for a large proportion of variance in the speed of handwriting; whereas this was a non-significant result for the typically developing peers. Thus, it could be argued that while these handwriting assessments are suitable for typically developing children, their validity for children with dyslexia should be considered in terms of the impact of spelling ability on handwriting results. Moreover, similar to the findings reported by Martlew (1992), even when completing copying tasks, children with dyslexia were found to make spelling errors in their writing.

In answer to the research question about consistency of handwriting performance across different task demands, the similarities/differences in group performance for execution speed was mirrored for each task, although increased or decreased depending on the task instructions. Additionally, children with dyslexia and the spelling-ability group showed a consistent finding of pausing for longer than writing in each of the handwriting assessments and the writing task. A strength of this study was that a range of measures were used to assess handwriting, varying from limited task demands to the influence of increased cognitive processing on handwriting.

The relationship between manual dexterity and the quality of the written compositions was explored, as the literature often reports a link between motor skill and writing (Berninger et al., 2008; Berninger et al., 1992). Manual dexterity was entered as a covariate and did not change the findings on handwriting speed and execution measures; and neither did manual dexterity significantly correlate with execution speed for any of the three groups. However, an interesting finding was revealed as manual dexterity was found to significantly correlate with the quality of the written compositions produced by children with dyslexia, and only for this group. It would appear that general motor ability might be related to writing per se but not in the commonly assumed way of constraining execution speed of handwriting.

Berninger et al. (1992) found a strong relationship between motor skills and text quality in children younger than those with dyslexia in the present sample; and in a later paper reported that this relationship diminished by the time typically developing children reach the age of those in the present study (Abbott & Berninger, 1993). Berninger argued that motor skills have a strong influence for beginning writers until handwriting reaches a level of automaticity. From this angle, it could be argued that these children with dyslexia are demonstrating a developmental delay in writing. However, if this were the case then the same pattern would have been expected from the younger spelling-ability matched group, which was not evident. An explanation for not detecting this pattern in the ability-matched children could be attributed to the smaller writing sample they produced. An important point to make here is that although a significant relationship was found when using the general measure of manual dexterity as the motor variable, a non-significant relationship was found between performance on the graphic speed task and the quality of writing by children with dyslexia. The graphic speed task actually required using a pen to assess motor control and therefore ought to be a more accurate comparison to handwriting than the general manual dexterity measure. This should be kept in mind when considering these correlations.

An alternate explanation for the relationship between manual dexterity and text quality could be the underlying influence from pausing. Significant correlations were found between the manual dexterity performance of children with dyslexia and their pause percentage when writing. Adults with dyslexia have difficulties with learning implicit sequence learning when completing motor tasks (Kleine & Verway, 2009; Menghini, Hagberg, Caltagirone, Petrosini, & Vicari, 2006). Motor acts require the activation of many processes, such as motor planning, memory, execution, and coordination. Writing can be a cognitively demanding task for children, especially for those with additional spelling difficulties and, therefore, it is possible that the association between manual dexterity and pausing could represent a problem with coordinating these many processes in parallel. While the high error rate of spellings demonstrates that children with dyslexia struggled with phonology and orthography, the high rate of pauses could relate to problems with rapidly accessing motor patterns from memory.

Furthermore, when considering the correlations performed for children with dyslexia it was apparent that when the task included pause times, significant correlations could be found in relation to text quality. For example, the manual dexterity tasks were an overall timed task (included pause times); yet, in contrast the measure of execution speed excluded pause time and was not significantly correlated with written text quality. Research that explored RAN performance by children with dyslexia has demonstrated that, similar to the findings of the present study, motor production (articulation rate) was in fact no different to children without dyslexia, and rather it was the inter-item pause time that influenced the overall poorer performance in the naming tasks (Araujo et al., 2011). Together these findings point towards a difficulty with parallel processing, resulting in pause time to refresh performance. Maggio et al (2012) proposed that, for some children, spelling and composing will need to be executed sequentially when the cognitive load is too high, providing an explanation for the present findings.

Regression analyses explored the predictive role of the transcription skills when composing written text, and also to determine which (spelling or motor) influenced the handwriting speed assessment. These analyses revealed that while handwriting speed (alphabet task) accounted for a significant proportion of the variance in written compositional quality in children with dyslexia, after spelling ability, this measure and the sentence copying task were largely influenced by general spelling ability. Although these two handwriting measures do not require children to produce their own spellings the level of orthographic processing that occurs as the participant reads the word and then encodes the sentence in verbal memory must influence performance. Interestingly, handwriting speed using the alphabet task was not found to be a significant predictor of written text quality for their peers. It is possible that the children in this group have reached a level whereby the transcription skills are no longer constraining writing development.

An important point to reiterate here is about the way that handwriting is currently being measured in the literature. There has been no consistent measurement to assess handwriting performance. The findings from the present study stress that a general assessment of the number of words written per minute largely mask the characteristics of handwriting execution and fluency. This could partly explain the common assumption that children with dyslexia have a slow speed of handwriting, when in fact it is has been demonstrated that they are slow to produce text and it is not a difficulty with the speeded motor act.

Another measurement issue to consider is the demands of the presented tasks. It is widely accepted that the alphabet and copying tasks do not impose a heavy cognitive load on the writer. However, even for typically developing adults completing a sentence-copying task, when the spelling demands are raised they have a direct influence on rate of transcription (Lambert et al., 2011). For children with dyslexia that have well-documented problems with phonology and orthography (Bernstein, 2009; Bourassa & Treiman, 2003) the processing of the information pertaining to the word in working memory appears to influence the fluency of the execution, and thus the number of words written in the set time. In addition, the writing task has an increased demand that encompasses linguistic and cognitive processing at a word, sentence and discourse level. Here, there are other possible explanations for a slow rate of words produced, other than handwriting difficulties. A range of tasks is beneficial, as shown in the present study, to demonstrate how and what is affected by the demands involved.

To summarise, children with dyslexia showed no impairment in handwriting execution speed. Rather, the fewer letters/words that were written per minute could be explained by the longer time that they spent pausing instead of physically writing on the paper. This is a key finding and one that has never before been brought to light. The benefit of using a spelling-ability matched group allowed for a clear comparison to be made with regards to the influence of spelling. The work by Lambert et al (2011) has illustrated that when spelling is difficult for participants, sequential processing of the spelling units and handwriting occurs. This could explain why children with dyslexia were found to have higher mean pause durations and longer pause percentages, in comparison to their peers.

The next step was to investigate the location of the pauses and their relation to spelling errors. As Wengelin (2007) previously demonstrated in university students with dyslexia, it could be expected that the writing of children with dyslexia would show a pattern of frequent pausing within words. In addition to this, the link between pausing while writing and the quality of compositions produced was explored in Study 2 (9.8).

9.8 Study 2

The focus in this study turns to the fluency of the written compositions produced and how these findings contribute to the model of handwriting (Van Galen, 1991) and writing development (Berninger & Swanson, 1994). Previous findings that university students with dyslexia spend a high proportion of their pauses within and between words suggest a processing problem at the word-level (Wengelin, 2007). In relation to Van Galen's (1991) model it could be hypothesised that processing of spellings can have a negative impact on the fluency of the following motor processes for children with dyslexia.

Alamargot et al (2006) discussed how pauses can be interpreted based on Foulin's (1995) explanations for pauses in oral language production. Four assumptions were postulated to describe why pauses occur: (1) the duration of pauses vary as a function of the complexity of the processes engaged; (2) that the location of the pause indicates the nature of this processing demand; (3) the process that occurs during the pause concerns the part of the text that will be written immediately afterwards; and (4) as the more demanding processes cannot be engaged in parallel with handwriting execution, they impose a writing pause.

Due to the nature of the difficulties that children with dyslexia experience, the focus of the pause analysis was directed to how pause behaviour was influenced by the programming of spellings in the real-time production of text. The aim was to identify where pauses in the text were a result of spelling difficulties and for how long these difficulties disrupted text making. Using the four points above, specific research questions for this study were devised.

Compared to their peers, do children with dyslexia:

a) Pause for longer around (directly before and within) spelling errors?
b) Pause more frequently within-words?

The following research questions were addressed across all groups:

c) Does pause performance relate to the quality of the written compositions produced?

A final research question links this work back to the previous chapter and the Van Galen (1991) model of handwriting production in terms of how spelling could be argued to influence vocabulary choices (higher up in the hierarchy) as well as motor production:

d) Do within-word pauses predict written lexical diversity for children with dyslexia?

9.8.1. Method

As this is a follow-up study from Study 1, the pool of participants, the writing task, and the materials that were used are the same as listed previously.

9.8.1.1 Online analysis

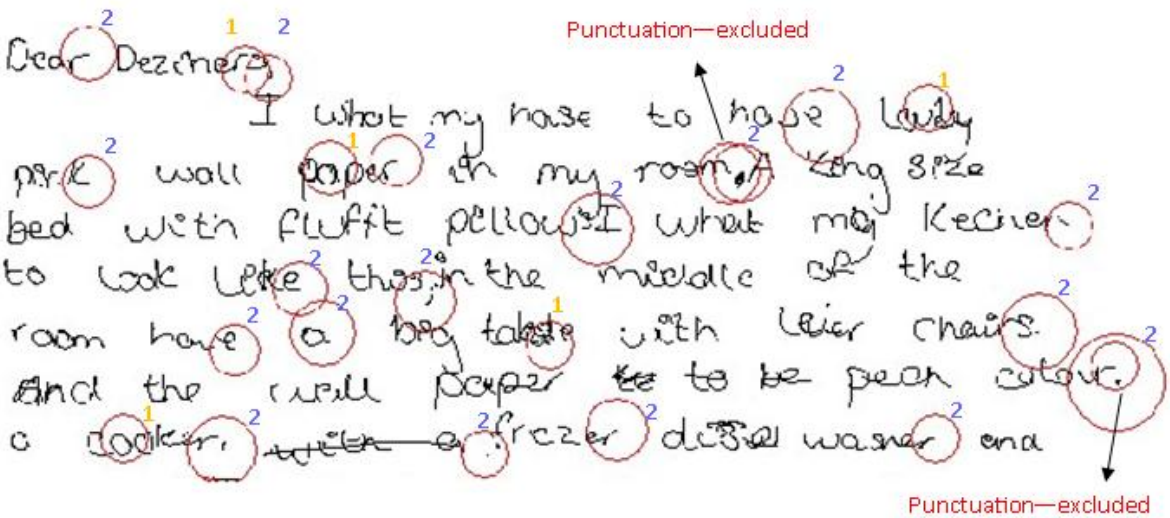
<u>Pausing around misspellings.</u> The first analysis focused on the location of pauses in relation to spelling errors (before, or within the misspelt word) and the total duration of these particular pauses. Here the pause threshold was set to 250 milliseconds (ms). This was increased from the baseline (30ms) threshold that was used in Study 1 because it provided a more suitable measure for this particular research question. Researchers have previously used the 250ms threshold to investigate the cognitive demands of handwriting (using a reaction time task, Olive et al., 2009; Olive & Kellogg, 2002). While this threshold is still quite low for a pause, it is thought to exclude pauses that were made for

mechanical reasons, such as pausing to dot an 'i' or pausing within letters. Using this higher threshold will eliminate some of the previous pause time and, therefore, a new overall pause is presented in the results section.

The mean latency (initial pause duration) before the misspelling was calculated, along with the total duration of all of the pauses that related to a spelling error. Percentages were derived to take into account the length of the written text.

<u>Word-level pauses.</u> The locations of pauses were then considered at the word-level, considering the whole text and not just spelling errors. In accordance with other studies in this area, the threshold was increased to 2 seconds for this analysis (Alves et al., 2007; Stromqvist & Ahlsen, 1999; Wengelin, 2007). The 2-second threshold recognises a significant pause from composing text and is assumed to represent higher-level processing (Alves et al., 2007). This higher threshold eliminated instances where children paused more than once within one word. Thus, the scores for the within-word pausing represent, where applicable, one pause per word. When a child paused after a word, marked punctuation and then paused again, the second pause was excluded from the analysis, as shown in the example in Figure 9.1.

Figure 9.1. An example of the within- (1) and between-word (2) coding of pause locations



The coding for this analysis was conducted using Eye and Pen software. It was possible to mark the location of each pause made in a written sample. Sentence-boundaries were initially coded but these were subsequently re-coded to between-word pauses, as very few children with dyslexia used punctuation to mark sentences. Within-word pauses were coded as 1; between-word pauses were coded as 2, as shown in Figure 9.1. The example provides is a section of writing by a girl with dyslexia, aged 10 years and 6 months. The codes have been labelled in orange (1) or blue (2) by each pause. This was more accurately viewed when using the software to work through the writing; however the image below provides a good illustration.

A frequency count of pauses considered text length, because the amount of text written between groups varied significantly. For example, in Figure 9.1 five within-word pauses were made, and there were a total of 58 words (5/58). This resulted in a sum of 0.09, reflecting that this child paused ‘within’ 9% of the total words. For the calculation of between word pauses, the total number of opportunities was always one less than for the within word calculation. For example, if there were 58 words, there would have been 57 possible opportunities to pause between words.

9.8.2. Results

9.8.2.1 Pausing around misspellings

A 250ms threshold was set for the analysis of pausing around misspellings, altering the overall pause time that was reported in Table 9.4. The new calculations are provided below in Table 9.11. Total pause time and spelling pause times are presented in minutes. The mean latency value (how long it took the child to start a misspelling) is shown in seconds.

Table 9.11. The total time spent pausing around misspellings when the threshold is > 250ms

	D (*n* = 31)	**CA** (*n* = 31)	**SA** (*n* = 31)	**Post hoc**
	Mean (SD)	Mean (SD)	Mean (SD)	
Pause time (mins)	4.91 (1.80)	5.18 (1.76)	3.49 (1.24)	
Percentage	*55%*	*45%*	*55%*	(D = SA) > CA
Spelling pauses (mins)	1.47 (.95)	.22 (.21)	1.28 (.71)	
Spelling %	*29%*	*4%*	*35%*	(D = SA) > CA
Latency (secs)	4.21 (2.41)	1.65 (1.53)	4.52 (4.37)	(D = SA) > CA

Note. All calculations used a 250ms threshold to mark a pause. Pause time and percentage of total time. Spelling pause time = total minutes spent before or within a spelling error; Spelling % of the total pause time reported above; Latency = the time spent pausing before a spelling error, measured in seconds.

A significant effect of group was still found for the total pause time, $F(2, 90) = 9.75$, $p < .001$, $\eta^2_p = .18$, and the percentage of pause time in relation to the time spent on the task, $F(2, 90) = 6.74$, $p = .002$, $\eta^2_p = .13$. Post hoc comparisons revealed that children with dyslexia were pausing for the same percentage of time as the SA group. In the same pattern as in Study 1, these two groups paused for significantly longer than the CA group.

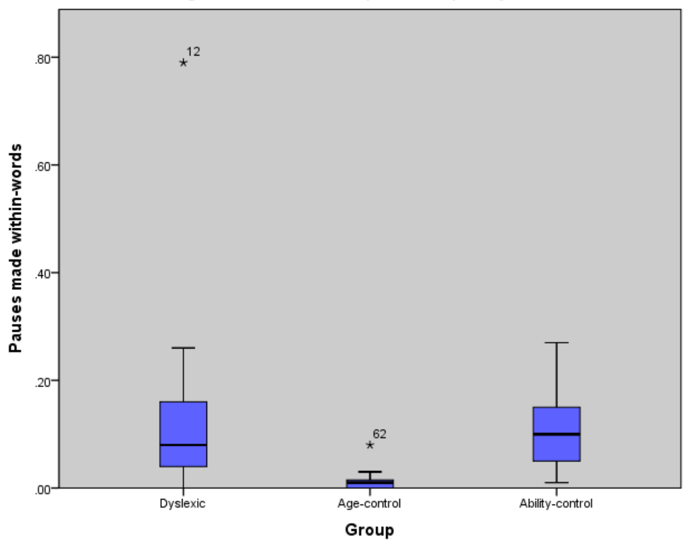
Almost half of the pause time made by children with dyslexia and the SA group was devoted to spelling errors. A significant effect was found for group membership for spelling pause time, $F(2,90) = 29.34$, $p < .001$, $\eta^2_p = .41$, and the percentage of this in relation to the overall pause time, $F(2, 90) = 47.84$, $p < .001$, $\eta^2_p = .52$. Children with dyslexia matched the performance of the SA group. In contrast, the CA group rarely paused around spelling errors, less than half a minute.

The final measure in Table 9.11 revealed a significant effect of group, $F(2, 90) = 7.02$, $p = .001$, $\eta^2_p = .14$, while the post hoc comparisons demonstrated that children with dyslexia paused for the same amount of time as the SA group before starting a misspelling. These two groups spent significantly longer pausing at these boundaries than the CA group.

9.8.2.2 Pause analysis at the word-level

The next set of analyses used a 2 second threshold to determine the frequency of pausing either within- or between- words, Figures 9.2 and 9.3 respectively. The Kruskal-Wallis test was used to analyse differences across the three groups of participants.

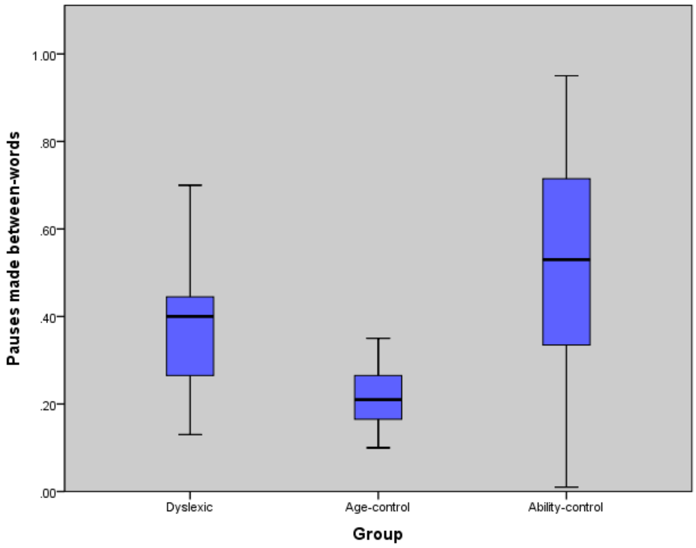
Figure 9.2 Within-word pause frequency



Two outliers were identified from Figure 9.2 but were included to illustrate that one child with dyslexia paused within nearly 80% of the total words written. For this measure of within-word frequency, a significant effect of group was found, $H(2) = 50.42$, $p < .001$. Mann-Whitney tests were used as a follow up procedure and revealed that children with dyslexia matched the performance of the SA group for this pause frequency count. These two groups paused more frequently within-words than the CA peers. The median frequency score for children with dyslexia was 13% of the overall word count, compared to the CA group that paused within only 1% of the total word count.

A significant effect of group, $H(2) = 40.80$, $p < .001$, was found for the between-word pause frequency, Figure 9.3. The median scores represented a stepwise pattern across the three groups. The CA group paused the least (25%) at this boundary, then the children with dyslexia (37%), with the SA group pausing between 58% of the words.

Figure 9.3 Between-word pause frequency



Together these findings demonstrate that children with dyslexia paused more frequently than the CA peers overall, and the SA group follow a similar trend to children with dyslexia.

9.8.2.3 Correlations

Table 9.12 shows the Pearsons bivariate correlations that examined the relationship between pausing and the WOLD raw score.

The only results that were significant were for children with dyslexia. These medium negative correlations suggest that the longer spent pausing, and in particular pausing around spelling errors, the lower the written texts were graded.

Table 9.12. Correlations between handwriting fluency measures and WOLD compositional quality

	D (n = 31)	**CA** (n = 31)	**SA** (n = 31)
Total pause % > 250ms	- .37*	- .21	- .38
Spelling pause %	- .47*	.00	- .29

Note. *Bonferroni correction p < .03 (two-tailed).

When correlations were computed also for the pause time with the baseline threshold (30ms), so including a larger number of pauses, children with dyslexia had a stronger correlation than shown in the table above (r = -.78). Again, this relationship remained non-significant for the typically developing groups.

The final stage of analysis was to consider whether within-word pausing predicted lexical diversity across the three groups, regression analyses are reported in Tables 9.13-9.15. The within-word pause frequency values were log transformed for the following regression analyses.

Table 9.13. Regression equations predicting written lexical diversity (*R*) for children with dyslexia

Dyslexic	ß	R^2	R^2 change	*F*	*df*	*p*
Within-word pauses	-.59	.35	.35	15.81	1, 29	< .001**

Note. * p <.05, ** p < .001

The frequency counts of within-word pausing when writing was a significant predictor for the written lexical diversity scores of children with dyslexia (35%) demonstrating that word related pausing relates to the vocabulary choices made while writing. This relationship was non-significant for the CA group, as can be seen in Table 9.14.

Table 9.14. Regression equations predicting written lexical diversity (*R*) for the CA group

CA	ß	R^2	R^2 change	*F*	*df*	*p*
Within-word pauses	-.11	.01	.01	.37	1, 29	.55

Note. * p <.05, ** p < .001

Finally, the regression analyses in Table 9.15 demonstrates that, similar to children with dyslexia, within-word pausing was a significant predictor of written vocabulary choices made by children in the SA group. Its predictive value accounted for 15% of unique variance.

Table 9.15. Regression equations predicting written lexical diversity (*R*) for the SA group

SA	ß	R^2	R^2 change	*F*	*df*	*p*
Within-word pauses	-.38	.15	.15	4.80	1, 29	.03
Note. * *p* <.05, ** *p* < .001						

9.8.3 Discussion

This study opened with a discussion about the four assumptions that relate to pausing behaviour (Alamargot et al., 2006). The first two assumptions concerned how the duration and location of pauses indicate the nature of the processing demands. The findings from the present study demonstrated that children with dyslexia spend a large proportion of their pause time pausing before and during spelling errors, similar to their spelling-ability matches, and dissimilar to their peers. It is confirmed that the demands of spelling significantly interrupts the flow of composing for children with dyslexia.

To consider the third assumption made by Alamargot et al (2006), which suggested that the process occurring during a pause concerns what is written next, the latency before a spelling error was considered. On average, children with dyslexia and the spelling-ability group paused for 4 seconds before starting a word that was spelt incorrectly. This latency duration could be attributed to considering what came next, in this case the spelling that was particularly difficult for these children. These pauses are much longer than the age-peers, representing a more demanding cognitive process. Similarly, Wengelin (2007) reported that university students with dyslexia paused frequently and revisited spelling errors when typing an expository text. Together, these findings present a strong argument that spelling constrains the fluency of text composed by individuals with dyslexia.

The fourth pause assumption (Alamargot et al., 2006) was that when the demands of the task can no longer be executed in parallel with handwriting execution, it results in a pause. This assumption covers the findings that have already been discussed that demonstrated a breakdown in fluency. Although the act of parallel and sequential processing cannot be directly analysed from using only a writing tablet (an eye tracker would have provided a more detailed analysis), it is reasonable to propose that the frequent and lengthy pauses around spelling errors were due to sequential processing of retrieving orthographic information and then transcribing this information in writing. The overall pause performance shown by children with dyslexia was found to correlate with the quality of the written compositions produced; demonstrating that the longer they spent pausing, the weaker the compositions were graded. This would make sense when considering that, overall, fewer words were written in comparison to their peers, which is a strong determinant of text quality.

Analyses were conducted on whether pauses were made more frequently within or between words. The pause threshold was purposefully set at a higher boundary (2 seconds) to conform to the design of other studies and to establish higher units of processing (Alves et al., 2007; Wengelin & Stromqvist, 2000; Wengelin, 2007). The findings support the study by Wengelin (2007), such that children with dyslexia were found to make a high percentage of within-word and between-word pauses, significantly higher than their peers while demonstrating a similar pattern of performance to the younger spelling-ability group. The present study developed the findings by Wenglelin (2007) by using an additional spelling-ability group, which enabled the difficulties that children with dyslexia experience to be confirmed as a specific problem with spelling.

When considering the results from the age-matched peers, they showed less frequent pausing and where pauses were made this is more likely to be between writing words, although this frequency is particularly low. For this group, further analysis could be directed at whether these between word pauses were at sentence boundaries, which may reflect a more superior strategy to plan the following sentence. This type of coding was originally included in the analysis but so few of the children with dyslexia marked sentences with punctuation that it seemed inappropriate to assume where sentences were supposed to end.

Pause analysis has raised questions for further study. A recent direction in psycholinguistics research has been to explore the effect of syllable and morpheme boundaries on the production of handwriting. Using a controlled writing task, Kandel and colleagues asked French children to write a selection of bisyllabic words on a digital writing tablet (Kandel et al., 2011). A pattern emerged of children taking longer to complete letter strokes at the syllable boundary of a word and, furthermore, overall production times were affected by syllable frequency. Similarly, in typing research when German undergraduate students were asked to complete a short sentence describing the order of the shapes presented on a screen, significant pauses occurred at syllable and morpheme boundaries (Nottbusch, Weingarten, & Sahel, 2007). Research in this area suggests that children and adults typically break down a word into manageable chunks and reiterates the strength of the relationship between the spelling processing module and the real-time movement of the pen.

In relation to the Van Galen (1991) model of handwriting, the hierarchy of spelling above the allograph selection and motor output is supported by the findings of Kandel et al (2011). However, it does probe the need for an expansion in the model to illustrate how units of spelling recursively influence handwriting execution. The influence of syllables in production times (Kandel et al., 2011; Kandel & Valdois, 2006) indicate that the mental lexicon is addressed while writing and in turn relates to the speed of composition. Comparisons to English would be possible as the French language has a deep orthography too (Sampson, 1985). Recognition of syllables in spelling implies an aspect of phonological processing accompanying writing. In terms of making predictions for children with dyslexia, it might be expected that identifying and segmenting syllables and phonemes when spelling would present more of a challenge than for children with no phonological difficulties (Wood, 2006). Additionally, if verbal working memory is restricted for these children (as suggested in the Rose 2009 review) then it could be predicted that the retrieval of this information while completing a writing task would be slower and may impact on the size of the information processed.

It remains as speculation here, that children with dyslexia may process spellings at smaller units than typically developing children, for example by rimes. This would be an interesting avenue for future research, with specifically designed spelling tasks using a digital writing tablet. It would not be feasible to do this kind of analysis on the narrative writing task in the present work because it was unconstrained, and the majority of spelling errors made by children with dyslexia were only of one syllable. Furthermore, issues of word frequency would need to be addressed when considering the production of unconstrained text.

Finally, to address the last research question that aimed to link handwriting, spelling and vocabulary choice. Within-word pauses were found to predict written lexical diversity for children with dyslexia and the spelling-ability group, supporting Wengelin (2007). This finding links the previous chapter to the present one by emphasising the connection between the production of spelling, vocabulary, and handwriting execution.

Possible limitations of this study relate to the selection of pause thresholds. At present, little justification is available in the literature for the various thresholds that are used, although researchers argue that as the higher thresholds focuses on longer pauses, they are capturing more demanding cognitive processes (Olive et al., 2009). In the present study thresholds were altered depending on the subject of analysis and were kept in accordance with the current literature. The lowest threshold was used in the Study 1 to capture all pause activity, whereas Study 2 required eliminated mechanical pauses to provide a stronger argument for word-related performance.

Another critique might suggest that there are external factors influencing pause behaviour. This was considered beforehand and for this reason all of the testing sessions were conducted in a room with only the researcher and participant, so that no distractions were possible. However, the use of an eye-tracking device would provide additional information with regards to gaze fixations when on task.

The findings from this study make a novel contribution to the literature on young children with dyslexia and contribute widely to the findings from Study 1. To conclude Study 2, the emphasis lies with the importance of spelling when producing written text. For children with dyslexia and typically developing children of a younger age, with less experience in writing, spelling seems to be constraining the fluency of writing and how much is actually written.

9.9 Overall conclusions

Study 1 and 2 highlighted that handwriting is not just a motor act and a presentation skill; it is also a language act. More specifically, for young children with dyslexia word-level difficulties appear to be constraining handwriting performance and as a result productivity is affected overall. The fact that the findings for execution speed were consistent across different task demands increases the reliability of the overall findings.

An important finding from Study 1 is the influence of spelling on handwriting tasks that are commonly used for research purposes to assess handwriting speed. This raises concerns about the use of these tasks in assessing handwriting speed and particularly the interpretation of performance in children with dyslexia.

The finding that children with dyslexia are not actually slow in the motor act to produce letters dismisses assumptions that have been based solely on the number of words a child can write. It has been clearly demonstrated that this slowness in producing text is a result of pausing frequently and in the case of children with dyslexia pausing around difficult spellings. Thus, it may be more prudent to concentrate on improving the spelling skills of children with dyslexia in order to have a greater impact on text writing.

10

General Discussion

10.1 Introduction

Overall, this thesis aimed to examine the specific writing characteristics of children with dyslexia and to identify how the writing processes interact for these children. This final chapter collates the key findings and proposes a new model of the writing foundations.

10.2 Overall findings

Children with dyslexia were selected based on their poor reading and spelling ability. General cognitive ability was not impaired and they did not present co morbid language or motor deficits. As a whole, the findings demonstrated that children with dyslexia do have problems with writing beyond their single-word spelling difficulties. A key aspect of trying to identify where children with dyslexia struggled with literacy and writing was to compare their performance on such tasks to typically developing children matched by age. In comparison to their age-matched peers, children with dyslexia produced written texts that were graded as lower, made a higher proportion of spelling errors when composing written text, had a more limited vocabulary in their written compositions, and wrote fewer words per minute. Through regression analyses, weaker performance in each of these areas was shown to relate directly to the spelling difficulties these children experience.

A general measure of handwriting speed (alphabet task) and spelling ability were both found to predict writing quality for children with dyslexia. Regression analyses that examined skills that related to handwriting performance demonstrated that productivity on these handwriting tasks (alphabet, copying tasks) was largely predicted by spelling ability and phonological analysis skills. This finding suggests that a level of phonological and orthographic processing, as well as motor skill, is required when handwriting and that for children with dyslexia spelling hinders speed of production.

Written lexical diversity was also found to predict the quality of writing produced by children with dyslexia. Similar to the handwriting analyses, spelling ability was found to be the unique predictor of written lexical diversity in children with dyslexia. Correlations demonstrated a positive relationship between spelling ability and lexical diversity, meaning the better spellers produced a wider range of vocabulary in writing. The regression output that highlighted within-word pauses as predicting written lexical diversity for these children further accentuated the close relationship between spelling, word choice, and handwriting execution. Frequent, long pauses before a misspelt word were common for children with dyslexia. Spelling disrupted the fluency of compositions, as these children may have searched for the right spelling or an alternative word. Pauses within-words reflect a difficulty with processing information at the word-level; here, an interruption to fluency was found to have a negative impact on written lexical diversity.

As mentioned above, children with dyslexia performed significantly below their peers on a number of writing related measures. Importantly though, the digital writing tablet demonstrated that handwriting execution speed was not impaired and a verbal compositional task also showed that vocabulary usage was not impaired at a general level. In the vocabulary and handwriting research strands, spelling was shown to have secondary consequences of pausing more often and therefore writing less, and avoiding writing words that were difficult to spell, thus exhibited weaker lexical diversity.

Historically, dual comparison groups have been used to address the debate of delay or difference in development for children with dyslexia. In the present study, the younger spelling-ability group were recruited to establish similarities and differences to children with dyslexia. Findings where these two groups were similar suggested that children with dyslexia were delayed in development.

The analysis of the nature of the spelling errors revealed that both children with dyslexia and the younger spelling ability matched group made similar errors in the phonetically implausible and orthographically inaccurate categories. However, children with dyslexia made a larger proportion of these types of errors. This might suggest that children with dyslexia show a different pattern in developing spelling knowledge. However, the spellings these groups completed did contain different word lists, which may affected results.

On several of the writing measures, children with dyslexia performed similar to the spelling-ability group. The overall score for the quality of writing produced by these two groups revealed no significant difference. Children with dyslexia were similar to the spelling ability group in terms of mean latency before starting a spelling error, pause behaviour around misspellings, overall pause percentage when writing, and within-word pausing and its predictive value for written lexical diversity. These findings suggest a delay in writing development linked to spelling and how it hinders the fluency of composing a written text.

In contrast, children with dyslexia performed some measures better than the spelling-ability group, albeit still below the age-matched group. Children with dyslexia composed a longer text, wrote more letters/words in the alphabet and copying tasks, and lexical diversity in the written and spoken modalities was higher than the spelling ability group. This would suggest that children with dyslexia use different strategies to the spelling-ability group to accomplish these tasks, reflecting deviant development. However, it is difficult to firmly establish whether overall children with dyslexia are delayed or deviant in writing. Reducing the findings to this debate makes it too simplistic, when in fact the many components of writing make it a very complex process. It is difficult to be clear-cut when each writing-related task can draw upon a range of skills and thus performance is affected by the ability to juggle these demands.

For children with dyslexia spelling has been demonstrated as having a clear role in constraining written performance. Trying to establish whether the development of these skills is delayed or atypical raises the question of how far apart are delay and deviance, when does delay become deviant? Environmental influences, such as more years experience to practise these skills, could account for the difference in performance between children with dyslexia and the spelling-ability group in the above measures. Therefore, the comparison groups were used only to profile strengths and weaknesses across different samples to contribute to the later proposed model.

By way of contrast to children with dyslexia, productivity (number of words) was the key predictor of writing quality for the two comparison groups. A different pattern had been expected for these two groups because they did not have specific literacy difficulties (in reading or spelling) that would act as a dominant constraint on writing. Regression analyses revealed that for all three groups, written lexical diversity was found to be a unique predictor of writing quality. Interestingly though, verbal ability was found to predict the lexical diversity in the writing produced by the two typically-developing comparison groups, whereas spelling was the unique predictor of written lexical diversity for children with dyslexia; highlighting how typically developing children can draw upon their spoken language skills when writing, whereas children with dyslexia are specifically constrained by spelling.

Overall, it would appear that children with dyslexia could be likened to the younger spelling ability group in terms of how spelling has wider consequences for the transcription component. However, to some extent children were dyslexia were able to compensate for the spelling difficulties by using their more proficient language and motor skills, than the younger children. The findings from the empirical studies stress that strong foundations in spelling are required while composing a written text. The spelling difficulties of children with dyslexia act as a constraint on the word choices made while writing and on the fluency of composing a text, leading to lower text quantity and quality. In contrast, for their age-matched peers proficient spelling assisted the execution of text, as these children produced longer compositions with a diverse range of vocabulary, they paused less when composing text and the result of spending longer writing was a higher graded piece of work.

10.3 Theoretical implications

An important aim of this project was to contribute to the current writing models and to expand on these if and where necessary to represent a model of atypical writing development for children with dyslexia. The findings contribute to theories of dyslexia also.

10.3.1 Proposing a new interactive model of the writing processes

Existing models of writing (Berninger & Swanson, 1994; Hayes, 2012, Hayes & Flower, 1980) identify key components of the writing process. In Chapter 2 the ‘simple view of writing’ was shown from the Berninger & Swanson (1994) findings (taken from Berninger & Amtmann, 2003). Figure 10.1 illustrates how Berninger and Swanson (1994) outlined the writing processes that are activated by children in the intermediate grades: the same age group as children with dyslexia and the age-matched peers in the present thesis.

Figure 10.1 Berninger & Swanson's (1994) "model of writing development in the intermediate grades: Continued development and relative emergence of component and sub component processes" (Figure 2, pp. 74)

A criticism of the model above is that the translation component does not provide detail about the influence of spelling or handwriting. Another criticism, which is borne out of the observations in the empirical studies presented in this thesis, is that it does not consider how these components may have a bidirectional relationship when composing text. Figure 10.1 illustrates these processes as linear, progressing from translation to text generation at the many levels, etc. Figure 10.1 appears to be more of an educational model of writing in terms of skills that are introduced in stages, rather than a model of the interactive cognitive processes involved while composing a written text.

An examination of children with dyslexia has allowed for exploration of the role of spelling when writing and in particular an expansion of the transcription and text generation components. This is important for informing models of typical writing development, where spelling has been largely bypassed. Figure 10.2 proposes a model of the writing foundations devised from the findings presented in Chapters 6-9.

Figure 10.2 A model of the writing foundations for children in the primary grades

Figure 10.2 illustrates how the transcription component is split into two hierarchical components: spelling and handwriting. In conjunction, text is generated at the word level to prompt the activation of spelling. Recognition of text being generated at the word, sentence, and discourse level comes from the previous Berninger model. The blue arrows in the model above depict the relationship between the listed components and sub-components for typical writing development, whereas the red arrows show the impaired pathways for children with dyslexia.

First of all, the red dotted arrow indicates the influence of phonology, orthography, and morphology when spelling, and how for children with dyslexia this route is impaired. Spelling is circled in red because of the significant difficulties children with dyslexia experience. The bold red arrow that feeds directly off spelling into text quantity and quality represents the predictive nature this skill was shown to have on these outcome variables in the regression analyses.

The other bold red arrows that come directly off spelling indicate the direct influence spelling has on handwriting fluency and word choice. Handwriting automaticity receives a lot of attention in the literature but little attention is given to the need for spelling to be automatic. The proposed model highlights just this. Certainly, cases where handwriting is slower may in fact be a result of a difficulty with spelling. The relationship between spelling and handwriting fluency is depicted as unidirectional. For example, children with dyslexia were found to pause more frequently before and around misspelt words in their texts and this disfluent profile resulted in fewer words being written in the same time as those without spelling difficulties that could alternate more proficiently between pausing and producing writing.

The bold arrow from spelling to word choice is bidirectional as the findings from Chapter 8 demonstrated that lower lexical diversity was specific to writing for children with dyslexia, as these children limit their vocabulary choices when composing writing text. Furthermore, pausing within-words predicted lexical diversity.

However, further consequences of poor spelling were noted. The use of the digital writing tablet allowed for the differentiation between fluency of producing text and speed (words per minute). This adds another dimension to the transcription component that was not included in the Berninger & Swanson (1994) model, even though Berninger and colleagues often refer to the need for handwriting to be automatised (Berninger et al., 1993; Berninger, 1999; Graham et al., 1997). The thinner red arrows in Figure 10.2 note the further effects of spelling. As spelling influenced handwriting fluency, children with dyslexia were found to pause more and thus in a set time had a slower overall speed. This slower speed correlated with text quantity and quality, as shown by the regression analyses in Chapter 9. Similarly, the thinner red line from word to text quality represents a knock-on effect from poor spelling limiting vocabulary choice to lexical diversity predicting the quality ratings of the written work.

Although the red arrows largely indicate the problem areas for children with dyslexia, this model does inform typical development too. Children in the matched spelling-ability group were typically progressing, however as these children were in the initial years of primary education their spelling level still influenced fluency of handwriting and thus speed (words per minute). This measurement of speed of handwriting influencing text length and quality is supported by research with beginning writers (Abbott & Berninger, 1993; Berninger et al., 1992) that has found both spelling and handwriting a constraint on the end product. Similarly, connections between pausing around misspellings and lexical diversity were found for this younger spelling-ability group. Thus, this model could be applied to typically developing writers in the sense that level of spelling proficiency influences the development and the execution of the subsequent writing processes. The age-matched peers did not show difficulties in this initial component and this provides a strong explanation for why as a whole their writing skills were more proficient.

This proposed model combined and extends previous handwriting (Van Galen, 1991) and writing models (Berninger & Swanson, 1994) by considering how relationships between components can feed forward and backward, and also by considering their influence on the end written product. Reference to ‘lower-level’ or the ‘higher-level’ processes are not made in the proposed model because of the connotations they bring and the difficulty of positioning vocabulary (text generation) under those labels. Berninger & Swanson (1994) did not explicitly define vocabulary in their developmental model. The findings from the present work demonstrate that as a word-level skill, vocabulary has a direct relationship with spelling, but will also contribute to the quality of the text too. Therefore, could be left in the middle of the lower and higher processes, when it would perhaps be best suited under the label of a foundation. The proposed model presents skills that are required to be strong, the foundation of the composing process, in order to develop proficiently in writing. This term is preferred to describe spelling and handwriting rather than lower-level skills, which implies that they are less demanding and require little effort; when in fact for children with dyslexia and beginning writers the transcription component could be considered to be a higher-level process in terms of cognitive demand.

As a template of the interactive writing processes it is conceivable that this model could be applied to wider populations and different age groups. There are ways in which this model could be expanded further and these will largely be discussed in the section of future research (10.6). Certainly, a more detailed breakdown of the spelling component would be useful. As shown in the alphabet task, orthographic skills largely influenced the speed (letters per minute) of performance. Work by Kandel et al (2011) has highlighted smaller units of processing that influence handwriting fluency, such as syllable and morpheme processing. Therefore, this component could still be developed further.

A final point relates to explanations for why spelling acts as a constraint on writing development. There could be more deep-rooted reasons for why spelling halts production. McCutchen (1996) proposed a capacity theory of writing whereby the demands of writing are dealt with through working memory and when the cognitive demands exceed the limits breakdown occurs. This could be one possible explanation for the halt in production, as poor spelling will demand more cognitive resources leading to sequential processing of the transcription components rather than parallel processing. Lambert et al (2011) demonstrated how the demands of spelling could influence sequential processing of information in this way. Alternatively, as mentioned before difficulties with spelling could lead to searching for a near synonym that is easier to spell, which would slow production. Finally, a more disfluent profile and producing less overall could link to lower self-efficacy and motivation to write. Confidence and motivation in spelling and writing would be an interesting area to research further, particularly for children with dyslexia that have significant problems with literacy.

10.3.2 Relating to theories of dyslexia

As well as proposing a new model of the writing processes, the present findings also contribute to cognitive theories of dyslexia. Current theories have a focus on the cause of the reading and spelling impairment but could be extended to understand the underlying cause of writing difficulties that stem from poor spelling. The spelling error analyses and the results from the initial selection measures lend support to the phonological deficit theory of dyslexia. While this theory accounts for the poor literacy foundations that children with dyslexia demonstrate, it would appear that problems with phonology extend to repercussions in writing. In relation to spelling, the development of phonology is required as a base to progress with orthographic and morphological knowledge (Ehri, 1997; Perfetti, 1997). In a similar way, phonological skills (phoneme segmentation and general spelling ability) have been shown to relate to the production of handwriting, how quickly letters/words can be produced. It may be that impaired phonological analysis skills, in the phonological loop of working memory, hinder the retrieval and execution of letterforms. Thus, poor phonology has been shown to have more widespread effects than previously recognised.

The speech sound processing theory of dyslexia and work on the auditory processing deficit currently lacks wide acceptance, although it does suggest that children with dyslexia have difficulties with identifying stressed patterns from speech (Goswami et al., 2002; Wood, 2006). If this were true and children with dyslexia have difficulty in identifying intonations, then it would be expected that they would show a different profile of producing spellings through handwriting than a typically developing group. This may also contribute to an explanation for the more disfluent handwriting profile shown by children with dyslexia if they are pausing more frequently to retrieve individual phonemes rather than identifying speech sounds which can chunk information for faster production. Although, the current work does not contribute directly to these particular theories of dyslexia it provides suggestions for future research in this area to help identify the root cause of problems with reading and spelling. A breakdown of the spelling components and how these are processed with the real-time movement of the pen could help to pinpoint the level at which children with dyslexia experience difficulty with spelling.

Indeed the link between phonology and spelling, and also to vocabulary has been validated by numerous studies (Baddeley et al., 1998; Gathercole et al., 2006; Snowling, 2001). Spelling and vocabulary choice both require a level of phonological processing in the phonological loop of working memory. The present sample of children with dyslexia did not exhibit a working memory deficit, as suggested by the theory (McLoughlin, 2002). These children scored close to the expected mean on measures assessing both verbal and visuo-spatial working memory capacity. Moreover, these measures were not found to be strong predictors of writing performance in the present work. Thus, the working memory deficit hypothesis of dyslexia is not supported by the current work. However, it is possible that a working memory deficit would be present in other samples of children with dyslexia. Individual differences and variability in performance is common for this group. The present sample tried to limit the amount of variation in the present sample by controlling for additional co-occurring difficulties. However, it is possible that for those children with more severe learning problems a working memory deficit would be present too.

The double deficit hypothesis suggests that for some children with dyslexia speed of processing information will be a problem alongside poor phonology (Wolf & Bowers, 1999). RAN tasks were not administered for this project and, therefore, this theory was not explicitly tested. However, verbal and written fluency measures were administered, and in a similar way to RAN tasks, required processing of semantic and phonemic information at speed. Weaker performance was expected and revealed from children with dyslexia in the written condition, because of the added transcription demands, whereas they did not present difficulties in the verbal condition as might have been expected if they had general problems with processing and retrieving information at speed. These tasks did differ to the RAN task used by Berninger et al (2008) to define characteristics of dyslexia, who instead asked participants to name letters at speed. It could be argued that since the children with dyslexia in the present study did not present a double deficit in terms of spoken processing problems; their difficulties were not as severe as those in the Berninger et al (2008) study. However, when asked to complete the fluency tasks in the written condition, problems with processing and retrieving phonetic and semantic information were apparent. The combined need for phonological and orthographic processing demonstrated an overall slower retrieval for children with dyslexia.

Araujo et al (2011) demonstrated that Portuguese speaking children with dyslexia were not slow to verbally articulate items in a RAN task, but rather they paused for longer between items than their peers, which subsequently accounted for the fewer items named in a set time. Speed of articulation, therefore, was not the issue but rather speed of retrieval. This could relate to the findings shown from the handwriting research in Chapter 9. Handwriting execution speed was not found to be impaired when completing a writing task, but instead children with dyslexia paused more frequently to retrieve information about the text, and subsequently fewer words were written overall. These pauses were mainly found to be associated with spelling difficulties; therefore speed of processing phonological and orthographic information could be an explanation for the overall findings. Looking at the findings from this perspective highlights a processing problem in written and not spoken language. It is reasonable to propose then that this sample of children with dyslexia were exempt from wider speech difficulties and as discussed previously they were a ‘pure’ group. This raises the issue once again of clearly defining characteristics of a dyslexic sample that is prone to being heterogeneous due to possible co-occurring difficulties.

Finally, the cerebellar/automatisation theory has lacked consistent findings in the literature and is largely confounded by additional motor difficulties that may co-occur with dyslexia (Ramus et al., 2003). This theory does not receive support from the current findings, as this sample of children with dyslexia was not found to have additional motor problems and therefore handwriting execution speed was not impaired. Rather, the link back to phonology and its consequences appears to be the strongest explanation to why handwriting is not ‘automatic’ for children with dyslexia in the sense of being produced as quickly as their peers. Poor phonology, and thus spelling skill, impacts on handwriting fluency, which in the previous literature may have given the impression of poor motor automaticity for handwriting (Berninger et al., 2008; Sovik & Arntzen, 1986).

In sum, the phonological deficit has been shown to be the most firmly associated with the literacy and written skills of children with dyslexia. Further work needs to be conducted to strengthen this theory in terms of how phonological difficulties impact on wider aspects of writing.

10.4 Practical implications

In terms of practical implications from this research, a direct link can be made to assessments of writing and spelling. Joshi (2012) argued that there is a need for a spelling inventory to be developed. If teachers are provided with a template of how to score errors in terms of problems with phonology, orthography, and morphology, and more in-depth analyses such as vowel positioning errors, etc. this can clarify the areas in which children need further support. Encouragement directed at teachers to use such spelling schemes would help to profile each child's specific spelling problems and can lead to more appropriate instruction. For example, consistent errors in morphology may prompt teaching in word constituents and tense. Moats (2012) argued the need for teachers to go beyond teaching basic phonics and to demonstrate word constituent meanings and grammar: in the hope of promoting confidence in word study (Moats, 2002). The present findings support the importance of teaching and supporting spelling to aid the development of the subsequent writing processes.

In relation to writing assessment, it is clear that to assist struggling writers additional characteristics need to be considered other than those scored from the end product. The confusion in the literature regarding whether children with dyslexia have poor motor skills can lead to unnecessary training of motor skill. Assessment of language and motor ability, two key skills that will influence written performance, will help to target specific support for writers. The motor aspect of writing can be assessed separately. Although, motor difficulties were not an issue for the present sample, performance in this area should be checked in order to gain a complete picture when working with children with dyslexia. Certainly, in other cases where handwriting is slower, spelling may in fact be the underlying difficulty. The process analyses in this thesis emphasise the need to look at the range of skills in order to generate a stronger profile of abilities that can lead to support (Sumner et al., 2012).

In certain cases where transcription is too arduous, the use of a script or word processor might be more suitable. For older children, it might be that a word processor and being able to use a spell-checker benefits their writing in terms of both quantity and quality, as the spelling demands are reduced. In line with the idea of using a word-processor, research could be conducted for older children or adults with dyslexia to see if the dissociation between text generation and translation is reduced when spelling demands are assisted. Also for younger children with dyslexia, whether dictating texts is more beneficial. However, Graham (1990) did note that while dictating essays increased the writing quality of children with learning difficulties this is not without complications regarding the formality of dictation and it was not a long-term solution to writing problems.

10.5 Limitations of the empirical studies

The young age of the spelling-ability matched group has been addressed previously as a limitation. It was not initially predicted that these children would be so young and it is possible that lack of experience in writing influenced their task performance to some extent. However, use of a spelling-ability match to children with dyslexia has the benefit of providing an extra comparison to how typically progressing children deal with writing related tasks.

A general point to make here relates to the selection of the writing assessment, which was a narrative prompt asking children to write a letter describing their perfect place to live. In the literature there is no consistent way of assessing writing and neither is there a specific writing topic/prompt that has been shown to be useful for this age group. Therefore, it is difficult to compare findings across studies. Furthermore, a range of writing tasks across different genres might have provided a more information on the writing characteristics of the three groups. However, the range of handwriting tasks and the narrative task enabled a sufficient profile to be established for the three groups.

Finally, as with any experimental design it could be argued that these children altered their performance because of the testing situation and they might have performed differently within the classroom. To ensure that children were in a natural setting, all research tasks were carried out within their school and in a study environment they were familiar with. The tasks used were also very similar to those that they might complete, or have completed at some stage within their education. This point also relates to an earlier discussion about the association between text length and text quality. In writing research a significant relationship between these two variables is often found (Graham et al., 1997; Graham & Harris, 2000) but manipulating a writing task in psychological research by imposing a time constraint might be influencing the end result. It could be that if participants are given an unlimited time to complete a piece of written work they will spend longer beforehand thinking about their answer. They might shape their written text more effectively than someone who had no time to plan beforehand, and as a result produce a more concise but perhaps shorter piece of text. Thus, imposing a time limit on the writing task could be affecting the performance and threatens ecological validity.

10.6 Suggestions for future research

Future research could be targeted to explore what characteristics of the written text are the best indicators of where a child is struggling. For children with dyslexia the indicator is spelling. However, research could use the proposed model (Figure 10.2) of the writing foundations to determine how this fits, or could be adapted, to other populations and age groups. Expansion of the model in this way would further validate the proposed relationships between the writing processes.

The spelling component could be further expanded by identifying the spelling processing units when handwriting. Relating this back to the speech sound processing theory (Wood, 2006), research into the psycholinguistic nature of handwriting production has identified syllable boundaries as a unit of processing when spelling, in typically developing French children and adults (Kandel, Herault, Grosjacques, Lambert, & Fayol, 2009; Kandel et al., 2011; Nottbusch et al., 2007). This finding was discovered through using a digital writing tablet, which identified longer pauses between syllables than within-syllables. Processing of manageable chunks (syllables) highlights that spelling does not only require phonological analysis. In fact, phonemes were not processed individually, and rather sensitivity to the structure of the word is required to identify syllables (Kandel et al., 2009; Kandel et al., 2011). French is a syllabic-timed language, whereas English has been defined as a stress-timed language (Wood et al., 2009), therefore a slightly different pattern might be expected.

It would be interesting to explore the role of syllable or stressed-syllables from the spellings of English children in future work. Furthermore, research in dyslexia would benefit from identifying the level of the processing unit that children with dyslexia work on when spelling. It might be that these children struggle to identify syllables and work on smaller units. Identification of when children with dyslexia are sequentially processing spelling and handwriting information, through the use of a digital writing tablet and eye tracker, would help to determine the area of weakness in spelling knowledge. Identifying a pattern would help to inform practise in terms of how to develop these skills in line with typically developing performance and would further expand the spelling component of the proposed model.

Another avenue to develop the model of writing would be to consider the effects that poor spelling has on the planning and reviewing processes of writing. This was beyond the scope of the present work but future research could consider the role of working memory while actually writing (using a dual-task method), or whether children with dyslexia are able to efficiently plan and review their own text. It is predicted that poor spelling would constrain the working memory resources while composing a written text and, therefore, the self-regulatory processes of reviewing and editing the text would not be as efficient as for those children without spelling difficulties.

The importance of planning a piece of writing and its effect on the fluency and quality of the end product could also be explored in more detail. It is likely that making an initial plan of ideas for the text would be beneficial for children with dyslexia, as this could reduce the cognitive load of composing especially since the demand of spelling is high. On the other hand, the role of online reviewing a text could be explored using a digital writing tablet and eye tracker to map performance. This type of analysis would add more to models of writing than the reviewing component proposed by Berninger & Swanson (1994) whereby they asked students to redraft an essay and then scored the difference between first and second drafts to highlight where students were using reviewing strategies (to correct spelling or to rewrite text) and how they related to the overall quality of the text. Reading back and forth through the text while writing has been shown to be a common occurrence for children and adults (see Wengelin, Leijten & Van Waes, 2010) and re-reading has been associated with increased text quality (Breetvelt, Van den Bergh, & Rijlaarsdam, 1996). Predictions could be made with regards to children with dyslexia in the way that they might be expected to re-read their text less than their peers, because of their reading and spelling difficulties.

By devising broader psychological models of writing a clearer understanding is provided of when and how cognitive processes develop. This is the first step toward recommending where to target support for educational demands and how this support will unfold. Work with adults with dyslexia could expand the present findings over a longer developmental trajectory.

Finally, in terms of future work providing a starting point for interventions for children with dyslexia, spelling would be the first area to target. Berninger et al (2008) noted:

> "Once dyslexics respond to instructional intervention for their reading problems, they should not be dismissed from special services without consideration of whether they need ongoing, explicit instruction in writing (handwriting, spelling, and/or composing) throughout the upper elementary and middle school and possibly high school years" (Berninger et al., 2008, p. 16).

Berninger et al (2008) recognised that difficulties in other areas of literacy and particularly handwriting, spelling and composing can ensue when entering a more demanding school level. Specific spelling instruction for children with dyslexia targeting phonology and morphology has been conducted in research and has shown a great improvement in their ability to spell derivational words, post intervention (Tsemeli & Seymour, 2006). Demonstrating the morphological structure of words to children with dyslexia taught them how to segment words into more manageable spelling chunks (Carlisle, 1987).

Scott (2002) suggests that interventions for poor spellers should have explicit word analysis training (in phonology and morphology) and should provide opportunities to apply this knowledge in reading and writing activities. By integrating explicit spelling instruction with literacy activities the gaps are bridged in terms of applying this knowledge when writing. After demonstrating the link between phonology and spelling, and even phonology and handwriting/written production, it is feasible to propose that interventions targeted at explicit spelling instruction would have a positive outcome on the writing produced by these children. It is reasonable to suggest that improving spelling first would release working memory resources to be devoted to higher-level planning, or increase fluency in writing.

In fact, a study by Berninger and colleagues found that administering specialised training in orthographic and morphological conventions, and also how to plan and review written text to 11 year old children with dyslexia resulted in improvement in spelling pseudowords and real words and also in their compositional skills (Berninger, Winn, Stock, Abbott, et al., 2008). Although the sample was relatively small, only 22 children with dyslexia, these findings yield promising results.

Finally, it is possible that instruction in spelling and thus hopefully improvement in this area, would lead to greater motivation to write. It would be expected that young children with dyslexia that have great difficulty in spelling would feel negative towards writing in and outside of the classroom. Specific and effective spelling training could have positive results for their confidence in this area, which would be beneficial in terms of motivation to take part in these activities daily.

10.7 Final conclusions

Overall, this thesis covers a cognitive, educational and developmental perspective. From a cognitive point of view it has considered the writing processes and how they interact to form the written product. Understanding the cognitive basis of dyslexia and writing should feed-forward to inform instructional educational practices. By considering typically developing comparison groups, the developmental nature of the foundational writing skills have been discussed, namely with relation to how children with dyslexia develop and how this compares to typically progressing children of a younger age.

The data that has been presented has shown that children with dyslexia have severe difficulties in spelling that have serious implications for written ability. Children with dyslexia experience difficulties with handwriting fluency, using diverse vocabulary in their writing, and producing a high quality of compositional work. A model of the writing processes has been devised from the research findings. This can be used as a template for typical and atypical development and to pinpoint the relationship between the writing processes. At present, this area of literacy is under researched and as a result opportunities to provide appropriate and full support are being missed. This raises concerns for the progression of these children when entering secondary school and also for their motivation in this area.

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Dr. Vince Connelly (Director of Studies)
Dr. Anna Barnett (2nd Supervisor)
Department of Psychology
School of Social Sciences and Law
Gipsy Lane Campus
Oxford Brookes University

8th April, 2010.

Dear Vince Connelly (Director of Studies) and Dr. Anna Barnett (2nd Supervisor)

UREC Registration No: 100463: "Do students with dyslexia encounter problems with writing beyond single word difficulties?"

Thank you for your email on the 7th April 2010 outlining your response to the points raised in my previous letter about the **PhD study of Ms. Emma Sumner**, and attaching the revised documents.

I am pleased to inform you that I have given Chair's approval for the study to begin on the basis that:

1. Once copies of the letter(s) of permission from the Head teacher(s) have been received copies will be sent to UREC before the PhD research commences.
2. That the PhD student has confirmed by email that they have an updated CRB clearance and this has been checked by the supervisory team.

The UREC approval period for this study is two years from the date of this letter, so the 8th April 2012. If you need the approval to be extended please do contact me nearer the time of expiry.

In order to monitor studies approved by the University Research Ethics Committee, we will ask you to provide a (very brief) report on the conduct and conclusions of the study in a year's time. If the study is completed in less than a year, could you please contact me and I will send you the appropriate guidelines for the report.

Yours sincerely

Dr Elizabeth T. Hurren
Chair of the University Research Ethics Committee

cc

Louise Wood
Morag MacLean
Jill Organ, Graduate School

PSYCHOLOGY DEPARTMENT
Institute for Research in Child Development
Buckley B1.01, Headington Campus,
Gypsy Lane, Oxford OX3 0BP

(Date)

Dear (Insert Headteacher Name),

Re: Research project on spelling and writing in individuals with and without dyslexia

My name is Emma Sumner and I am currently studying for my PhD in Psychology at Oxford Brookes University. My specific area of research is writing development, whereby I am looking into how individual variation in reading and spelling ability impacts on writing skill.

I am writing to ask if your school would be willing to assist me in my research, which is proposed to begin from [April] 2010. I hope to work with a number of schools. This project is jointly funded by Oxford Brookes and the Waterloo Foundation; and closely supervised by Dr Vince Connelly and Dr Anna Barnett, also from Oxford Brookes.

The research project primarily concerns children with dyslexia from the age of 8 and upwards, who are recognised as experiencing difficulty with reading and spelling. Therefore, I would need to ask teachers of the year groups to identify children who have a formal diagnosis of dyslexia and also those which are recognised as showing significant difficulties in reading and spelling. These difficulties would also need to be known by the parent. The aim of the study is to define the writing profile of these individuals, and subsequently suggest possible avenues for future interventions. The attached information sheet provides further details about the study.

In addition to working with children with dyslexia, this project will also involve the study of typically achieving children in order to distinguish how writing performance differs between these groups.

I have a current CRB check and the research has received approval from the University Ethics Committee. Information would be sent to all parents of the children approached, alongside a consent form, before any research can be performed.

Thank you for your kind attention. I do hope that your school will consider participating in the project and look forward to hearing from you at your earliest convenience.

Yours Faithfully,

Emma Sumner
Oxford Brookes University
emma.sumner@brookes.ac.uk
Tel: 01865 483776

PSYCHOLOGY DEPARTMENT
Principal Researcher: Emma Sumner
Email: emma.sumner@brookes.ac.uk Tel: 01865 483776

Dear (Insert Headteacher Name),

Research project: Exploring the impact of spelling skill on writing performance

Your school is being invited to participate in the above research project. Before you decide if you want to take part, please take time to read the following information carefully to understand why this research is being conducted and what it will involve.

What will the research involve?
I hope to work with each student involved in this research to obtain a general indication of their reading, spelling and writing ability. The next stage would look specifically at vocabulary and working memory capabilities. The majority of the tasks are commonly used within educational settings for teaching and research purposes, and the writing tasks will include the use of a graphics tablet to study performance. Session would last approximately 20 minutes but can be shortened if necessary to suit both the child needs and the class teachers' arrangements.

Why is my school being asked?
I am contacting several schools and colleges in, and surrounding, Oxfordshire in an attempt to recruit a large sample of students from Year 5 of their schooling and above.

Do I have to give my consent?
It is entirely up to you whether, or not, you give your permission allowing your school to take part. Even if you do give consent you are free to withdraw at any time and without giving reason. This also applies to all of the children taking part in this research.

Benefits and disadvantages of your school taking part
Granting permission for children to take part in the proposed study will enable us to gain a better understanding of the writing profile of these children, in comparison to typical development.

What will happen to the findings of this study?
The findings from this research will initially be published as part of a PhD thesis, and used in developmental and education based journals. There will be no reference to specific children and individual results will be strictly confidential. A summary of the overall findings will be available to all schools taking part.

Ethics
This project has been approved by the University Research Ethics Committee of Oxford Brookes University (Number: 100463). If you have any concerns please contact ethics@brookes.ac.uk.

Contact
If you have any further questions or queries you would like to discuss, please do not hesitate to contact me. My contact details can be found at the top of this information sheet. Thank you for taking time to read this. If you agree to your school taking part please contact me and we can organise a meeting to discuss arrangements and schedules.

Emma Sumner

SCHOOL OF SOCIAL SCIENCES & LAW
PSYCHOLOGY DEPARTMENT
Principal Researcher: Emma Sumner
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Director of Studies: Dr Vince Connelly, vconnelly@brookes.ac.uk
Supervisor: Dr Anna Barnett, abarnett@brookes.ac.uk

(Date)

Dear Parent/Guardian,

Research project: The impact of spelling on writing performance

Your child is being invited to participate in the above research project. Before you decide if you want to allow them to take part I feel it is important for you to understand why this research is being conducted and what it will involve. Please take time to read the following information.

What is the research about?
The demands of writing are extremely high for young children, and spelling is just one skill to acquire in the whole process. Some children encounter difficulties in learning the rules of spelling and this project will explore how these difficulties can impact on the other aspects of writing.

What will my child be asked to do?
If your child takes part they will work individually with the researcher and be asked to perform two sets of tasks. Firstly, they will be asked to complete some reading and spelling tasks. Secondly, they will perform a series of short writing and language tasks looking more specifically at vocabulary, handwriting and working memory. All the tasks used are often used in schools by teachers and for research purposes. By choosing to take part in the project this will have no impact on their school marks, assessments, or future studies.

Why is my child being asked to take part?
Several schools and colleges in, and surrounding, Oxfordshire have been invited to take part. A large sample of students, aged 8-25 years, shall be recruited. I understand, via the class teacher, that your child has shown specific signs of difficulties in reading and spelling acquisition. Therefore, your child is being asked to participate in this research to help us understand the impact of these specific difficulties on overall writing performance. Any child with other known developmental disorders will not be included, in order to keep the research question specific.

Where will the research take place?
All tasks will take place during normal classroom time within the school, with permission from the headteacher of the school. The two sessions will run on different days, organised for a time suitable for the child and the teacher. The initial session will be to screen for the level of literacy and cognitive performance, they will need to meet our research criteria of poor reading compared to other cognitive skills. Then each child will be met with a week later to determine writing performance.

Do I have to give my consent?
No, it is entirely up to you whether, or not, to give permission for your child to take part. Before the sessions begin your child will also be asked if they are happy to take part. If your child is above 16 years old, they will also be provided with an information sheet and consent form, which you are free to discuss with them at any time. They will also need to sign their

consent form before the research can begin. Even if you do give consent, you and/or your child are free to withdraw from this research at any time and without giving a reason.

What will happen to the findings of this research?
The data collected will be kept strictly confidential and securely stored at Oxford Brookes University, for up to five years. The findings from this research will be published as part of a PhD thesis. They may also be used in developmental and education based journals. Individual children's names will not be identified in any publications and to maintain strict confidentiality it will not be possible for parents or teachers to have access to the results of individual children. A summary of the overall group findings will be available to all schools and parents if requested. All information collected will be retained in accordance with the University's policy on Academic Integrity and will be destroyed when no longer needed.

What are the possible benefits and disadvantages of taking part?
All we ask is some time during the school day for your child to take part. Most children enjoy completing the tasks, which are similar to school literacy activities. This research will further our understanding of writing development and assist teachers to provide effective support for children learning to write.

Who is organising and funding the research?
The principal researcher is conducting this project as part of a doctoral qualification. This research is funded by Oxford Brookes University and The Waterloo Foundation; and supervised by Dr Vince Connelly and Dr Anna Barnett, Department of Psychology. The Waterloo Foundation is an independent charitable trust and they have chosen to fund this particular study as they consider literacy development as a core area in need of attention. The project has been approved by the University Research Ethics Committee of Oxford Brookes University (UREC Registration Number: 100463). If you have any concerns or queries please contact ethics@brookes.ac.uk.

What to do if you agree to this research going ahead.
If you wish to give permission for your child to take part please complete and return the attached consent form provided. Please ask your child to return the completed consent form to their teacher.

If you wish to contact me personally I have provided my contact details at the top of this information sheet.

Thank you for taking the time to read this.

Emma Sumner

CONSENT FORM

The impact of spelling on writing performance

Principal Researcher: Emma Sumner
Psychology Department
Buckely B1.01, Headington Campus
Gypsy Lane, OX3 0BP
Email: emma.sumner@brookes.ac.uk
Tel: 01865 483776

Please tick box

1. I confirm that I have read and understand the information sheet for the above study ☐

2. I agree that my child can take part ☐

3. I understand that my child's participation is voluntary and that they are free to withdraw at any time, without giving reason. ☐

Name of Parent/Guardian	Date	Signature
Name of Child	Date of Birth	

WOLD Prompt Scoring Sheet

Participant Information

ParticipantID: ________ Class: ________ School: ______ D.O.B: ___________ **M/F**

Written Expression Subscale Mark Scheme

Ideas and Development	
Extensive development of idea(s), with the extension and elaboration on all or most of the points. Look for uniqueness, interest to audience, and strong support of the main idea.	4
Good development of idea(s), with many details elaborated and extended. Ideas are fairly well supported.	3
Adequately supported idea(s), with some details extended or elaborated. May be an extensive list.	2
Weak idea(s) minimally supported, with little or no extension of details, or incoherent.	1

Organization, Unity and Coherence	
Completely organized, with smooth flow from one idea to the next through the use of transition and sequencing. Unity is strongly evident, with no wandering from the primary theme or plan.	4
Fairly well organized, with good unity of plan. Some transitions may be used. Little or digression from main idea.	3
Small amount of organization. Weak plan that may not be well unified. Ideas may be only minimally connected.	2
Lack of plan. May be incoherent.	1

Vocabulary	
Precise, appropriate, accurate, and specific word choices that convey the correct meaning and appeal to the audience. May be vivid and imaginative.	4
Good word choices that are appropriate, specific, and varied, and have	3

some appeal. May lack "sparkle" but meaning is clear.	
Fair use of words. May be specific and have a little variety but is very elemental. May be simplistic but effective.	2
Very simplistic. Lacks variety and precision. Meaning may be unclear. May be inappropriate.	1

Sentence Structure and Variety	
Excellent control and formation of sentence. Variety of sentence structure and sentence lengths contribute to fluency. Few if any errors in structure.	4
Adequate amount of sentence variety. Good mix of sentence lengths and structures. May contain a small number of errors that do not interfere with fluency. Error-free papers with no variety.	3
Sentences constructed fairly well. May have some variety in length and structure or may be somewhat monotonous or choppy. May contain several errors and lack control.	2
Poor sentence structure with many errors that may inhibit fluency or clarity.	1

Grammar and Usage	
Error free of very few errors, in approximate proportion to the length of the paper.	4
Good grammar and word usage. Errors that do not detract from the overall quality of the paper.	3
Fair grammar and usage. Errors may interfere with meaning.	2
Poor grammar and word usage, with frequent or serious errors.	1

Capitalization	
Error free or very few errors in punctuation and capitalization, in approximate proportion to the length of the paper.	4
Most punctuation and capitalization done correctly. Errors do not interfere with clarity.	3
Some errors in capitalization and punctuation; no serious interference with	2

communication.	
Frequent and/or serious capitalization and punctuation errors that may interfere with communication.	1

Notes

Reference to article:

Sumner, E., Connelly, V., & Barnett, A. L. (2012). Children with dyslexia are slow writers because they pause more often and not because they are slow at handwriting execution. Reading and Writing: An Interdisciplinary Journal, DOI: 10.1007/s11145-012-9403-6.