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Working memory, language, motivation and children's early writing: A three-year longitudinal study

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30th October 2013

Thesis submitted in fulfilment of the requirements for the award of Master of Science (MSc)

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Acknowledgements

I wish to thank my supervisor, Dr. Fíona Lyddy, without whose calm support, expertise, and sense of humour this thesis would not have materialised.

I am grateful too to my family for their accommodation of my new and lengthy study schedule.

I am appreciative of the financial support that I received from the INTO to complete the research.

I wish to acknowledge with gratitude the permission granted to me, by the Boards of Management, Principals and Teachers of the two schools who participated in this study, to carry out research in their schools.

Finally, but by no means least, I wish to express my sincere appreciation to the parents and the children who participated in the research and were helpful and co-operative at all times.

Abstract

The goal of the current research was to study the cognitive processes that support the emergence of writing in young children and to ascertain whether working memory, language ability or motivation to write underlined children's early attempts to learn how to write. Working memory, language ability and the emergent writing skills of 30 Irish children were tested, in a longitudinal study over a three year period, starting at ages 4 to 5 years in their first year of formal education. A cross-sectional study of 31 children in Junior Infants and 13 children from both Senior Infants and First Class was also conducted. Working memory was tested using the Automated Working Memory Assessment (AWMA). Tests of letter names and sounds, morphological knowledge/ grammar were administered. The children completed free writing tasks and writing output was analysed for linguistics features (e.g. spelling errors) as well as creativity, originality and task relevance. Children rated their liking of writing as an index of motivation to write.

The results showed that working memory was associated with the originality of children’s emergent writing, as well as structural aspects of writing, particularly the use of connectives. Verbal working memory played a key role in particular. Participants’ early knowledge of grammar and sounds was associated with fewer orthographic errors in early writing and also with later measures of originality and detail. Children’s liking of writing had a more modest effect. Gender differences, contrary to expectations, were absent; however, trends in the data suggest differences that might have emerged at older ages. These findings highlight the complex interactions of language and memory functions in supporting early writing.

Glossary of terms

Alphabetic: letters arranged in order according to the alphabet.

Central executive: the component of working memory that controls attention, co-ordinates storage and mental processing and is involved in higher level processing.

Digit Recall: a verbal short-term memory test requiring a participant to listen to a sequence of digits and recall each sequence in the correct order.

Dot Matrix: a visual short-term memory test that requires the participant to recall the position of a red dot or more than one red dot in a series of four by four matrices.

Emergent writing: the earliest stage at which children express themselves in written form.

Episodic buffer: a construct to explain how material is stored temporarily in a multimodal code, combining information from verbal and visuospatial components of working memory along with long term memory to provide a unitary episodic representation.

Free writing: a technique in which a person writes continuously for a set period of time without regard to spelling or grammar.

Grapheme-phoneme correspondence: when the written symbol of a letter matches the sound the letter makes.

Grapheme-phoneme consistency: when the written symbol of a letter matches the sound the letter makes each time it appears in print.

Grapho-motor skills: a combination of cognitive, perceptual and motor skills that enable a person to write.

Lexical access: the recognition and/or choice of words from an individual's own word bank/lexicon.

Listening Recall/ Processing: a verbal working memory test that requires an individual to listen to a series of individual sentences and judge if they are true or false and recall the final word in each sentence in the correct order.

Memory span: the number of items, usually words or numbers that a person can recall.

Morphological knowledge: understanding of word structure in generative grammar.

Opaque: a term used in linguistics to describe the orthographic depth of a language; an opaque language is one which has a more complex phoneme-grapheme correspondence and has more irregularities.

Oracy: the ability to express oneself in and understand spoken language.

Orthographic: the representation of the sounds of language in written symbols; spelling.

Phonological loop: stores material that can be expressed in spoken language.

Phonological awareness: a knowledge and awareness of sounds within words.

Semantic: the meaning of words.

Spatial Recall /Processing: a visual working memory test that requires the individual to identify if shapes are the same or opposite and recall the position of a red dot(s).

Syntactic: the structure, rules or grammar of a language.

Verbal Short-term memory: an individual's ability to recall verbal information over a very short period of time.

Verbal Working Memory: the ability to recall and manipulate verbal information over a short period of time.

Visuospatial Short-term Memory: the ability to recall visual or spatial information over a very short period of time.

Visuospatial sketch pad: holds images, pictures and information about locations.

Visuospatial Working Memory: a hypothetical structure determining an individual's ability to recall and manipulate visual or spatial information over a short period of time.

Working memory: a construct that refers to the capacity to store and manipulate information for brief periods of time. It consists of the central executive, phonological loop, visuospatial sketch pad and episodic buffer.

Chapter 1: Introduction

1.1 Background to the thesis

The aim of this study was to examine the linguistic features of children's emergent writing, at age four or five years and beginning formal primary education, and to investigate the cognitive mechanisms, within the working memory construct, that underlie children's writing ability. The study examined the development of writing skills in young children across three consecutive age groups in an initial cross-sectional study, with longitudinal follow-up of the youngest age group of four to five year olds over a three year period. In the study, writing is defined as the ability to express meaning in written and alphabetic form, so that meaning can be interpreted by the writer or both reader and writer independently of each other (Bourke & Adams 2010; Hoskyn and Tzoneva 2008; Olive, 2004; Puranik & Apel 2010). Samples of free writing produced by emergent and developing writers across three class levels, and for the youngest class level over a three year period, were examined. The focus of the research was on the cognitive mechanisms that underlie children's writing ability, in an effort to ascertain what aspects of working memory predict mastery of the writing process. The study examined whether working memory, language or motivation to write, predict the mastery of the writing process.

Writing is a complex activity that integrates the cognitive functions of long term and working memory, vocabulary, semantic, syntactic and spelling knowledge, reading and general cognitive ability with orthographic and motor function, in order to communicate meaning in written form, within the social and linguistic conventions in which the writing is performed (Olive, 2004; Puranik & Apel 2010). Bruce, Collins, Rubin and Gentner (1982) point out that, as the skill of writing involves the

integration of communication, life experiences, thinking, talking and writing, it is a complex process to study. Bourke and Adams (2010) propose that, for the emerging writer, scribbles and pictures constitute meaning and, as the learning and experience increases, progress is made to an alphabetic code that is specific to a social, cultural and linguistic experience. Hoskyn and Tzoneva (2008, p.36), in their study of emergent writers, define (children's) writing as the "ability to print letters legibly in isolation (i.e. to create letters from memory) and to assemble letters to make a known word."

Earlier studies, such as those conducted at the end of the 20th century, researching the component skills necessary for children to learn to read and write, predominantly claimed a reciprocal relationship between the functions of reading and writing (Read, 1975; Juel,1988). Tests scores that have produced high correlations between reading and spelling led some theorists (Goug, Juel & Griffith, 1992) to believe that the processes of learning to read and to spell are fundamentally the same. However studies that show the importance of phonological awareness to both reading and writing (Maclean, Bryant & Bradley,1987; Juel, 1988) acknowledge the asymmetrical developmental pattern between both processes, and note the fact that the children tested were exposed to a curriculum that emphasised the teaching of reading more than writing and spelling. Phonological awareness has been found to play a more important role in early spelling development in writing systems where there is grapheme–phoneme consistency (Sénéchal, Basque & Leclaire 2006), as spelling is a more sensitive index of phonological processing than reading (Babayigit & Stainthorp 2009; Perfetti 1997). A study conducted by Pecher (2001) highlights the extent to which English is grapheme to phoneme as well as phoneme to grapheme inconsistent and its results show that responses to inconsistent words were slower than to

consistent words, demonstrating the challenges confronted by the writer of English. It further demonstrates that the opaque nature of English as a written language (that is its complex grapheme–phoneme correspondences) makes it more complex and difficult to learn (Katz & Frost, 1992).

Puranik (2006) points out that research into writing is not as advanced as that carried out in reading and a substantial body of research that has been conducted has involved participants in late childhood, adolescence and adulthood (Holmes, Malone & Redenbach 2008; Olive, Kellogg & Piolat 2007; Sénéchal, Basque & Leclaire 2006; Swanson & Berninger, 1996) where the focus of study has been the development of writing skills along with the spelling strategies used.

More recently research studies have been carried out with children aged three and four years in pre-schools or at the start of formal education and have focused on the process of emergent writing (Bourke & Adams, 2010; Hoskyn & Tzoneva, 2008). These studies have been undertaken mainly in the USA, Canada and the UK. The role of working memory in predicting writing skills in young children has not been extensively examined. The roles of grammatical and alphabet knowledge and non-language related factors such as motivation are also underrepresented in the research literature on children's writing. This thesis aims to address these issues.

This chapter will review current literature on models of writing and examine language knowledge, working memory, gender and motivation to write in predicting writing skills in English, at the emergent stage of writing. Before examining each of these factors, the main approaches to writing are examined.

1.2. Approaches to writing

Writing consists of the creation of ideas and their execution using grapho-motor skills (Flower and Hayes, 1981; Hayes and Flower, 1986), with a limited working memory

capacity underlying the process (McCutchen 1996). Spelling skill is treated as a key aspect of writing. The stage theory of writing (Ehri 1997; Gentry 1982), proposes that learning to write progresses in a sequential, unidirectional and ordered manner from a reliance on one type of spelling strategy of lesser sophistication to another more sophisticated strategy, as spelling skills develop. Ehri (1989) suggests that there are four stages of development in learning to spell. At the pre-communicative stage, the emergent speller does not recognise letter–sound correspondence and his/ her writing reflects this. At the second and semi-phonetic stage the writer begins to use letter–sound correspondence and this leads to the third stage where the writer spells words phonetically. Finally the writer, with an increasing awareness of the derivation of words, gets to the morphemic or transitional stage and uses her/his knowledge of morphology for spelling.

Frith (1985) suggests that at the initial stage of writing children rely on visual patterns within words. Frith proposes that spellers go from a logographic to alphabetic to orthographic stage within the stage development process. Research by Nunes, Bryant and Bindman (1997), is consistent with the stage approach to writing and their results suggest that children initially go through a period of writing phonetically and then progress to morphologically based writing. Leong (2000) proposes that when children reach the more sophisticated level of morphological knowledge it makes a significant contribution to their spelling accuracy. Nunes, Bryant and Olsson (2003) found that explicit training in morphology significantly improved children's spelling after twelve weeks. However the question of how children move from one strategy to another more sophisticated one remains unanswered.

A study on orthography conducted by Cassar and Treiman (1997) with kindergarten children who were shown non-words, one with legal doubled letters and

one with an illegal doublet, showed that children were able to select which of the two was orthographically legal. Treiman and Bourassa (2000) point out that children are exposed to environmental print from a very young age and they demonstrate knowledge of the orthographic structure of the language they are learning from the age of three years or younger. A study conducted by Bernstein and Treiman (2001), on the effects of positional and phonemic context on very young children's ability to learn spelling, demonstrates that children as young as five and a half, and some in kindergarten, are sensitive to the position in which graphemes occur within a word. Furthermore they show that children begin to generalise their knowledge of positional graphemes after just one exposure. A study by Abbott and Berninger (1993) revealed that the speed and efficiency with which words are visually encoded has a greater influence on learning to spell than the phonological encoding of words.

In a challenge to the stage approach, Siegler's overlapping-waves model (1996) proposes that children's thinking is adaptive and dependent upon mechanisms for generating strategies flexibly. The overlapping-waves approach (Rittle-Johnson & Siegler 1999, Varnhagen, Mc.Callum & Burstow, 1997) suggests that children oscillate between more and less sophisticated strategies and after a time they come to rely more on effective strategies and less on ineffective methods of spelling. Consistent with this theory, a study by Varnhagen (1995) showed that children use phonological, orthographic, morphemic and mnemonic strategies at any one time for spelling purposes. Bernstein and Treiman (2001) point out that the ambiguous nature of the English language challenges children who are learning its spelling which suggests that emergent writers are required by necessity to use strategies adaptively. A four year longitudinal study conducted by Nassaji (2007), with students from grade one to grade four who were learning English as a second language, found that children

produced simple and complex errors involving phonetic, orthographic and morphological types over the four years, suggesting that the development of spelling may involve the overlapping of all these processes at any one time.

Kreiner (1992) in a study testing a two strategy model of spelling found that both the rule and lexical strategy were used by skilled spellers and that working memory played an important role in combining factors from both strategies. Weekes (1994) found that readers who had been characterised as lexical readers had less difficulty and were more accurate in the spelling of irregular words, that required lexical access, but showed no difference in accuracy with regularly spelled words, thereby indicating that, at any one time, multiple and adaptive strategies are used for spelling. Findings from empirical studies suggest that phoneme–grapheme inconsistencies in the English language require the use of a multi-strategy approach for accurate spelling (Bernstein & Treiman 2001; Nassaji, 2007; Varnhagen, 1995).

According to the constructivist perspective, children gain knowledge about letter strings prior to learning the rules of phonology. This theory, based on case studies and clinical interviews, proposes that, universally, children at the emergent stage of writing possess a common store of letter patterns. A study conducted by Puranik and Lonigan (2011) on the development of writing skills in pre-school children provides clear evidence that very young children possess knowledge about writing prior to the commencement of formal education and at this stage the children's writing demonstrates universal features which then progress along a sequential path. However a study by Pollo, Kessler and Treiman (2007), with four year old children, found that while early spellers were non-phonological there was no evidence that patterns of spelling were universal; instead children's writing reflected patterns from their own writing environment. These findings are consistent with

studies which show that children are better at printing letters from their own name when writing words (Treiman & Broderick 1998; Treiman, Kessler & Bourassa 2001).

Hayes and Flower (1980) put forward a cognitive model of writing providing a more comprehensive understanding of how a text is composed. The Hayes and Flower model (see Figure 1.1) proposes that there are three major cognitive processes involved in writing:

1. planning, involving the setting of goals along with the generation and organisation of ideas;
2. translating, which requires the verbal encoding of ideas and thoughts;
3. reviewing, which includes the sub-process of reading and editing.

Modifications to this model made by Berninger et al. (1992) specify two sub-processes involved in the translating stage which include text generation, involving the translation of ideas into meaningful words, phrases and sentences and transcription which involves letter formation, spelling and punctuation. Levelt (1989) distinguishes the components of writing along similar lines to Hayes and Flower but uses the terms *conceptualiser* to explain the planning stage of writing, *formulator* to describe the translating stage and *articulator* to show how words are put into phonemes and then graphically transcribed.

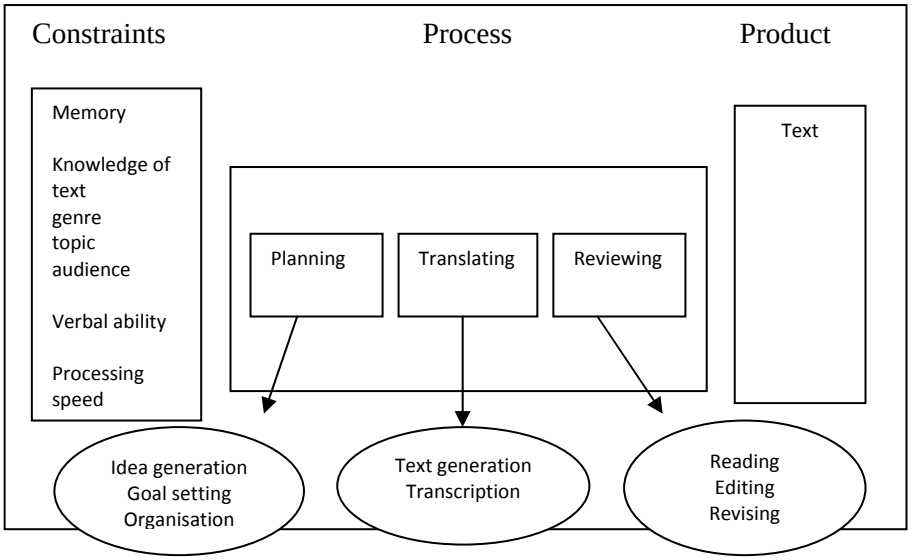


Figure 1.1 The Hayes and Flower model of writing (1980)

The Hayes and Flower model of writing 1980 from Puranik (2006). Each of the cognitive processes proposed by the Hayes and Flower model and modified by Berninger et al. (1992) suggest that sub-vocalisation and oral language contribute to the writing process both directly and indirectly.

1.3. Language knowledge and writing

That there is a highly interactive relationship between verbal and written language is recognised in the psychological literature (Vachek 1989; Babayigit & Stainthorp 2009). Luelsdorff (1989) notes that spoken language has a phonetic basis providing an instant and transient linguistic reality, while written language is based on graphics and is more permanent. Babayigit and Stainthorp's (2009) study, while recognising that children's written capacity lags behind that of verbal ability, found that oral language and verbal working memory were the strongest longitudinal predictors of writing quality in six to seven year old children. A study conducted by Scanlan (2012) found that oracy, i.e. the ability to understand and express oneself in spoken language, played an important role in the writing process, whereby children discussed what they

planned to write prior to writing. These results are supported by a study by Ferreira and Correa (2008) on the influence of instruction on children's writing. They showed that children who experienced discussion and preparation wrote better stories than children who did not receive any instruction.

The role of oral language in the development of writing skills is acknowledged in educational psychology from the earliest stage of instruction. The Department of Education and Skills in Ireland emphasises the importance of oral language development in literacy training and in writing in particular (Review of the Curriculum, 1999). Kellogg, Olive and Piolat (2006) point out that speaking and writing share some underlying processes, as oral language requires phonological encoding and, for the purpose of writing, a writer may encode lexical entries phonologically and then convert them to the orthographic code when writing. Adams and Gathercole (1996) propose that the language children write originates in their spoken language and its creation makes demands on the phonological component of working memory (see section 1.4 on working memory). Swanson and Berninger (1996) argue that, prior to writing, ideas are encoded linguistically and the process of text generation involves translating those ideas into written symbols.

A study conducted by Berninger, Yates, Cartwright, Rutberg, Remy & Abbott, (1992) demonstrates that while reading and writing share many of the same working memory sub-processes, including verbal, phonological and orthographic systems, the sub-processes relate differently to reading than to writing. Chenoweth and Hayes (2001) examined the extent to which fluency in speech enhances the writing process. They found that as knowledge of spoken language increased, it had a positive influence on the number of words produced and the complexity of the written sentence. Kellogg (2008) argued that the verbal domain of working memory partially

mediates reading and writing. Typically-developing children who present at pre-school have learned how to speak naturally, while reading and writing is taught formally and therefore makes more demands on working memory. A 3-year longitudinal study conducted by Caravolas, Hulme and Snowling (2001) on the foundations of spelling ability in four to six year olds (who were spelling mainly monosyllabic words) led the authors to conclude that orthographic knowledge, alongside phonemic awareness, is a strong predictor of spelling ability. In interpreting results from their study on the component skills necessary for emergent and developing writers, Abbott and Berninger (1993) note the fundamental role of oral language in the acquisition of both reading and writing. This emphasises the importance of articulacy in contributing to compositional fluency.

Bruce, Collins Rubin and Genter (1982) propose that a child's written language ability is founded upon her/his oral language experience and for the emergent writer, whose syntactical and vocabulary knowledge is not as efficient as an experienced writer, the organisation of writing is more challenging. Perfetti and McCutchen (1987) claim that language underlies all literary skills but also point out that while reading is dictated by the text, the writing process is managed by the writer in order to create text. The literature, based on empirical research, recognises that the central executive and phonological memory in particular are central to oral language development alongside the skills of reading and writing (Adams & Gathercole 1996; Alloway et al., 2005; Kellogg, 2008). Both reading and writing can be distinguished from oral language because of their written form and writing is further distinguishable from reading in its complexity as it requires the creation and transcription of text and therefore makes more demands on working memory.

The ability to produce quality writing, however, requires more than good syntactic ability and the capacity to retrieve words from long term memory. McCutchen, Covill, Hoyne and Mildes (1994) point out that the ability to control working memory resources and manage the interacting sub-goals of writing and reading processes at different cognitive levels at the same time were the necessary prerequisites of good writing.

1.4. Working memory and the relationship between working memory and writing skills

1.4.1 Working memory

According to Olive (2004), working memory is a construct that helps explain how information is temporarily stored and processed, in a limited capacity system, so that cognitive activities can function. While there are differing models of working memory (e.g. Just & Carpenter, 1992; Morey & Cowan, 2004) this study focuses on one of the most influential accounts, that of Baddeley and Hitch (1974), revised by Baddeley (2000). This model proposes that working memory is a multicomponent system consisting of several discrete components. The *central executive* is responsible for the control of attention and the retrieval of information from long term memory, and it controls resources and monitors information that is stored by two domain specific systems: the *phonological loop* and the *visuospatial sketch pad*. The phonological loop is responsible for the storage and rehearsal of verbally encoded information. Its speed of processing is unique to each individual. Information that is visually or spatially encoded is stored in the visuospatial sketchpad. A fourth component, the *episodic buffer*, is capable of unifying information across all systems.

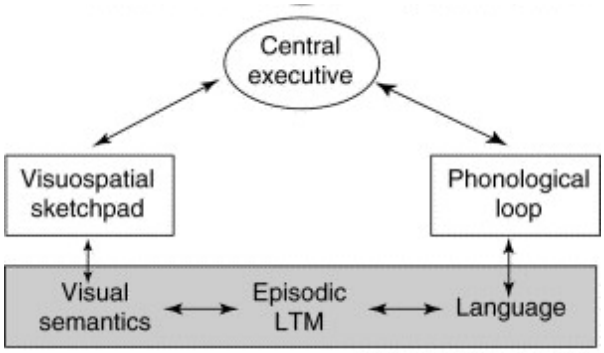


Figure 1.2 Baddeley's working memory model

The model of working memory proposed by Baddeley and Hitch (1974) from Baddeley (2000) showing the three main components of the model and their link to long term memory.

Both experimental and neuroimaging research findings (e.g. Vallar & Papagno, 1995) concur that the visuo-spatial sketchpad is fractionated into separate spatial and visual components (Hecker & Mapperson, 1997; Olive, Kellogg & Piolatt 2007). Results from a study conducted by Alloway, Gathercole and Pickering (2006) which included participants from four to eleven years were consistent with that of Baddeley and Hitch's model of domain general processing alongside a domain specific storage construct. Alloway et al. (2006) found that the structure of working memory is in place by the age of four with evidence of developmental changes, such as the link between the visuo-spatial sketchpad and the domain general system being stronger in four to six year olds, resulting in young children placing more demands on central executive resources when processing visual information. Findings from a study conducted by Gathercole, Pickering, Ambridge and Wearing (2004) show consistency in working memory across childhood years, with linear increases in performance from four years to adolescence.

In his summary of experimental findings on the role of working memory in writing, Olive (2012) concludes that "as writing is one of the most effortful cognitive activities, working memory is strongly involved when composing a text" (p.1). The question of *how* working memory is involved in the composition of a text, particularly at the emergent stage of writing, remains unanswered.

1.4.2 The relationship between working memory and writing skills

The traditional belief has been that writing is dependent on phonological encoding. However, Bourke and Adams (2003) found that poor phonological memory, while associated with weak spoken language skills, is not linked with a poorer ability to write. This study suggests that the key to fluency in writing lies in the ability to simultaneously perform the sub-processes of planning, word retrieval, grammar, and sentence formation while managing and coordinating limited cognitive resources. Consistent with this are the results of a writing study conducted by Olive, Favat, Beauvais and Beauvais (2009) which shows that the increase in writing fluency from grade five to nine is the result of efficiency in high level processes.

A study conducted by Bourke and Adams (2010) further suggests that visuo-spatial memory and reading are strong predictors of writing skills, in pre-school children, possibly because both reading and writing rely on overlapping cognitive processes in working memory. Neuropsychological evidence challenges the theory that verbal working memory is necessary for the creation of lexical representations. Using a case study, Vallar and Baddeley (1984) showed that a patient whose phonological memory was impaired was able to speak and write. Clinical case studies, such as those conducted by Shelton and Caramazza (1999) and Shelton and Weinrich

(1997), support the claim that written language production is not exclusively dependent on the phonological component of working memory and therefore provide a challenge to psychological research to explain to what extent the processes of learning to write and writing are underscored by working memory. According to a study conducted by Ehri and Rosenthal (2007), children who were exposed to the spelling of words had an enhanced vocabulary and were better readers than those who had not been taught the orthographic structure of words. The authors of the study concluded that as writing draws upon children's existing grapho-phonemic knowledge, vocabulary growth and writing make greater demands upon orthographic memory rather than on phonological memory as was previously believed.

An observational study conducted by Gathercole, Lamont and Alloway (2006) shows that writing was one of the most difficult tasks for children with poor working memory capacity. McCutchen's capacity theory (2000) explains the variations in writing acquisition and efficiency in terms of the difference in working memory capacity. Several writing studies confirm that writing places heavy demands on the central executive and that the processes involved in writing compete with each other for limited resources. While a large number of studies have addressed the relationship between working memory and verbal tasks (Swanson & Berninger, 1994, 1996), research into the link between working memory and writing has only recently appeared.

According to Bourdin and Fayol (1994) message generation, both oral and written, is cognitively demanding. In a study conducted to compare the difficulties of language production in written and oral form, they found that the serial recall of words, for children but not adults, was poorer when writing compared to speaking. This suggests that lexical retrieval and syntactic generation, which are required for

speaking and writing at the translation stage, both rely on overlapping cognitive processes that are phonologically based. These findings are consistent with those of Olive (2004) who found that the cognitive demands made at the translation stage of writing involve the same sub-processes as those involved in speech production.

Bourke and Adams (2010) reported that British pre-school children found writing to be more difficult than both reading and oral work which suggests that while all three tasks share overlapping cognitive processes, the practice of writing makes greater demands on working memory than either speech or reading. The literature recognises that writing and speech draw upon the same cognitive resources but writing differs from speech in requiring visual, phonological and motor resources and is therefore, because of the requirements of transcription skills, more cognitively complex (Bourding & Fayol, 1994, 2002). In a study conducted by Alloway et al. (2005), with four to five year olds, on the extent to which working memory and phonological awareness predict learning, it was found that both factors play a crucial role in learning from the beginning of formal education. The findings show that writing performance was linked specifically to complex memory span and awareness of phonology. While reading draws predominately upon verbal working memory, writing, which requires the ability to reproduce the alphabet in words, phrases or sentences, rather than merely recognising it, makes greater demands on both verbal and visual working memory (Olive 2012).

Levelt's writing model suggests that both the conceptualiser and formulator function as high level activities while the process of graphic transcription is regarded as a low level activity in practised writers. Bourdin and Fayol (2002) propose that handwriting makes heavy demands on working memory resources. In line with this, Olive, Favat and Beauvais (2009) suggest that as handwriting becomes more

automated, resources are freed up for planning and revision which are essential for writing achievement. However in their study of 5th and 9th graders, Olive et al. (2009) found no link between handwriting and fluency in writing for older children after grade 5. There was a reduction in cognitive effort between the two age groups however. For children, graphic transcription, i.e. drawing letters in sequence to compose words, may be more cognitively demanding, as formulation and transcription skills are less automated. The recursive nature of these processes requires the management and co-ordination of several cognitive, linguistic and motor functions simultaneously, which demonstrates the complexity of writing and the extent to which it is more cognitively demanding than both oral work and reading.

Empirical studies have emphasised the importance of working memory in underpinning the writing process and there is general agreement that writing places heavy demands on working memory (Hayes 2006; Kellogg 1996, 2008). Kellogg (1996, 2008) and McCutchen (2011) have been influential in investigating the link between the planning, translating and reviewing stages of writing and the central executive, the phonological loop and the visuo-spatial domain of working memory. McCutchen's capacity theory (1996) proposes that as writing efficiency increases, fewer demands are placed on working memory resources and this results in better writing. Kellogg (1996) outlines the cognitive systems within working memory that relate specifically to particular aspects of writing. He places the onus for translating and reviewing specifically in the verbal domain of working memory. A study conducted by Ransdell, Arecco and Levy (2001), found that the phonological loop was also involved in the planning stage of writing. Kellogg (1996) found that the storage and processing of information at the translation stage of writing made demands on the central executive and the phonological loop. According to results

from a study conducted by Le Bigot, Passerault and Olive (2009), memory for words located within a text is underpinned by the visuo-spatial sketchpad, which suggests that the planning and reviewing stages of writing make demands on visual aspects of memory, contrary to what was previously believed. Kellogg's study (1996), which examined how skilled writers use working memory in the process of writing, found that the planning aspect of writing involved visualisation and therefore made demands on the visuospatial sketchpad. In a more recent study that sought to discriminate between different aspects of the translation stage of writing, Kellogg, Olive and Piolat (2006) found that while the conversion of inner speech into text predominately involves verbal working memory, visual working memory was engaged for the conversion of concrete as opposed to abstract nouns in the construction of a sentence. Findings from a study conducted by Olive, Kellogg and Piolat (2007), on the extent to which visual, verbal and spatial memory assist writing, support the theory that the encoding of ideas into words at the translation stage of writing makes demands on verbal working memory (Kellogg et al., 2006).

However in conducting their study, Olive et al. (2007) examined visual and spatial elements of working memory separately and found that the process of text composition placed equally high demands on verbal and visual components of working memory but less on spatial memory, thereby suggesting that writing places higher demands on visual memory than was previously thought. The study found that spatial working memory was not engaged in the definition of either abstract or concrete nouns. Galbraith, Ford, Walker and Ford (2005) found that the spatial layout of writing at the planning stage made demands on spatial working memory while Olive and Piolat (2002) argue that handwriting is supported by both visual and spatial working memory. Translation is resource consuming and results in distraction from

high level processing for emergent writers according to Olive (2004). He proposes that the process of translating is less resource intensive for the experienced writer because it is used more constantly than planning and revision and it engages the same sub-processes as those required for oral language. Planning and revision, however, place higher demands on working memory because they are activated to greater or lesser extents throughout the writing session. Ang and Lee (2010) claim that visual memory places greater demands on executive resources than phonological memory. Alloway, Gathercole and Pickering (2006) showed that the link between the visuospatial construct and the central executive is stronger in four to six year olds and that young children draw more on the central executive resources when processing visual information. This suggests that children make heavy demands on the visuospatial function for writing and may explain why children find writing more difficult than oral work and reading. Writing necessitates that children identify graphemes that match with sounds and this makes demands on the central executive along with the phonological loop and visuospatial sketch pad (Olive, Kellogg & Piolat 2008). Studies conducted by Kellogg et al. (2006) as well as Olive and Piolat (2002) suggest that text generation and letter formation in emergent writers may place more demands on visual memory than has been previously suggested.

Hoskyn and Tzoneva's study (2008), on the link between working memory and writing in pre-school children, found that children's exposure to writing practice and the enhancement of orthographic awareness outweighed the influence of working memory in predicting writing ability. However the study also found that for very young children writing was cognitively challenging. The results suggest that the ability to focus on the task of letter formation in order to write from memory is synonymous with controlled attention which is underscored by the central executive.

The traditional view that writing is dependent on phonological encoding from the orthographic lexicon is challenged by empirical evidence. A study conducted by Frith (1978), with twelve year olds who were good at reading but not spelling, found that as their spelling was phonologically based, their difficulty was likely to lie with the retention of orthographic information and therefore underscored by the visuospatial construct. Further research on this aspect of writing was undertaken by Holmes, Malone and Redenbach (2008) and results show that poor spellers were weak in orthographic processing rather than having an inferior visual sequential memory. Poor spellers spent longer distinguishing between words and were slower to detect letters that were incorrectly ordered within words. The results suggests a strong link between spelling and an underlying visual processing construct as well as confirming a strong link between reading and writing based on weaker lexical rather than phonological accessibility.

Working memory is important for the mechanics of writing, but it is also crucial for higher level aspects of writing development such as storyline, the ability to link sentences, and depict characters and plotlines. Motivation to write and attitude towards writing will also be important factors to consider. We turn next to these aspects of writing.

1.5 Sense of story and gender differences in emergent writing

According to Brown (1977), children develop an understanding of the concept of story between two and three years of age. By the age of five, while they are still unable to link sentences together independently of the main character, their sense of story influences their use and choice of sentences and syntax. A study conducted by Yoshinaga-Itano and Downey (1992), established that the inclusion of connectives in

a story was an important factor in the development of a good story. Zeman (1969) found that children with above average reading ability used more complex sentences in their writing, while children with below average reading ability used more simple rather than complex sentences. The results from a study conducted by Martin (1995) found a strong correlation between the number of words written and the rating of story quality. Sun and Nippold (2012), examining children's narrative writing, found that stories that included abstract nouns and metacognitive verbs (e.g. assume, discover, realise) showed greater complexity than stories that did not employ them. Bird, Howard and Franklin (2003), in a study of aphasia, (a disorder caused by dysfunction in specific brain regions, affecting the comprehension and formulation of language), found that the participants had greater difficulty in the written production of verbs than nouns. This suggests that the production of verbs in writing is an indication of a more sophisticated level of literacy. Hinkel (2002) argues that accuracy in the use of tenses in writing plays a key role in providing meaning and results in higher ratings for what is written. A comparative study on the knowledge of tenses, conducted by Bonnette and Fayol (1997), found that children did not have as developed an understanding of tenses as adults, suggesting that a child's writing that includes a variety of tenses indicates a level of complexity of linguistic understanding.

Fay, Catts, Williams, Tomblin and Zhang (2005) found that, based on ratings given to the stories for characters, physical settings, endings and language sophistication, girls told stronger stories than boys. Gelati (2012) provides evidence from the National Assessment of Educational Progress (2008), the monitoring agency for academic achievement in writing in the United States, to show that girls' academic writing was superior to that of boys in narrative, persuasive and informative texts. Analysis of work written by boys and girls in elementary and middle school in the

US, conducted by Gelati (2012), showed that the girls scored higher in both the mechanics and higher order writing skills. In a further study, conducted by Gelati (2012), on gender differences and the influence of motivation in writing, it was found that the gap between boys' and girls' writing performance widened when the participants wrote on a topic of specific interest to girls and narrowed when the topic of writing was of greater interest to the boys. Further study of writing measuring the number of words, verbs, and tenses as well as an examination of gender differences in writing is warranted particularly at the emergent stage of writing.

1.6 Writing experience and motivation to write

The purpose for which children write differs according to the individual child and the stage of writing at which the child is functioning. According to Bourke and Adams (2010), early attempts at writing are for the purpose of communicating meaning even though the reader may not be able to interpret what has been written. When children go to school and are introduced to the alphabetic system they write as part of the practice necessary for learning to occur. Flower (1979) suggests that emergent or ineffective writers express themselves subjectively rather than from the reader's perspective. Consistent with this are results from O'Rourke (2008) on the development of perceptions and writing skills in emergent writers, which showed that young children initially write entirely from their own perspective. According to O'Rourke the emergent writer's focus is on letter formation and a hugely motivating factor for children is when they realise others are listening to or reading their stories; they then shift their focus from their own perspective and the process of handwriting to that of entertaining their audience. Consistent with this, Nolen (2007) suggested that the biggest influence in motivating struggling young writers to produce a written

text is the provision of a supportive environment and a purpose for writing. Cialdini, Eisenberg, Green, Rhoads and Bator (1998) found that providing external rewards while aligning the reward with an internal trait of the participant produced positive results in motivating young children to write. Potter, McCormick and Busching (2001), examining the influences that motivated adolescents to write, found that the biggest factor was the extent to which the young writers were encouraged by their teachers and the respect which their work received from significant adults in their lives. A study by Daniels (2004) investigating the motivational effects of information technology on children's writing found that while the integration of computers into children's writing class incentivised 5th grade pupils' performance it also found that personalised assistance along with teacher participation proved equally motivational. A recent study by Scanlan (2012) found that writing quantity and quality improved alongside increased motivation and confidence in writing ability when there was close liaison between home and school.

That there is a substantial link between children's motivation to write and their writing performance in terms of quantity and quality is evident from the literature (Daniels, 2004; Scanlan, 2012). According to Benton, Corkhill, Sharp, Downey and Khramtsova (1995), interest in and knowledge of a topic is influential in the choice of subject matter for writing. Ainley, Hidi and Berndorff (2002) point out that interest in a particular area increases attention, effort, concentration and motivation when working on that subject. Hidi, Berndorff and Ainley (2002), examining the argumentative texts of junior and middle school students in Canada, found that participants' interest in a subject was closely associated with their self-efficacy (a measure of one's own ability to complete tasks) and the quality of the writing produced. This pattern was clearer for boys than for girls.

However, how children's enthusiasm to write at the emergent stage of writing influences their writing fluency has not been extensively studied or established, nor have links with working memory been investigated in any detail. Deficits in working memory might be expected to be associated with lower motivation to write, a relationship that will be addressed in the present study.

1.7 The current study

A substantial amount of research that has been conducted on the writing process has focused on consistent alphabetic systems such as Italian and Turkish, where the emphasis is on phonology along with the regularity with which sounds map on to symbols (Joshi & Aaron, 2013). The phoneme–grapheme mapping irregularity in English, alongside the contribution made to the meaning of text by the non-alphabetic code such as commas, capitals and full-stops, results in the inaccurate application of the findings from studies of transparent languages to those of opaque languages such as English. The current study examined the development of the skill of writing in the English language in the context of the Irish education system.

Many studies that have established links between working memory and writing (e.g., Bourke & Adams, 2003; Covill, Hoyne & Mildes, 1994; McCutchen, Swanson & Berninger, 1996) have been conducted with older children and adults whose writing can convey meaning for both the reader and the writer independently of each other. Results from studies suggesting that planning and reviewing employ greater cognitive effort than transcription (Olive 2004) are applicable to adults and are inaccurately applied to children where the process of learning to write as a new skill is shown to be cognitively expensive. However, empirical evidence on the extent to

which transcription skills are resource consuming (Bourdin & Fayol, 2002; Olive Favat & Beauvais, 2009) is contradictory and requires further study.

What are the cognitive mechanisms underlying emergent writing and early orthographic sensitivity in the English language? Prior to schooling, children's writing is spontaneous and graphic. The written form used by very young children may not be legible, and the marks made on the page may not be in a culturally acceptable alphabetic code, but it nonetheless demonstrates their ability to think, memorise, create and write concurrently. Arguably this skill is slowed down in school where children learn a phonetic approach to writing and the purpose for which they write alters from one of purposeful communication to that of learning an alphabetic code. Previous research has linked the phonological loop, the visuo-spatial sketchpad and the central executive to various stages of the writing process (Kellogg,1996, 2008; McCutchen, 2011). Baddeley and Hitch (1974) describe the visuo-spatial sketchpad as the inner eye. The processes underlying text generation, translation, planning and reviewing require internal visualisation and vocalisation alongside the coordination of creative thought, memory and grapho-motor skills during the writing process (Berninger, 1999; Flower and Hayes, 1981; Hayes and Flower, 1986; Lancioni, Nirbhay, O'Reilly, Sigafoos, Green, Olive & Lang, 2011; Murray, 1965; Murray, Birch, Chase, Eyolfson & Simms, 1991; Paton, 2012; Villalon & Calve 2011). While earlier research findings (e.g., Kellogg, 1996) situated the basis of writing skill in the verbal domain of working memory, more recent studies propose that the visuo and spatial domains of working memory play an important role in underpinning the task of writing (Galbraith, Ford, Walker & Ford, 2005; Kellogg, Olive & Piolat, 2006; Le Bigot, Passerault & Olive 2007; Olive et al. 2007; Olive & Piolat, 2002).

Research findings on the cognitive processes affecting the writing process in adults suggest that the verbal, visuo-spatial and executive domains of working memory are involved (Bourke, Davies, Sumner, & Green, 2013; Covill, Hoyne & Mildes, 1994; McCutchen, Swanson & Berninger, 1996; Olive, 2012). The link between visuo-spatial memory and writing has not yet been investigated extensively. It is possible that it supports the emergent writer at the text generation and transcription stages to a greater extent than has been demonstrated.The question that remains is how this information applies to children at the initial stages of learning to write in the English language.

The current study examined the role of the central executive along with the phonological and visuo-spatial domain of working memory in children's first, second and third year of formal education in a cross-sectional study while also comparing samples of free writing of the children within the three groups. The longitudinal study used tasks linked to the central executive, the phonological and visuo-spatial memory of the youngest group over a three year period while concurrently examining their free writing samples between 4 and 8 years of age in an effort to establish if and which domains of working memory best predict writing fluency.

The current study concurrently examined the grammatical and alphabetic knowledge alongside the free writing of 4-8 year olds in order to ascertain to what extent language knowledge contributed to writing fluency. Evidence from empirical research demonstrates the importance of the number of words, the complexity of sentences and the variety of verbs and tenses in rating quality writing (Bird, Howard & Frankin 2003; Bonnette & Fayol 1997; Hinkel 2002; Martin 1995; Sun & Nippold 2012; Zeman 1969). Studies that have examined and rated texts have established some differences in the quality of writing along the lines of gender (Fay, Catts, Williams,

Tomblin & Zhang 2004; Gelati 2012). However the focus of research has been on the writing of children in middle and upper elementary school. The current research used the criteria of number of words, verbs, tenses and complexity of sentence to rate the stories of emergent writers. The study compares the ratings of boys' with girls' stories on a topic neutral to both genders.

Research into the influence of motivational factors in increasing children's writing fluency is limited. The current study sought to establish if the child's motivation to write affected the content and quality of the written text produced in free writing. To what extent does a child's motivation to write predict the speed and efficiency with which she/he learns and performs the skill of writing?

It was predicted that writing will draw upon a multiple capacity system. It was predicted that the relative importance of the WM components would change over time as the children became more proficient writers.

It was further predicted that children's knowledge of grammar alongside their ability to name letters and produce the sounds of letters will positively influence their writing skill.

Finally it was predicted that the level of motivation with which children approach the writing task will contribute to the fluency of their writing.

Chapter 2: Methodology

2. 1 Cross sectional study

2.1.1 Participants

Fifty-seven Irish, English speaking, children took part in the study. The children, 33 girls and 24 boys, aged between 4 and 8 years of age, attended Junior Infants, Senior Infants and First Class, in two town schools in the South of Ireland. The Junior Infant children (mean age = 66.29 months) were in three different classrooms; the Senior Infants (mean age = 79.77 months) and First Class children (mean age = 91.23 months) were in two different classrooms. Only those children with no documented sensory, physical or intellectual impairments, as ascertained from school records, were recruited for the study.

Table 2.1 Number and age of pupils in each class group

	Junior Infants	Senior Infants	First class	Total
Number	31	13	13	57
Average age (in months)	66.29	79.77	91.23	-
Age range	59-85	76-100	85-101	-

Children in Junior and Senior Infants attended school for a four hour day, while children in First Class attended school for a five hour day and all classes received formal instruction in literacy and numeracy.

2.1.2 Materials

The tests administered are outlined below. Four memory measures were taken from the Automated Working Memory Assessment (Alloway et al., 2007): Digit Recall, Listening Recall/ Processing, Dot Matrix and Spatial Recall/ Processing. The Listening Recall/Processing and the Spatial Recall/Processing tests involve storage-plus-processing components and are referred to as working memory tasks. The remaining two measures are referred to as short-term memory tasks.

Test reliability of the AWMA has been measured in a subset of children (n=128) aged between 4.10 years to 22.5 years, selected randomly across schools and universities in England (Alloway & Gathercole 2006). The performance of the children at the first and second time of testing remained consistent, which indicates no significant difference as a function of age or practice.

All working memory tests were presented aurally, visually or both, on a laptop computer. The details of each task are outlined below.

Verbal Short-term memory

The Digit Recall task of the AWMA commenced with a trial in which the child heard one digit, then two digits, then three digits, and was required each time to recall the digits in the order in which they were presented. Once the participant had completed the trial the test began in the same order, from one digit to nine digits, and required the participant to recall the digit(s) in the order in which they were presented.

Verbal Working Memory

The Listening Recall/Processing test commenced with practice trials in which the participant was presented, firstly, with one spoken sentence and then two spoken

sentences and had to verify if the sentence or sentences were true or false as well as recalling the last word of the sentence(s) in the order in which they were presented. Once the practice items were completed the child was presented with, from one to a series of six sentences and was required to state if the sentence(s) was true or false as well as recall the last word in each sentence in the correct order. The storage and processing components of the verbal working memory tasks were presented independently and scores were then combined, following the AWMA procedure. The following is an example of sentences from two blocks:

1. People have two eyes: (eyes) (true).
2. Bananas live in water (false); Flowers smell nice (true) (water, nice).
3. Trucks have wheels (true); Worms crawl in the soil (true); Bicycles eat grass (false) (wheels, soil, grass)

Visuospatial Short-term Memory

The Dot Matrix task commenced with a practice trial in which the participant was shown the position of one red dot, then two red dots and then three red dots, in a series of four by four matrices and had to recall the position of the dot(s) by tapping the squares on the computer screen. The dot was held in position on the screen for two seconds. On completion of the practice items the test items appeared on the screen ranging from one to a series of nine dots, to be recalled in the order in which they appeared in each matrix.

Visuospatial Working Memory

The Spatial Span task started with a practice trial in which the child was presented with a picture of two shapes, where the shape on the right had a red dot on it. The participant was required to identify whether the shape on the right, which may be

rotated, was the same or opposite to the shape on the left. At the end of each trial the child was asked to recall the location of each red dot, by pointing to a picture on the computer screen with three compass points, in the order in which they appeared on the screen. Once the practice items had been completed the test commenced in a similar manner to the practice trial, and increased in complexity until the child was required to recall the position of up to seven dots in sequence as well as identify if the shapes were the same or opposite. The storage and processing components of the visuospatial working memory tasks were presented independently and then combined.

Knowledge of letter names and sounds

This task was adapted from a similar test in a study by Caravolas, Hulme and Snowling (2001). The participants were presented with cards containing individual lowercase letters of the alphabet, such as *a,h,n,z,* etc., as well as four blends, *br, sl, cl, dr*, and four digraphs, *th, sh, ch* and *ph*.

The Morphological Generation Task

This task was adapted from a study by Muter et al. (2004) and required knowledge of regular and irregular plurals and grammatical inflections. It consisted of 24 pairs of picture cards and each picture card was presented accompanied by a sentence provided verbally. When the first picture card of each pair was shown, the researcher provided a stem sentence followed by a second sentence in which the final word was omitted. The participant was asked to complete the second sentence which required a variation in grammatical knowledge from that used in the first sentence. The first ten items required knowledge of plural endings, both regular and irregular. The remaining

fourteen items elicited the child's knowledge of grammatical inflections, both regular and irregular. The test was discontinued if a child had four consecutive incorrect answers or refusals. The following is an example of the sentences used to test grammatical knowledge (see Appendix 1 for the complete task):

Here is a picture of a man

Here is a picture of three _____.

This boy likes to climb.

Yesterday this is the rock that he _____.

This girl likes to paint.

Here she is _____.

Measures of Free Writing

This task was adapted from a study by Bourke and Adams (2010). The children, within their class groups, were asked to write on the topic *'What I would like to do at the weekend'*, in order to examine the children's orthographic knowledge, language structure, vocabulary, spelling and motor function (handwriting).

Motivation to Write

The procedure used to assess children's motivation to write was a self-reported degree of liking to write which was measured along a visual analogue scale, 0cm to 25cm, with 0 being 'really don't like to write' and 25 being 'like to write very much'.

2.1.3 Procedure

Language and memory measures

The cross-sectional study was conducted in June 2011, across 3 age groups, involving Junior Infants (n=31), Senior Infants (n=13) and First Class (n=13)

In the first week in June 2011, the participants were asked to produce a piece of free writing, within their class group, on the topic 'What I would like to do at the weekend'. The experimenter explained to the children that she would enjoy reading their stories; that it was okay to make a mistake and that if they were unsure how to write a word fully, to write what they knew. Some children asked for assistance e.g., "How do you write 'cinema'?" or "how do you spell 'park'?" On each of these occasions the researcher asked the children to write what they thought the word looked like and assured them that she would be able to read whatever they wrote because she loved reading their stories so much. The researcher walked around the room throughout the writing session encouraging the children and thanking them for writing and for working hard at their writing. In the final ten minutes of the test for Junior Infants (n=31), the researcher asked each participant what they had written and she wrote what they said at the end of their story page. The rationale for doing this was to acknowledge the children's ability to create stories even though their writing was in some instances partially legible or illegible.

The remaining tests were administered, individually, in a quiet room in the school, for a single session of approximately twenty to twenty five minutes. In the letter names and sounds task, the children were presented with a series of 26 cards, containing all lowercase letters, in random order and asked "what is the name of this letter?" The child was not given any prompts and where there was a failure to respond

the tester moved on to the next letter after 10s, approximately. Testing was discontinued after four consecutive mistakes or refusals to name the letter. A record was made of correct and incorrect answers and one point was awarded for each correct answer out of a possible total of 26. On completion of the letter name test, the children were shown the same letter cards plus four cards with the blends , *br, sl, cl, dr,* and four cards with the digraphs, *th, sh, ch* and *ph*, (a total of 34 cards), in random order. This time they were asked "what sound does this letter make?" They were given approximately 10s to answer, without a prompt, and testing was discontinued after four consecutive mistakes or refusals to give the letter sound. One point was awarded for each sound correctly made, out of a possible total of 34 points. Raw scores are reported.

When the letter sounds test was completed, children completed the working and short term memory tests of the AWMA, the Digit Recall task, the Listening Recall/Processing test, the Dot Martrix and the Spatial Span task (Alloway et al., 2007). The visual and/or aural instructions for the practice trials and tests were presented on the computer screen as part of the AWMA program. The researcher recorded each participant's response using the right arrow key on the keyboard if the response was correct and the left arrow key for an incorrect response. The computer program automatically awarded a score of 1 for each correct answer. If a child responded correctly to the first four trials within a block of trials, the program automatically moved on to the next block, awarding credit for the trials that were not administered. If a participant made three or more errors within a block of trials the program automatically stopped and returned to the main menu. The child was credited with a point for each item correctly answered up to the time at which testing ceased.

On completion of the short-term and working memory tests each child was tested, individually, on the morphological generation task. The researcher explained this test in the following way: "I am going to show you picture pairs. I will tell you what is in the first picture in each pair and when I show you the second picture of each pair, I want you to finish the sentence for me." The participant was shown the first picture card and the researcher said "Here is a banana." The researcher then showed the second card in the pair and said "Here are 3 _____?" The child was required to respond with 'bananas' and one mark was awarded for each correct answer, out of a possible total of 24 marks. The task continued in this manner until all 24 pairs of picture cards were completed. All participants finished this task.

Measures of Free Writing

The children, within their class groups, at a separate time-point within the same week of language and working memory testing, were asked to write on the topic *'What I would like to do at the weekend'***.** The title was provided verbally and the participants were given twenty to thirty minutes to complete their stories. The children were encouraged to write from their own knowledge and assured that everything they wrote including possible mistakes was acceptable. They were not assisted in any manner other than with encouragement. When the children signalled that they had completed their stories, the writing samples were collected by the researcher and the children were thanked. When the children in group one (n=31) indicated that they had finished their stories, they were asked by the researcher what they had written or what they intended to write. This was done because it was sometimes difficult to decipher the words, sentences or sentiments in the stories written by the children in Junior Infants. A note was made of this at the end of the child's story page.

All compositions were examined and a record was made of the presence and number of the following elements in each story: letters made; correct letter orientation; message conveyed; words; sentences; correct spellings; phonological errors; orthographic errors; other errors; unknown words; verbs; tenses; connectives; full stops; letter strings; disconnected letters; disconnected numbers; level of detail; originality; and relevance, that is the extent to which the story was linked to the title. Account was taken of the different age and class groups in awarding marks for detail, originality and relevance to the title.

Samples of free writing were measured according to the extent to which each story was original (3 marks), detailed (4 marks) and linked to the title (3 marks). A sample of 30% of the children's writing was independently assessed by a second-rater. The independent assessor read the stories given to her and assessed them according to the criteria set out above. The marks awarded by the second rater were then compared to the marks given by the experimenter for the six texts and there was 100% agreement.

Motivation to Write

The final task administered, individually, was the motivation to write exercise. Each participant was asked if she/he liked the task of writing and of writing stories. They were shown a picture of a ‘stick’ girl/boy (according to whether a girl or boy was being asked) and a smiley face at the right end of a 25cm analogue line, a neutral face in the middle and stick girl/boy and an unhappy face at the left end of the line. The smiley face depicted the child’s enthusiasm for writing, the neutral face represented the extent to which the participant was neither highly motivated nor uninterested in writing and the unhappy face provided an expression of the child’s dislike for writing. While being shown the picture of the continuum, the examiner pointed to the smiley

face on the right and said ‘this girl/boy loves to write’. Then the researcher moved her hand slowly left along the line saying ‘likes to write, it’s okay, not so much,’ and when her hand reached the unhappy face, said ‘really don’t like writing’. Then she asked the participant to point to the position on the line that showed how much they liked or did not like to write. The researcher put a small mark on the point of the continuum shown by the child and the task was measured with a ruler and marked between 0 and 25, 0 being ‘really don’t like writing’ and 25 being ‘love to write’.

This exercise completed the individual testing. The participant was thanked for answering all the questions and asked if they would like to play with a toy for a while before returning to class. All participants accepted this option and while playing, talked to the researcher. The child was then walked back to her/his classroom.

2.2 Longitudinal study

2.2.1 Participants

Thirty Irish, English speaking, children took part in the longitudinal study, with testing at four time points. This was the same group of children, less one child, who had taken part in the cross-sectional study. (One child was excluded having left the school after time one.) The children, 18 girls and 12 boys, aged 4/5 years, were attending Junior Infants, in two town schools in the South of Ireland. The participants (mean age = 66.29 months) were in term three in Junior Infants in three different classrooms at Time 1 of testing. At Time 2 of testing the children were in term one of Senior Infants (mean age =70.93). At Time 3 of testing the participants were in term three of Senior Infants (mean age = 77.1). At Time 4 of testing the children were in term two of First Class (mean age = 85.77). Only those children with no documented

sensory, physical or intellectual impairments, as ascertained from school records, were recruited for the study. All the children participating in the study had English as a first language.

2.2.2 Materials

The tests administered are as outlined in Section 2.1, as the same tests were used for both the cross-sectional and longitudinal studies.

2.2.3 Procedure

Testing for Time 1 of the longitudinal study was conducted in June 2011, with three Junior Infants groups (n=30). This was followed with testing the same group of children at Time 2 when they were in term one of Senior Infants, at Time 3 when the participants were in term three of Senior Infants and at Time 4 when the children were in term two of First Class.

In June 2011, when the children were in term 3 of Junior Infants they were asked to produce a piece of writing titled ‘What I would like to do at the Weekend’. The same procedure was followed as in the cross-sectional study (Section 2.1 above). In October 2011, January 2012, March 2012, and June 2012, when the children were in term two and term three of Senior Infants, the same process was repeated. In October 2012, January 2013, March 2013 and June 2013, when the children were in First Class they were asked to write again on the same topic.

The remaining tests were administered individually, in a quiet room in the school, for a single session of approximately twenty to twenty five minutes, as outlined in Section 2.1.

2.3 Ethics

Ethical approval for the study was granted by the University Ethics Committee. Written parental permission was obtained for all the children who participated in the study. The participants (children) were told that the researcher was trying to find out more about writing and how children write interesting stories. They were told that the examiner was interested in all their stories, and would be asking them some questions. The children were told that they could tell their parents or anyone at home or in school about the questions that the researcher asked. They were further told that the researcher would not be talking about them to anybody. Each of the memory tasks were explained to the children, e.g. that the tester was interested in how many numbers they recalled etc. Where a participant displayed any sign of fatigue or distress, testing was to be terminated, but this need did not arise.

At the end of each testing session the examiner talked informally to each child, thanked her/him for answering all the questions and asked if she/he had any questions. Data collected were recorded and encrypted on a file on the researcher's laptop, the identities of the participants remained confidential and the participants' names were not written on the data records or the final report.

Names and a key code were recorded in an encrypted file on the researcher's laptop, which only the researcher had access to. The key code linked responses to the working memory and language tests. The children's names or initials were written on the stories they wrote, as would occur normally in school. These were filed and stored safely.

Chapter 3 Cross sectional study: Results

3.1 Overview of the analysis

The results are presented in three sections examining: (1) children's working memory performance; (2) performance on the language tasks; and (3) performance on writing measures. In each section, differences between the three age groups are considered, and gender differences are presented. A correlational analysis exploring the interrelationships between working memory, language and writing then follows.

3.2 Working memory measures

Table 3.1 shows the age-adjusted (standardised) scores for children's working memory, which did not differ significantly across the three year groups. The AWMA is standardised and age-normed and, as was anticipated, the children in First Class did not have a different distribution of standardised working memory scores than the children in Junior or Senior Infants. Scores on the verbal and visual short-term and working memory fell within the normal range for all three age groups, with no significant differences across the three age groups. A two way analysis of variance (Gender x Class group) was conducted for each of the measures. There was no significant difference between performance of boys and girls in any of the short-term and working memory tasks (all $p>.16$), nor were there any interaction effects between gender and age group (all $p>.16$).

	Verbal short-term memory		Verbal working memory				Visuo-spatial short-term memory		Visuo-spatial working memory			
Groups	Digit recall		Listening recall		List. recall processing		Dot matrix		Spatial recall		Spatial recall processing	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Junior Infants	100.92	14.48	105.68	15.69	105.85	15.81	104.85	13.24	115.92	23.48	120.46	24.42
(n=31)	106.78	16.48	99.17	14.44	99.78	11.77	98.39	13.08	105.94	15.44	102.89	17.57
Boy												
Girl	104.32	15.69	101.90	15.18	102.32	13.70	101.10	13.33	110.13	19.51	110.26	22.16
Total												
Senior Infants	113.83	6.31	101.67	16.02	104.65	19.13	118.67	13.40	106.80	14.20	109.17	19.13
(n=13)	104.43	16.42	88.43	24.21	99.26	12.88	102.86	8.49	107.56	15.06	106.86	20.51
Boy												
Girl	108.77	13.24	94.54	21.14	101.75	15.59	110.15	13.35	107.21	14.15	107.92	19.08
Total												
First Class												
(n=13)	109.58	12.76	97.89	6.92	96.60	11.87	102.20	15.48	111.60	9.37	106.40	4.04
Boy	103.88	15.92	105.11	10.64	99.63	13.09	107.50	17.39	112.38	17.40	110.00	16.28
Girl												
	106.07	14.51	102.37	9.75	98.46	12.21	105.46	16.23	112.08	14.35	108.62	12.78
Total												

Table 3.1 Accuracy and standard deviations for four measures of working memory and two measures of short-term memory

3.3 Language measures

The language measures consisted of letter names, letter sounds and grammar. Letter names were measured as the number of letters correctly named out of a total of 26. Letter sounds were measured as the number of individual letter sounds, blends and digraphs correctly identified out of a total of 34. Grammar was measured by the number of correctly given regular and irregular plurals, tenses and grammatical inflections out of a total of 24.

Table 3.2 show the means and standard deviations for the language measures. Children in Junior Infants knew significantly fewer letter names (M =19.87; SD =7.8) than both children in Senior Infants (M= 26; SD=0) and First Class (M=26; SD=0), $F(2,57)=6.9$, $p=.002$. Letter names had been acquired by all pupils by Senior Infants.

Children in Junior Infants knew fewer letter sounds (M=21.90; SD=6.42) than children in Senior (M=30.77; SD=2.48) and First Class (M=31.92; SD=3.09), $F(2,57)=22.91$, $p<.001$. Post-hoc tests (LSD and Bonferroni) showed differences between Junior Infants and Senior Infants and between Junior Infants and First Class at $p<.001$ but there was no difference between Senior Infants and First Class.

Children in Junior Infants performed significantly more poorly on the grammar task than children in the other two groups (Junior Infants, M= 14.68, SD= 3.10; Senior Infants, M= 18.77; SD=2.74; First Class M=20.54, SD=2.60), $F=(2,57)=20.45$, $p<.001$. Post-hoc testing (LSD and Bonferroni) showed differences between Junior Infants and Senior Infants and between Junior Infants and First class at $p<.001$ but there was no difference between Senior Infants and First class.

There was no significant difference between boys and girls in performance on letter names, sounds and grammar.

Table 3.2 Mean accuracy and standard deviation for letter names, letter sounds and grammar knowledge as a function of class group and gender

Groups	Letter names (max.26)		Letter sounds (max.34)		Grammar (max.24)	
	Mean	SD	Mean	SD	Mean	SD
Junior Infants						
Boy	22.15	4.51	21.31	7.12	14.31	1.93
Girl	18.22	9.30	22.33	6.05	14.94	3.77
Total	19.87	7.81	21.90	6.42	14.68	3.10
Senior Infants						
Boy	26	-	31.67	1,82	19.50	2.74
Girl	26	-	30.00	2.83	18.14	2.80
Total	26	-	30.77	2.48	18.77	2.74
First class						
Boy	26	-	32.20	3.49	20.20	1.92
Girl	26	-	31.75	3.06	20.75	3.06
Total	26	-	31.92	3.09	20.54	2.60

These data show that the children had acquired all letter names and a majority of sounds, as well as the basic grammatical inflections used in writing, by Senior Infants, with performance at 100%, 94%, and 85% for the three tasks, respectively.

3.4 Writing measures

The writing measures were based on the children's written responses to the free-writing task on the topic 'What I would like to do at the weekend'. Measures taken on the writing task included: the total number of words and sentences written; the number of phonological and orthographic errors; the number of verbs, tenses, connectives and full stops; the proportion of correct spelling and the rating given for originality (score out of a total of 3), detail (score out of a total of 4) and relevance (score out of a total of 3). The child's self-reported liking of writing was also estimated along a visual analogue scale.

Table 3.3 shows that the number of words written was significantly greater for children in First Class (M=59.77, SD= 39.78) compared to those in Senior Infants (M= 30.92, SD=12.78) and Junior Infants (M=2.81, SD=2.20), $F(2,57)=35.49$, $p<.001$. A small number of children (7%) were unable to write any words, and therefore there was no score for correct spellings in these cases. The difference in the percentage of correctly spelled words in samples of free writing produced by the children in Junior Infants (M= 71.98, SD=34.44) Senior Infants (M= 82.38, SD=12.83) and First Class (M= 91.51, SD= 3.78) did not reach statistical significance however, $F(2,53)=2.78$, $p=.07$. The proportion of correct spelling must be considered taking into account the lower number of words produced by the Junior Infants and the larger standard deviation in this group (see Table 3.3).

The children's free writing was assessed for level of originality, detail and relevance, that is the extent to which the writing was linked to the title given to the children (see Chapter 2 for methodology). The rating for writing, under the categories of level of detail, originality and relevance, was given in the knowledge of the child's

age and class. The scores given reflect the increased expectations of the assessors at each class level.

The originality in the children's writing was judged to be greater in First Class (M=2.15, SD=.69) than in Senior Infants (M=1.77, SD=.73) and Junior Infants (M=.68, SD=.70). This difference was statistically significant, $F(2,57)=23$, $p < .001$. Post hoc tests show a statistical difference, at < .001, between Juniors and Seniors and between Juniors and First Class, but not between Seniors and First Class.

There was less detail in the children's writing in Junior Infants (M=1.06, SD=.36) than in Senior Infants (M=1.92, SD= .86) and First Class (M=2.92, SD= 1.12). The difference was statistically significant, $F(2,57)=28.73$, $p<.001$. Post hoc tests reveal that the difference was significant at <.001 between Juniors, Seniors and First class, showing that detail increased from Junior, to Senior to First Class.

Ratings for relevance (story linked to title) showed that the children's writing in Junior Infants was less linked to the title of the story (M=.45, SD=.93) than the children in both Senior Infants (M= 1.54, SD=1.2) and First Class (M= 2.46, SD=.78). The difference was statistically significant $F(2,57)=21.87$, $p <.001$ Post hoc tests show a statistical difference between Juniors and Seniors and between Juniors and First Class, at <.001, but not between Senior Infants and First class.

Table 3.3 Mean and standard deviation scores for the number of words, percentage of correct spelling and the extent of originality, detail and relevance contained in individual samples of free writing.

Groups	No. of words		% Correct sp.		Originality		Relevance		Detailed	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Junior Infants										
Boy	2.46	2.47	67.17	35.95	.54	.66	.46	.88	1.43	.44
Girl	3.06	2.01	74.80	24.32	.78	.73	.44	.98	.94	.24
Total	2.81	2.19	71.98	34.44	.68	.70	.45	.93	1.06	.36
Senior Infants										
Boy	26.67	6.02	81.91	9.83	1.83	.98	2.17	1.33	1.67	.82
Girl	34.57	16.21	82.78	15.76	1.71	.49	1.00	.82	2.14	.90
Total	30.92	12.77	82.38	12.83	1.77	.73	1.54	1.20	1.92	.86
First Class										
Boy	50.60	24.72	94.32	2.65	2.00	.71	2.60	.55	2.80	1.30
Girl	65.50	46.61	89.75	3.35	2.25	.71	2.38	.92	3.00	1.07
Total	59.77	39.70	91.51	3.77	2.15	.69	2.46	.78	2.92	1.12

These data show that in the three years from the time the children started school to the end of First Class there was a significant growth in the number of words written and spelled correctly.

Table 3.4 shows the mean and standard deviation for two writing measures: phonological and orthographic errors. Children in Junior Infants made fewer phonological errors (M = .26; SD= .51) than both children in Senior Infants (M = 2.77; SD= 2.68) and children in First Class (M=3.38; SD= 2.60), F(2,57) = 15.96, P,<.001. There was no significant difference between Seniors and First Class. The lower errors in the Junior group must be considered in light of the lower output from

that group; as they produced fewer words, it follows that there will be fewer errors, but this does not reflect competence.

There was no significant difference in the number of orthographic errors made by children in Junior Infants (M=.42; SD=.67), in Senior Infants (M=1.23; SD= 1.64) and in First Class (M= 1.00; SD=1.41), F(2,57)=2.49, P>.001.

Table 3.4 Mean and standard deviation for the number of phonological and orthographic errors.

Groups	Phonological Errors		Orthographic Errors	
	Mean	SD	Mean	SD
Junior Infants				
Boy	.23	.44	.54	.78
Girl	.28	.58	.33	.59
Total	.26	.51	.42	.67
Senior Infants				
Boy	2.67	1.97	1.50	2.07
Girl	2.86	3.34	1.00	1.29
Total	2.77	2.68	1.23	1.64
First Class				
Boy	2.00	2.12	.60	.89
Girl	4.25	2.61	1.25	1.67
Total	3.38	2.60	1.00	1.41

These data show that children made more phonological and orthographic errors in First Class than in Junior Infants. When this information is put alongside the number of words (Table 3.3) and sentences (Table 3.5) that children wrote in both these classes it is evident that the errors reflect an increase in the amount of text written rather than a decrease in orthographic and phonological knowledge.

Table 3.5 shows the mean and standard deviation for the number of sentences, connectives, full stops, verbs and tenses included in children's free writing across three age groups along with a rating for how much they like to write. Sentence structure and length contribute to the accuracy and efficiency with which meaning is conveyed. The number and variety of verbs and tenses adds sophistication and meaning to what is written. For this reason the study examined the number of sentences along with the amount of full stops, connectives, verbs and tenses which reflect complexity in sentence writing. The extent to which children like to write contributes to the quality of their composition and for that reason this aspect of children's writing was also measured.

Children in Junior Infants wrote significantly fewer sentences (M=.13; SD=.34) than children in Senior Infants (M=4.77; SD=1.96) and children in First Class (M=5.69;SD=5.05) $F(2,57)$, $P<.001$. There was no significant difference between Senior Infants and First Class. The average score for the number of connectives used differed significantly between Junior Infants (M= .00) and First Class (M= 1.15; SD= 1.28) $p< .001$ and between Seniors (M=.23; SD=.60), $F(2,57)=11.94$ $p<.001$, and First but not between Juniors and Seniors.

Children in Junior Infants included significantly fewer full stops in their free writing (M=.03; SD=.18) than children in Senior Infants (M=3.38; SD =2.29) and children in First Class (M=6.23; SD=5.37), $F(2,57)=22.39$, $P<.001$. There was no difference between Senior Infants and First Class.

The average score for the number of verbs written differed significantly between Junior Infants (M= .23; SD= .43), Senior Infants (M=5.59; SD= 2.25) and

First Class (M= 8.46; SD= 5.77), F(2,57)=37.47, P<.001, reflecting the increased output with age. There was no significant difference between Seniors and First Class.

The average score for the number of tenses used also differed significantly between Junior Infants (M= .23; SD= .44), Senior Infants (M= 1.85; SD= .80) and First class (M= 1.77; SD= .6), F(2,57)=50.59, P<.001, with no significant difference between Seniors and First Class.

These data, which link with the data on grammatical inflections (Table 3.2), show that children have acquired knowledge on verbs and tenses that enable them to write a story by the time they have reached their second year of formal education.

The average score for children's liking of writing was consistent across the three age groups (Junior Infants M=18.95, SD= 7.71; Senior Infants M= 21.04, SD= 7.45; First class M=17.46, SD= 8.07), F92,57)=.87, P =.4, with most children giving positive ratings of writing. Seventy eight per cent of girls in Junior Infants expressed a liking (marked after the half-way point on the analogue scale) for writing compared with 85% of boys in the same year group. One hundred per cent of girls in Senior Infants indicated that they liked writing a lot while the percentage of boys in Senior Infants dropped to 67%. One hundred per cent of girls in First Class indicated a strong liking for writing while the boys' liking of writing had dropped to 50% by year 3 in school.

Table 3.5 Mean and standard deviation for the number of sentences, connectives, full stops, verbs and tenses in the children's free writing and the extent to which children like writing

Groups	Sentences		Connectives		Full stops		Verbs		Tenses		Liking of writing	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Junior Infants												
Boy	.15	.38	.00	-	.08	.28	.23	.44	.23	.44	18.04	7.11
Girl	.11	.32	.00	-	.00	.00	.22	.43	.22	.43	19.61	8.25
Total	.13	.34	.00	-	.03	.18	.23	.43	.23	.43	18.59	7.71
Senior Infants												
Boy	3.67	1.37	.50	.84	2.33	1.86	5.17	2.23	1.83	.98	17.42	9.89
Girl	5.71	1.98	.00	.00	4.29	2.36	6.14	2.34	1.86	.69	24.14	2.27
Total	4.77	1.96	.23	.60	3.38	2.29	5.69	2.25	1.85	.80	21.04	7.45
First Class												
Boy	4.20	3.56	.80	.84	4.40	4.04	8.20	4.66	1.80	.84	13.80	6.91
Girl	6.63	5.83	1.38	1.51	7.38	6.00	8.63	6.68	1.75	.46	19.75	8.29
Total	5.69	5.06	1.15	1.28	6.23	5.36	8.46	5.77	1.77	.60	17.46	8.07

These data demonstrate the emergence of complexity in children's writing, with significant development of ability between Junior Infants and subsequent years. This may be linked to the data shown on Table 3.2 which show that children have acquired knowledge of letter names, sounds and grammatical inflections by Senior Infants and there is not a further significant growth in this knowledge by the time the children reach the end of First Class. Given these age-related differences, we might expect to see differences in relationships between the variables, by age group, the analysis of which we turn to next.

3.5 Relationships between measures in Junior Infants

Table 3.6 shows a number of small positive, statistically significant correlations between working memory and writing in Junior Infants. However, all are at the .05 level and are eliminated by Bonferroni correction. There is a significant correlation at, $r=.38$, $p<.05$, between the number of orthographic errors children made and their ability to recall and process spatial information.

Children's ability to create detail and link their story content to the title correlated at a significant level with their ability to listen, recall and process information. Listening recall and processing measures children's verbal working memory and their ability to listen, retain and manipulate the information they have heard and then produce answers or create a story based on what they have listened to. The children in Junior Infant who were able to listen and manipulate the content that they heard wrote more detailed stories linked to the title of the story given to them verbally.

Table 3.6 Correlations between working memory and writing in Junior Infants

	Digit recall	List.recall	List. recall processing	Dot matrix	Spatial recall	Spatial recall proc.
#Words	.11	.17	.00	.22	.13	-.00
#Sentences	.09	.30	.09	.22	.17	.22
#Correct sp.	-.07	.13	.01	.18	.06	-.09
Phon. errors	.32	-.02	-.07	.06	-.10	-.14
Orth. Errors	.33	.30	.04	.14	.32	.38*
Verbs	.06	-.01	-.16	.18	-.02	-.03
Tenses	.06	-.01	-.16	.17	-.01	-.03
Connectives	a	a	a	a	a	a
Full stops	.15	.14	.06	.15	.28	.32
Writing pref.	-.05	.21	.11	.27	-.20	-.26
Original	.03	.18	.19	.37*	-.05	-.13
Linked to title	.41*	.35	.43*	.25	-.17	-.19
Detailed	.07	.38*	.42*	.28	.07	.11
% Correct sp.	-.36	.01	-.06	-.00	-.17	-.23

*Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 3.7 shows that there is a correlation between the number of orthographic errors children made and their knowledge of letter names suggesting that children's letter recognition assists them in their writing. There is a correlation between children's phonological errors and their knowledge of grammar. There is also a correlation between children's ability to link their story to the title and their knowledge of grammar.

Table 3.8 shows that children's digit recall score is linked to children's knowledge of letter names and grammar, and is consistent with the suggestion that

children's ability to learn letters and grammar is enhanced by their short-term memory.

Table 3.7 Language and writing in Junior Infants

	Letter names	Letter sounds	Grammar
#Words	.05	.11	-.10
#Sentences	-.01	.19	.20
#Correct sp.	-.14	-.03	-.32
Phon. errors	.30	.22	.41*
Orth. Errors	.37*	.27	.34
Verbs	.13	.20	.08
Tenses	.13	.20	.08
Connectives	a	a	a
Full stops	.15	.18	.20
Writing pref.	-.13	-.07	-.09
Original	-.04	-.04	.06
Linked to title	.21	.20	.45*
Detailed	.05	.05	.05
% Correct sp.	-.32	-.20	-.37

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Table 3.8 Working memory and language in Junior Infants

	Digit recall	List.recall	List. recall processing	Dot matrix	Spatial recall	Spatial recall proc.
Letter names	.45*	.15	.12	.14	.05	.14
Letter sounds	.35	.06	.05	.08	.21	.22
Grammar	.38*	.23	.16	.08	.01	.05

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

3.6 Relationships between measures in Senior Infants

Tables 3.9, 3.10 and 3.11 show a number of correlations between writing, language and working memory in the Senior Infants group. The small group size must be considered here, however. Table 3.9 shows the correlations between working memory and writing in Senior Infants. The score for the listening recall test correlates negatively with the number of phonological errors while the scores for the listening recall processing test correlate positively with the number of orthographic errors made in the children's free writing samples. These data suggest that as writing becomes more complex verbal short term memory plays an increasingly important role.

Table 3.9 Correlations between working memory and the writing measures in the Senior Infants group

	Digit recall	List. recall	List. recall processing	Dot matrix	Spatial recall	Spatial recall proc.
#Words	-.19	-.47	-.32	.07	.16	.12
#Sentences	.06	-.16	.20	-.15	.02	.02
#Correct sp.	-.18	-.34	-.34	.08	.27	.21
Phon. errors	-.06	-.76**	-.22	-.07	-.39	-.32
Orth. Errors	.08	.20	.58*	.15	-.31	-.23
Verbs	.25	-.04	.31	.33	.19	.21
Tenses	-.19	-.31	-.38	.05	.14	.01
Connectives	.10	-.26	-.48	.40	-.07	.06
Full stops	-.11	-.14	.34	-.18	-.18	-.25
Writing pref.	-.12	.01	.25	.10	.06	-.05
Original	.40	.31	.35	.11	.27	.30
Linked to title	.41	.12	-.17	.41	.25	.35
Detailed	.26	.11	.35	-.30	-.10	-.09
% Correct sp.	.20	.14	-.10	.32	.37	.32

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Table 3.10 shows a negative correlation between children's knowledge of letter sounds and the amount of detail that they put into their stories. In Senior Infants there is a strong focus on learning letter sounds. Their writing experience is greater than that of Junior Infants but still limited and they may be attempting to apply their

knowledge of phonology to their written work instead of writing a detailed story. No other correlations are apparent however.

Table 3.10 Language and writing in Senior Infants

	Letter names	Letter sounds	Grammar
#Words	a	.29	-.35
#Sentences	a	-.13	.02
#Correct sp.	a	.38	-.31
Phon. errors	a	-.35	-.37
Orth. Errors	a	-.23	.31
Verbs	a	.12	.10
Tenses	a	.27	-.09
Connectives	a	.21	-.12
Full stops	a	-.39	.40
Writing pref.	a	-.00	.19
Original	a	.15	.26
Linked to title	a	.21	-.11
Detailed	a	-.63*	.38
% Correct sp.	a	.55	.06

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 3.11 shows a correlation between children's knowledge of grammar and their listening recall and processing scores, with a strong positive relationship between

listening processing recall and grammar knowledge in particular, r=.67, p<.01. As letter names are known by Senior Infants, no correlations were computed for that variable.

Table 3.11 Working memory and language in Senior Infants

	Digit recall	List.recall	List. recall processing	Dot matrix	Spatial recall	Spatial recall proc.
Letter names	a	a	a	a	a	a
Letter sounds	.08	.13	.40	.25	.21	.13
Grammar	.31	.64*	.69**	.26	.08	.00

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

3.7 Relationships between measures in First Class

Table 3.12 shows the correlations between working memory and writing in First Class. Again, the small sample size must be considered here. These data show a significant relationship between digit recall and the percentage of correct spelling, r=.57, p<.01. Digit recall is a test of verbal short-term memory and these results suggest that verbal short-term memory supports accuracy in spelling. The negative correlation of digit recall with writing preference is skewed by the large number of high writing preference ratings in the First Class group.

Table 3.12 Working memory and writing in First class

	Digit recall	List.recall	List. recall processing	Dot matrix	Spatial recall	Spatial recall proc.
#Words	.31	.14	.18	.31	-.11	-.06
#Sentences	.28	.15	.11	.39	.02	.09
#Correct sp.	.32	.13	.18	.30	-.12	-.06
Phon. errors	.18	.25	.18	.33	-.12	-.15
Orth. Errors	-.29	-.01	-.10	-.34	.42	.35
Verbs	.21	.24	.34	.03	.10	.03
Tenses	.04	-.23	-.34	.04	.05	.35
Connectives	.14	.02	-.05	-.28	.06	.23
Full stops	.46	.25	.25	.40	-.04	.09
Writing pref.	-.59*	-.27	-.47	-.38	-.02	-.22
Original	.47	.50	.42	.36	.12	.20
Linked to title	.20	.16	.05	-.16	.06	-.03
Detailed	.38	.24	.35	.10	-.12	-.07
% Correct sp.	.57*	.02	.24	.08	-.02	.05

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 3.13 provides scores on the correlation between language and writing in First Class. The results show that there is a significant relationship between children's knowledge of letter sounds and the originality of their stories and proportion of correct spelling in their writing. Table 3.2 shows that letter sounds are predominantly learned by Senior Infants. However Table 3.10 shows that there is no significant correlation between letter sounds and originality or percentage of correct spelling in the Senior Infants group. These data suggest that as the children gain experience in the application of letter sounds to writing it assists them in both originality and spelling.

Table 13.13 Language and writing in First Class

	Letter names	Letter sounds	Grammar
#Words	a	.37	.22
#Sentences	a	.26	.32
#Correct sp.	a	.39	.21
Phon. errors	a	.05	.21
Orth. Errors	a	.04	.18
Verbs	a	.45	.17
Tenses	a	-.10	.19
Connectives	a	.40	.25
Full stops	a	.46	.36
Writing pref.	a	-.40	-.32
Original	a	.55*	.14
Linked to title	a	.36	-.05
Detailed	a	.53	.27
% Correct sp.	a	.60*	.14

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table 3.14 shows the correlation between working memory and language in First Class. The results show a significant relationship between digit recall and children's knowledge of letter sounds and grammar suggesting that these language measures are supported by verbal short-term memory. These data also show a significant correlation between spatial recall processing and letter sounds and grammar which suggests that these language measures are further supported by visual working memory.

Table 3.14 Working memory and language in First class

	Digit recall	List.recall	List. recall processing	Dot matrix	Spatial recall	Spatial recall proc.
Letter names	a	a	a	a	a	a
Letter sounds	.61*	.35	.33	.01	.17	.46*
Grammar	.70**	.33	.24	.23	.42	.74**

*Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Overall the results suggest changing relationships between working memory, language and writing from the Junior Infant stage through to First Class. However, the group sizes here are quite small, and differences may reflect a cohort effect. The longitudinal study, presented in Chapter 4, will provide a more robust assessment of the relationships between these variables. A key question that is posed for the longitudinal study is 'does working memory and/ or language at Junior Infant level predict writing performance in First Class?'

Chapter 4 Longitudinal study: Results

4.1 Overview of analysis

Testing occurred four times over a three year period for the same group of children (n=30). At Time 1, the children were in term three of Junior Infants and were beginning to learn to read and write (see Chapter 3). At Time 2 the children were in term one of Senior Infants, at Time 3 they were in term three of Senior Infants and at Time 4 the children were in term two of First Class.

The results are presented in four sections: (1) the children's working memory performance; (2) performance on language tasks; (3) performance on writing measures; (4) correlations between measures at Time 4 and between measures at Time 1 and Time 4. Descriptive and inferential statistics are considered and gender differences are explored. A correlational analysis of the interrelationships between working memory, language, motivation and writing across the three age groups and class levels then follows.

4.2 Working memory measures

Table 4.1 shows the standardised scores for children's working memory remained within the normal range across the time points. As shown in Table 4.1 the average digit recall score measuring short-term verbal memory differed slightly over the four times of testing (Time 1, M=104.80, SD=15.73; Time 2, M=105.83, SD=13.93; Time 3, M=104.16, SD=14.67; Time 4, M=101.16, SD=16.35), $F(3,87)=2.91$, $p= .039$, but remained within the normal range. Listening recall measures verbal working memory and the average standardised score for this measure was consistent across the four test times (Time 1, M=101.53, SD=15.19; Time 2,

M=104.60, SD=15.10; Time 3, M=98.70, SD=14.18; Time 4, M=98.93, SD=11.18), F(3,87)=1.48, p=.225.

The average standardised score for listening recall processing, a measure of verbal working memory, was also consistent across the four times of testing, with small differences within the normal range (Time 1, M=101.83, SD=13.66; Time 2, M=107.20, SD=14.52; Time 3, M=100.32, SD=13.19; Time 4, M=98.13, SD=12.41), F(3,87)=3.342, p=.023.

Dot matrix is a measure of short term visual memory and the average standardised score in this measure, over the four test times, did not differ significantly (Time 1, M=101.20, SD=13.54; Time 2, M=103.73, SD=11.22; Time 3, M=100.43, SD=14.62; Time 4, M=101.17, SD=13.87), F(3,87)=.647, p=.587.

Spatial recall, which is a measure of visual working memory, was less consistent across the four test times (Time 1, M=109.60, SD=19.62; Time 2, M=106.63, SD=13.19; Time 3, M=101.10, SD=11.90; Time 4, M=97.70, SD=15.14), F(3,87)=6.5, p=.002, but scores remained within the normal range.

The average score for spatial recall processing, which is a measure of visual working memory, differed significantly over the four testing times (Time 1, M=109.63, SD=22.26; Time 2, M=103.67, SD=14.28; Time 3, M=98.37, SD=12.40; Time 4, M=95.13, SD=12.67), F(3,87)=8.33, p<.001, but again scores remained within the normal range.

Table 4.1 Mean accuracy and standard deviations for four measures of working memory and two measures of short-term memory for a group of children while in Junior Infants, Senior Infants and First Class (n=30)

	Verbal short-term memory		Verbal working memory				Visuo-spatial short-term memory		Visuo-spatial working memory			
Groups/time	Digit recall		Listening recall		Listening recall processing		Dot matrix		Spatial recall		Spatial recall processing	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Junior Infants Time 1	104.80	15.73	101.53	15.19	101.83	13.66	101.20	13.54	109.60	19.62	109.63	22.26
Senior Infants Time 2	105.83	13.93	104.60	15.10	107.20	14.52	103.73	11.22	106.63	13.19	103.67	14.28
Senior Infants Time 3	104.16	14.67	98.70	14.18	100.32	13.19	100.43	14.62	101.10	11.90	98.37	12.40
First Class Time 4	101.16	16.35	98.93	11.18	98.13	12.41	101.17	13.85	97.70	15.14	95.13	12.67

4.3 Language measures

The language measures consisted of letter names out of a total of 26, letter sounds including individual letters, blends and digraphs out of a total of 34 and grammatical inflections out of a total of 24.

Table 4.2 show the means and standard deviations for the language measures. At Time 1, term three of Junior Infants, the children knew significantly fewer letter names (M=20.07, SD=7.87) than when they had reached term two in First Class (M=25.90, SD=.40), $F(3,87)=11.29$, $p<.001$. However the largest growth in knowledge of letter names occurred between Time 1 and Time 3 (M=24.30, SD=2.74), $F(2,58)=8.51$, $p<.001$.

There was a significant increase in children's knowledge of letter sounds between Time 1 (M=22.53, SD=5.48) and Time 4 (M=30.30, SD=3.88), $F(3,87)=44.45$, $p<.001$ with the biggest change occurring between Time 1 and Time 3 (M=27.13, SD=4.24), $F(2,58)=21.99$, $p<.001$.

The children at Time 1 performed significantly more poorly on the test of grammatical inflections (M=14.73, SD=3.14) than at Time 4 (M=20.73, SD=2.56), $F(3,87)=58.51$, $p<.001$.The largest growth in children's grammatical knowledge occurred between Time 1 and Time 3 (18.73, SD=2.15), $F(2,58)=40.83$, $p<.001$.

Table 4.2 Mean accuracy with standard deviation for letter names, letter sounds and grammatical inflections as a function of time of testing

Time	Letter names (max 26)		Letter sounds (max 34)		Grammatical inflections (max 24)	
	Mean	SD	Mean	SD	Mean	SD
Time 1	20.07	7.87	22.53	5.48	14.73	3.14
Time 2	22.10	7.11	22.90	6.92	16.83	3.06
Time 3	24.30	2.74	27.13	4.24	18.73	2.15
Time 4	25.90	.40	30.30	3.88	20.73	2.56

These data show that children had acquired almost all letter names and a majority of sounds, as well as the basic grammatical inflections used in writing, by the end of Senior Infants, with performance at 93%, 79% and 78% respectively.

4.4 Writing measures

The children produced four samples of free writing between term three in Junior Infants and term three in First Class and the following measures were assessed: number of words, sentences, verbs, tenses, correct spelling, full stops, orthographic errors, phonological errors, originality, detail and relevance to the title of the story (see Section 3.4).

Table 4.3 shows that the number of words written by the children at Time 1 (M=2.90, SD=.41) was significantly less than that written at Time 4 (M=33.40, SD=2.85), $F(3,87)=.70$, $p<.001$. The percentage of correct spelling in Junior Infants (Time 1) is high (M=74.74, SD=31.92) because the children wrote very few words and the words written included their names and words that they knew. There is a significant increase in the number of words written and the number of words correctly spelled by the time the children reached First Class (M=84.83, SD=10.48), $F(3,75)=6.06$, $p=.003$.

The rated degree of originality in the children's writing was judged to be lower at Time 1 (M=.70, SD=.70) than at Time 4 (M=2.07, SD=.64), F(3,87)=21.55, p<.001 and the extent to which the children linked the content of their story to the given title differed significantly between Time 1 (M=.47, SD=.94) and Time 4 (M=1.93, SD=1.05), F(3,88)=17.83, p<.001. The children's free writing was judged to have less detail at Time 2 (M=.93, SD=.87) and Time 1 (M=1.07, SD=.37), compared to Time 3 (M=1.43, SD=.94) and Time 4 (M=2.03, SD=.89), F(3,87)=14.14, p<.001.

Table 4.3 Mean and Standard Deviation scores for the number of words, % of correct spelling, level of originality, relevance and detail contained in individual samples of free writing

Time	No. of words		% correct spelling		Originality		Linked to title		Detail	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Time 1	2.90	.40	74.74	31.92	.70	.70	.47	.94	1.07	.37
Time 2	5.70	1.44	57.60	39.41	1.13	1.04	.43	.86	.93	.87
Time 3	14.11	1.93	56.60	23.30	1.67	.92	1.27	1.36	1.43	.94
Time 4	33.40	2.85	84.83	10.48	2.07	.64	1.93	1.05	2.03	.89

Table 4.4 shows that the number of sentences written at time one (M=.13, SD=.35) was significantly less than at time four (M=4.13, SD=2.73), F(3,87)=39.65, p<.001. The use of connectives and full stops as well as the number of verbs and tenses that were included in free writing demonstrate a greater level of writing ability. The average score for these elements of writing differed significantly between Time 1 and Time 4 (connectives, Time 1, M=0, SD=.83; Time 4, M=.90, SD=1.24, F(3,87)=6.67, p=.003; full stops, Time 1, M=.03, SD=.18; Time 4, M=2.10, SD=2.22, F(3,87)=21.40, p<.001; verbs, Time 1, M=.23, SD= .43;

Time 4, M=5.20, SD=2.86, F(3,87)=51.22, p<.001; tenses, Time 1, M= .23, SD=.43, Time 4, M=1.63, SD=.62, F(3,87)=41.19, p<.001. Children's self-rated liking of writing did not increase significantly between Time 1 (M=18.98, SD=7.84) and Time 4 (M=20.60, SD=8.10), F(3,87)=.46, p=.71.

Table 4.5 shows the number of phonological and orthographic errors produced in children's samples of free writing at the four time points over three academic years. The children, when in Junior Infants, made fewer phonological errors (M=.27, SD=.52) than when they were in Senior Infants at Time 1 (M=1.53, SD=4.18) and at Time 3 (M=3.17, SD=2.95) and significantly fewer errors than at Time 4 when they were in First Class (M=3.57, SD=3.45), F(3,87)=8.10, p<.001.

At Time 1, the children had fewer orthographic errors (M=.07, SD=.37) than at Time 2 (M=.90, SD=1.35), Time 3 (M=1.50, SD=1.68) and Time 4 (1.20, SD=1.85), F=5.51, p=.006. The children wrote fewer words at Time 1 and their writing included their names and words displayed in the classroom. At Time 4, the children wrote more and therefore had more opportunity to make mistakes.

Table 4.4 Mean and standard deviation for the number of sentences, connections, full stops, verbs, tenses and rating of the children's liking of writing

Time	No. of sentences		No. of connections		No. of full stops		No. of verbs		No. of tenses		Children's liking of writing	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Time 1	.13	.35	0	-	.03	.18	.23	.43	.23	.43	18.98	7.84
Time 2	.53	1.2	.27	.83	.07	.25	.70	1.39	.33	.55	20.15	7.38
Time 3	1.43	1.38	.30	.70	.60	1.28	1.87	1.48	1.13	.63	20.80	8.25
Time 4	4.13	2.73	.90	1.24	2.20	2.22	5.20	2.86	1.63	.62	20.60	8.10

Table 4.5 Mean and standard deviation for the number of phonological and orthographic errors in samples of free writing

Time	No. of phonological errors		No. of orthographic errors	
	Mean	SD	Mean	SD
Time 1	.27	.52	.07	.37
Time 2	1.53	4.18	.90	1.35
Time 3	3.17	2.95	1.50	1.68
Time 4	3.57	3.45	1.20	1.85

4.5 Correlational analysis of relationships between variables at Time 4

Correlation analysis, using Spearman rank order correlation, was undertaken to examine the strength and direction of any relationships between language and writing as well as working memory and writing at Time 4. Table 4.6 shows a correlation between the children's knowledge of letter sounds and grammar at Time 4 and the rated degree of originality in their writing. However, children's performance on knowledge of letter sounds and grammar was already close to optimal at Time 4.

Table 4.6 Correlations between language and writing measures at Time 4

	Writing preference	Original	Detailed	Linked to title
Letter names	-.14	.16	.11	-.10
Letter sounds	.23	.48**	.34	.20
Grammar	-.01	.62**	.22	.29

*Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

There were no correlations between children's knowledge of language and the number of words, sentences, correct spelling, phonological and orthographic errors produced in writing samples.

Table 4.7 shows that there is a correlation between verbal working memory at Time 4 and the number of words written along with the number of phonological errors made by children at Time 4. As both of these correlations are at the .05 level their effect is eliminated by Bonferroni correction, however.

Table 4.7 Correlations between working memory measures at Time 4 and the number of words, sentences, correct spelling, phonological and orthographic errors in writing at Time 4

	Digit recall	Listening recall	Listening recall processing	Dot matrix	Spatial recall	Spatial recall processing
Words	.21	.32	.37*	.09	.10	-.18
Sentences	-.15	-.04	-.03	-.12	-.06	-.11
Correct spelling	.20	.27	.32	.07	.15	.04
Phonological errors	.17	.35	.41*	.26	-.01	-.07
Orthographic errors	-.12	.01	-.07	-.31	-.29	-.31

*Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 4.8 shows that there is a correlation at p <.01 between verbal working memory and the number of connectives children used in their writing. It was expected that children who are able to retain larger amounts of verbal memory while processing it could be expected to write more complex sentences.

Table 4.8 Correlations between working memory measures at Time 4 and the number of verbs, tenses, connections and full stops in writing at Time 4

	Digit recall	Listening recall	Listening recall processing	Dot matrix	Spatial recall	Spatial recall processing
Verbs	.06	.27	.28	.02	.04	-.01
Tenses	-.12	.10	.09	-.04	-.14	-.25
Connections	.47**	.53**	.54**	.27	.24	.21
Full stops	-.10	-.21	-.24	.11	.06	.16

*Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

The data on the compositional aspects of writing demonstrate a significant link between working memory, particularly verbal working memory, and the originality in children's writing. Table 4.9 shows correlations, at p< .01, between verbal short-term and working memory along with visual short-term memory and the originality in children's writing at Time 4. There is also a correlation between visual short-term memory and children's ability to link their story to the title that they were given, but as this is at the .05 level its effect is eliminated by Bonferroni correction.

Table 4.9 Correlations between working memory measures at Time 4 and children's liking of writing, originality, detail and relevance to the title in children's writing at Time 4

	Digit recall	Listening recall	Listening recall processing	Dot matrix	Spatial recall	Spatial recall processing
Like to write	.14	.12	.14	.15	.35	.24
Originality	.62**	.50**	.54**	.55**	.40*	.41*
Detailed	.10	.27	.29	.23	.31	.27
Linked to title	.33	.28	.33	.42*	.20	.13

*Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

It was expected that children with a good verbal or visuospatial memory would find it easier to learn how to write and would therefore show a stronger preference for writing. However this was not the case and the table shows that participants' self-rated liking of writing is not associated with working memory here.

In summary, correlational analysis of the measures at Time 4 support an association between working memory, and particularly verbal working memory, and originality of writing as rated by independent judges, but there are fewer clear relationships between

language or working memory and the more linguistic aspects of the writing produced by the children, the exception to this being connectives. There was a strong positive correlation between the verbal memory measures and the number of connectives produced by the children, suggesting that verbal working memory may support sentence complexity. However, it may also be that working memory and language at the earlier stages of development predict later writing skill.

The next stage of the analysis examined whether the earlier measures of language and working memory, at Time 1, predict later writing, at Time 4.

4.6 Correlational analyses of relationships between language measures at Time 1 and writing at Time 4

The question being asked here was: is there a relationship between children's language knowledge in Junior Infants (Time 1) and their ability to write in First Class (Time 4)? The longitudinal study was thereby examining if, over a 3 year period of time at the emergent stage of writing, language supports writing ability to a greater extent than working memory or motivation (indexed here by liking of writing).

Correlations were conducted between language measures at Time 1 and children's writing output, liking of writing, level of originality, detail and relevance in children's writing at Time 4. As can be seen in Table 4.10 there is a negative correlation between children's knowledge of letter sounds and grammar at Time 1 and the number of orthographic errors made in their writing at Time 4, that is better grammar and letter sound knowledge is associated with fewer orthographic errors. There is no such relationship for phonological errors. There are no correlations between language measures at Time 1 and the number of verbs, tenses, connectives and full stops recorded in children's writing at Time 4.

Table 4.10 shows that there is a relationship, at p< .01, between children's knowledge of letter names at Time 1 and the rated level of detail in children's stories at Time 4. There is also a correlation between children's knowledge of letter names and sounds and their ability to write in detail and with originality, but as this is at the .05 level its effect is eliminated by the Bonferroni correction. There is no association between children's language knowledge at Time 1 and their liking of writing at Time 4.

Table 4.10 Correlations between children's knowledge of letter names, sounds and grammar at Time 1 with the number of words, sentences, correct spelling, orthographic errors and phonological errors at Time 4

	Words	Sentences	Correct spelling	Orthographic errors	Phonological errors
Letter names	-.01	-.17	.07	-.32	-.21
Letter sounds	.20	-.08	.26	-.48**	-.02
Grammar	.70	.46	.89	-.39*	.13

*Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 4.11 Correlations between children's knowledge of letter names, sounds and grammar at Time 1 with originality, detail, relevance to title and writing preference at Time 4

	Originality	Detail	Linked to title	Writing preference
Letter names	.54*	.53**	.15	.18
Letter sounds	.43*	.42*	.10	.08
Grammar	.34	.04	.16	.06

*Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

4.7 Working memory measures at Time 1 and writing at Time 4

The question here was: does early working memory predict later writing ability?

There are no correlations between working memory at Time 1 and the number of words, sentences, correct spelling, phonological and orthographic errors at Time 4.

As can be seen in Table 4.12 there is a correlation between verbal short term and working memory at Time 1 and children's use of connectives and full stops in their writing at Time 4. There is also a correlation between visual-spatial working memory and children's ability to use connectives in writing. This suggests that children are capable of writing longer and more complex sentences when they have the working memory capacity to support their work.

Table 4.12 Correlations between working memory measures at Time 1 and the number of verbs, tenses, connectives and full stops in children's writing at Time 4

	Digit recall	Listening recall	Listening recall processing	Dot matrix	Spatial recall	Spatial recall processing
Verbs	.21	.25	.19	-.08	.09	.01
Tenses	-.02	.06	-.06	-.06	.05	.02
Connectives	.48**	.36*	.25	.27	.46*	.38*
Full stops	.14	.39*	.34	.15	.03	.02

*Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 4.13 shows a correlation between verbal short-term and working memory at Time 1 and the originality and detail of children's writing at Time 4. This suggests that the children

with a good working memory capacity are capable of producing more detail and creativity in their writing.

Table 4.13 Correlations between working memory measures at Time 1 and children's liking of writing, the originality, detail and relevance of their stories to the title at Time 4

	Digit recall	Listening recall	Listening recall processing	Dot matrix	Spatial recall	Spatial recall processing
Writing preference	.10	.12	.14	-.17	-.11	-.24
Original	.66**	.48**	.53**	.27	.20	.11
Detailed	.33	.41*	.39*	.07	.20	.16
Relevance	.35	.04	.27	.05	-.22	-.36

*Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

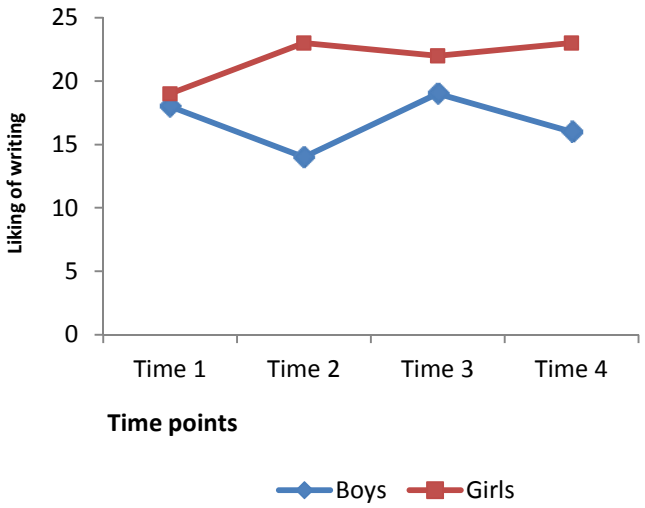
There is further evidence here that the children's writing preference does not correlate with any aspect of working memory (see also Table 4.8).

4.8 Children's liking of writing and writing measures

The graph shows children's liking of writing over the four time points, from Junior Infants to First Class. A Two Way Repeated Measures analysis of variance was conducted to examine liking of writing over the four time points as a function of gender. There was no significant difference in liking ratings nor was there any interaction effect with gender. As shown in Table 4.11, self-rated liking of writing is not linked to any aspect of working memory, nor was it associated with better performance on the language tasks (see Table 4.10). While liking of writing at times 1, 2 and 3 showed no association with later writing performance, there was a modest positive correlation between liking of writing at Time 4 and the number

of words produced during the writing task at Time 4 (r_s =.42, n=30, p=.021) and the number of correct spellings (rs=.39, n=30, p=.04), n=30.

Figure 4-1 Liking of writing over the four time points, by gender of child



4.9 Conclusion

The children's growing competence in writing is evident in the increasing performance on the language and writing measures. The results show that working memory at Time 1 is associated with rated originality in writing but also with the number of connectives and full stops that children included in their writing at Time 4. Children's early knowledge of language influenced the originality of their writing at Time 4, and the children's early language competency was associated with fewer writing errors of an orthographic type at Time 4, and also with originality at Time 4. The results suggest that both working memory and language play a key part in the development of writing, with liking of writing playing a more minor role.

Chapter 5: Discussion

5.1 Overview

The questions posed at the beginning of this study were (1) is it working memory or language that most influence emergent writing performance in young children?; and (2) what role does motivation, or liking of writing, play in children's developing writing ability? This research sought to address the relative lack of enquiry carried out on how the skill of writing is acquired separate to the acquisition of reading. The study extends previous research, which has investigated the procedures involved in writing, e.g., pencil grip, dictation of sentences, letter/word/sentence formation, letter writing from memory and phonetic attempts at spelling (Bourke, & Adams, 2003; Bourke & Adams, 2010; Hoskyn & Tzoneva, 2008). It did this by focusing on both the mechanics and the composition of writing a story i.e. the level of originality, detail and relevance to title, regarding these as two separate functions. A further extension on previous research was made by examining the influence of language measures, such as grammar and alphabetic knowledge as well as non-language related factors (i.e., motivation) on young children's early writing.

Children's working memory, knowledge of language and the extent to which they like to write were examined and the relationship between these features and writing output was explored. Working memory was found to play a key role in children's emergent writing at both structural and compositional levels. Children whose working memory was stronger wrote stories with sentences of greater complexity both in terms of sentences structures using more connectives and in terms of originality. The relationship between language and writing was found to play a lesser role, with participants' knowledge of letter sounds and grammar in

Junior Infants related to fewer orthographic errors in First Class. Children's self-rated like or dislike of writing was examined alongside their writing output. It was anticipated that children who expressed an enjoyment of writing would have a more complex structural and compositional basis to their stories. This was not found to be the case, however, with self-rated liking of writing unrelated to the performance measures.

The discussion will explore details of the findings of this research, in the context of past and current literature, in four sections: (1) emergent writing and early working memory; (2) working memory and writing composition; (3) language and writing; (4) motivation and writing. The limitations of the research and conclusion then follow.

5.2 Emergent writing and early working memory

The findings from this research provide support for the notion that writing is an intricate activity that involves complex cognitive, sensory and motor functions (Bourding & Fayol, 1994, 1996, 2002; Olive, 2004; Puranik & Apel 2010). Consistent with research conducted by Bourke and Adams (2010) it was found that children's early writing consisted mostly of scribbles and pictures that constituted meaning to the children with an average of three words written by each child at Time 1.Then progress was made to the alphabetic system that established meaning for both the writer and reader independently of each other with the average number of words written by each child rising to five at Time 2 and 14 at Time 3. The writing samples taken from the children provide evidence to support Brown's (1977) contention that children's understanding of the concept of story is clearly established by the age of 4, even though the sentences were not always linked sequentially. Writing samples, throughout the three years, contained orthographic and phonological errors and a combination of both suggesting that, in line with empirical research, and contrary to the stage approach to

writing (Ehri 1995; Gentry 1992), a multi-strategy approach (Bernstein & Treiman 2001; Nassaji, 2007; Varnhagen, 1995) was used by the participants in an effort to achieve accuracy in spelling. These findings are supported by Siegler's (1996) overlapping waves model of writing. The opaque nature of the English language may explain the need to use a multi-strategy approach to writing.

From stage one when the children were in Junior Infants, their writing demonstrated some knowledge of the orthographic structure of written English. The orthographic spelling errors that were made looked like legitimate English words but with incorrect spelling. This corresponds with findings from previous research which found that pre-school children showed an awareness of the position of graphemes within words (Bernstein & Treiman, 2001; Cassar & Treiman, 1997; Treiman & Bourassa, 2000).

A strong significant relationship was found between verbal working memory at Time 1 and the children's use of connectives in writing at Time 4. The relationship between verbal working memory and complexity in children's writing, as indexed by the use of connectives, was replicated at Time 4. A more modest association was found at this stage between visual working memory and the children's use of connectives. It was anticipated that children whose verbal and visuospatial working memory was strong would be able to write with greater intricacy than those with a poorer working memory. The findings here are supported by Yoshinaga-Itano and Downey's (1992) study, which demonstrated the importance of the use of connectives in writing a more complex story.

At Time 4, when the participants were in First Class, a significant relationship was found between verbal working memory and the number of words written and phonological errors made. While the correlation is modest, its importance is supported by the fact that in the cross-sectional study there was a significant relationship between digit recall and the

percentage of correct spelling, which further suggests that writing and spelling are supported by verbal short-term and working memory. It was expected that children with a good verbal working memory would write more words as they would be able to retain a larger vocabulary in memory, which is supported by Martin's (1995) findings that such stories are of a higher quality. The results are consistent with findings by Alloway et al. (2005) where working memory, and phonological awareness in particular, was found to play an important role in learning and is specifically linked to writing performance. The results are in conflict, however, with findings from Bourke and Adam's study (2003) which showed that weak phonological memory was not linked with poorer writing ability. Challenges to the importance of phonological knowledge have also emerged from neuropsychological evidence which showed that impairment of phonological memory did not result in writing deficiency (Vallar & Baddeley, 1984). The inconsistency surrounding the importance of phonological knowledge on writing ability may be best explained by Sénéchal, Basque and Leclaire's (2006) theory that phonological awareness plays a greater role in the stages of learning to write and spell in transparent writing systems where there is grapheme/phoneme and phoneme/grapheme consistency. As this study was conducted with pupils learning to write English which is an opaque language the application of findings on phonological awareness is ambiguous.

5.3 Working memory and writing composition

It was found that at Time 1 in the longitudinal study, when the participants aged 4/5 years were in Junior Infants, there was a small but significant relationship between verbal working memory and the amount of detail that children wrote in their stories and the relevance of their writing to the story title. When a correlational analysis was conducted of the data at Time 1

and Time 4 this relationship between verbal working memory and detail was replicated. At Time 4, the findings show a stronger relationship between verbal working memory and the originality in the children's writing. A correlational analysis conducted on working memory and writing at Time 1 and Time 4, showed that a strong relationship existed between children's verbal working memory and originality in their stories. The children, at this stage, were in First Class and their alphabetic and grammatical knowledge had reached a ceiling, giving the children an opportunity to focus on story content rather than on letter or word formation. The results suggest that working memory played an important role in the composition of their writing. The findings are supported by Berninger et al.'s theoretical modification of the Hayes and Flower model of writing which states that sub-vocalisation, underscored by verbal working memory, contributes both directly and indirectly at the planning, translating and reviewing stages, of the writing process.

Findings from the current longitudinal study also show a link, at Time 1, between visual short-term memory and the originality of the story content. At Time 4 of the same study there was a stronger correlation between the visual component of working memory and the originality of the children's writing, suggesting that children's visual memory supports creativity within children's writing. This result is not surprising as children with stronger verbal and visual working memories would be expected to retain the title of the story in memory while working on the detail and originality of the content. These findings are supported by Olive et al's. (2007) theory which holds that writing places heavy demands on both verbal and visual working memory and concurs with findings by Bourke and Adams (2010) which demonstrate that visuospatial memory is a strong predictor of writing skills in pre-school children. Olive, Favat, Beauvais and Beauvais (2009) found that children's writing ability was linked to competence in high level processing suggesting that the

children's ability in this study, to write more creatively, in greater detail and with relevance to the title was the result of complex processing associated with a strong working memory.

5.4 Language and writing

The relationship between children's language facility and their ability to write creatively and in detail was found throughout the longitudinal study. At Time 1 a small but significant relationship was found between children's knowledge of grammar and their ability to link the content of their story to the title. This suggests that children with greater proficiency in language were better able to retain the title of the story in memory while writing towards it. At Time 4, a strong correlation was found between children's knowledge of letter sounds and grammar and the rated originality of their stories. The study also found that the children's knowledge of letter names and sounds at Time 1 correlated with the level of originality and detail in children writing at Time 4. The results from this study demonstrate that there is a significant link between early language development and competence in writing at a later stage. The findings concur with theories based on empirical evidence that oral language plays a fundamental role in the acquisition of writing skills (Abbott & Berninger, 1993). Research has found that children who were grammatically challenged are less efficient in writing and as spoken language improved written language increases in complexity (Bruce, Collins Rubin & Genter, 1983; Chenoweth & Hayes, 2001).

Throughout the longitudinal study a modest but significant relationship was found between children's language ability and the component skills of writing. At Time 1 there was a link between the children's knowledge of grammar and the phonological errors made. This concurs with previous research (Scanlan, 2004) that oral language plays an important role in

the acquisition of writing and that it is underscored by the phonological component of working memory (Adams & Gathercole, 1996).

At Time 1 a modest correlation was also found to exist between children's knowledge of letter names and the number of orthographic errors made in their writing. Children who had a good knowledge of letter sounds at Time 1 were found to have fewer orthographic errors in their writing at Time 4. This is an interesting finding because much of the previous research has focused on verbal working memory and phonological errors. Orthographic knowledge alongside phonological knowledge was noted by Caravolas, Hulme and Snowling, (2001) as fundamental to writing and spelling. Swanson and Berninger (1996) state that writing requires the translating of ideas into written symbols and this may explain the link between letter knowledge and orthographic errors in this study.

It is interesting to note that the greatest change that occurred in the learning of letter names, sounds and grammar did so between Junior and Senior Infants. Children had learned the letter names by Senior Infants and their knowledge of letter sounds and grammar increased only marginally between Senior's and First Class. By the time the children in the longitudinal study had reached First Class they knew almost all the letter sounds and grammatical inflections and this must be taken into account when considering the correlation found between letter sounds, grammar and originality.

At the earlier stage of emergent writing, language and verbal working memory were important and played a role in children's ability to write. However when the children reached First Class and their third year of formal education the influence of language (as measured here) had diminished and instead aspects of working memory were significant to the development of both the mechanics and composition of writing.

5.5 Motivation and writing

The participants' partiality to writing, as an index of motivation, was recorded and the extent to which motivation was related to writing performance was examined. The participants' self-rated incentive to write remained high throughout the longitudinal study and there was no significant difference found between boys' and girls' compositions. Consistent with findings from previous research, (Nolen, 2007; O'Rourke, 2008; Potter, McCormick & Busching, 2001), results from the longitudinal study show that the children were motivated to write in the knowledge that others (e.g. the researcher) were interested in reading their stories. There is a substantial body of evidence recorded in the literature linking children's enthusiasm to write with the quality and quantity of the writing (Daniels, 2004; Scanlan, 2012). It was expected that as the children demonstrated an enjoyment of writing there would be a relationship between this and the structure and composition of their stories. The findings in the current study show that children's motivation to write did not correlate with the mechanics or the composition of their writing. This may be explained by the fact that the writing topic was not chosen by the participants and was neutral to them i.e. not specifically related to any particular interest or aspect of their lives. The literature also states that interest and knowledge in a topic influences its choice and enhances motivation to write, though this is found to apply more to boys than to girls (Ainley, Hidi & Berndorff, 2002; Benton, Corkhill, Sharp & Downey, 1995). Further research is needed to establish the influence of motivation on content and composition of children's emergent writing.

5.6 Summary of findings

The goal of the current research was to seek answers to the question: what underscores children's ability to write at the emergent stage? This study treated the composition and mechanics of writing as two separate functions, underlined by varying cognitive mechanisms. While language knowledge played a significant role at the earliest stage of writing, its importance lessened and was not significant by the time the children reached First Class at age 7/8 years. Findings from the longitudinal study show that working memory, particularly verbal working memory, played a small but significant part in the composition of writing when the children were in Junior Infants at 4/5 years of age. When the children reached First Class it was found that both visual and verbal working memory were significantly related to both the mechanics and compositional aspects of children's emergent writing. Data analysis, examining how children's language and memory in Junior Infants related to their writing in First Class, found that verbal and visual working memory were associated with children's writing ability, at a mechanical and compositional level three years later. Contrary to findings from previous research, as stated in the literature, there was no evidence in this study to suggest that motivation played an important role in children's emergent writing. Examination of gender differences in relation to the content and composition of children's writing, over the three year period, did not show any significant disparities.

The evidence from this study suggest that writing development, along with the relationship between working memory and emergent writing ability in young children, is complex and this is supported by previous research which found that writing involved the control and management of working memory along with varying reading and writing resources (e.g., McCutchen, Covill, Hoyne & Mildes,1994).

5.7 Limitations of the study

The limitations of this study were examined in order to ascertain their potential impact on the quality of the research findings and therefore the capacity of this study to effectively answer the research questions.

The study used the Automated Working Memory Assessment to measure children's verbal and visuospatial working memory. This is a standardised test, extensively used in research. However, the results, while remaining within the normal age range, varied considerably over the four time points of testing, which may reflect inconsistency of tets administration or aspects of the test environment.

The compositional aspects of the writing samples, originality, detail and relevance, were rated by the researcher on a scale. This was a subjective measure, and not a standardised marking system. In order to minimise the level of subjectivity, a second rater was engaged to examine 30% of each set of writing samples. Both examiners set down a clearly defined marking system for the compositional aspects being examined within the stories and inter-rater reliability was high. However, a more objective measure of the compositional aspects of the children's stories may have produced different results.

The study of how children learn to write English is underrepresented in the research literature, challenging any researcher on the topic to establish a starting point at which to initiate inquiry or advance what has already been investigated. The baseline set for this study was Junior Infants, when the participants were at the earliest stage of formal learning. The Irish Curriculum does not provide for the formal assessment of writing at any stage in its eight year primary cycle and therefore there wasn't any measure from which to gauge children's writing ability. The research process was restricted by the absence of a standardised measure for writing at the beginning and end of the study.

The topic of the children's writing also requires consideration. Writing samples were requested from the participants at four different points over three school years and each time the children were given the same neutral topic, which did not relate specifically to the children's interests, upon which to write. The literature provides evidence of a link between the quantity and quality of children's writing and their interest in, and their choice of, the theme upon which to write (Ainley, Hidi & Berndorff, 2002; Benton, Corkhill, Sharp & Downey, 1995). As the participants in the current study were not given the opportunity to choose their own topic the ratings given to their work may not be a true reflection of their writing potential. However the quality of boys' stories, more than girls', has been found to be influenced positively by allowing participants to write on a subject of interest to themselves. As the content of boys' stories, in the current study, were rated equally with the girls' texts any possible limitations caused by giving the participants the same title each time was minimal.

The morphological generation task, adapted from the study by Muter et al. (2004) was limited in the extent to which it examined the children's knowledge of grammar. It could more accurately be described as an assessment of the participants' knowledge of grammatical inflections. The results of the language tests, therefore, and their applicability to children's emergent writing may be compromised by the narrowness of the measures.

In the examination of the participants' knowledge of letter sounds, as well as testing for the sound of each letter individually, the researcher chose four digraphs and four blends that were commonly used in English. A more comprehensive selection of digraphs and blends may have provided a broader picture of children knowledge of this aspect of language. However, a representative sample of language tests was chosen which could be administered within the time allocated by the schools, and each child was tested individually, with care to allow them to demonstrate their ability.

A measure of the participants' motivation to write was taken by asking each child individually if they liked writing or not. In doing so they were requested to point along an analogue line that ranged from dislike to liking of writing. This was not a standardised test and it was a broad question, for very young children, which was open to many forms of interpretation. Depending on the participants' perspective on the question, for example, it could refer to writing stories, practising writing in class or writing when playing with friends. Furthermore, it is unclear whether liking of writing and motivation to write are one and the same, at a young age. The children's interpretation was not explored further. Any further study of how children learn to write might consider other ways of assessing children's motivation to write.

5.8 Conclusion

The longitudinal and cross-sectional studies which formed the basis of the current research sought to explore the cognitive mechanisms that underscored young children's ability to learn how to write English. The study found that working memory and verbal working memory in particular along with early language development play a key role in children's emergent writing. Both the originality of children's stories and complexity in sentence structure that involves the use of connectives relate significantly to verbal working memory. The acquisition of language skills such as letter names, sounds and grammar at an early stage were linked with originality and detail in children's stories as well as fewer orthographic errors being made. The current study did not find any difference between boys and girls in their partiality towards writing, nor was there any relationship here between motivational levels and the composition, content and structure of children's writing. The study raises many interesting questions that might be explored further in future research.

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Appendix 1

Adapted grammar test (pictures removed – copyright)

Here is a picture of a banana.

Here is a picture of four _____. (bananas)

Here is a picture of a dog.

Here is a picture of lots of _____ .(dogs)

Here is a picture of a tree.

Here is a picture of three _____. (trees)

Here is a picture of a flower.

Here is a picture of three _____.flowers)

Here is a picture of a hand.

Here is a picture of two _____. (hands)

Here is a picture of a knife.

Here is a picture of three _____. (knives)

Here is a picture of a leaf.

Here is a picture of three _____. (leaves)

Here is a picture of a man.

Here is a picture of two _____. (men)

Here is a picture of a mouse.

Here is a picture of three _____. (mice)

Here is a picture of a foot.

Here is a picture of two _____. (feet)

This boy likes to climb.

Yesterday this is the rock that he _____. (climbed)

This boy likes to dig.

Here is a picture of him _____.(digging)

This girl likes to drink.

Here she is _____. (drinking)

This man likes to paint.

Here is a picture of him _____. (painting)

This girl likes to ride.

Here is a picture of her _____. (riding)

Santa carries his sack.

Last Christmas this is the sack that he _____.(carried)

The girl sees birds.

Yesterday these are the birds that she _____. (saw)

The burglar steals jewels.

This is a picture of the jewels that he _____. (stole)

The man brings flowers to the woman.

Yesterday these are the flowers that he _____. (brought)

The boy likes to write.

Yesterday this is what he _____. (wrote)

The man finds something.

Here he is pointing to what he _____. (found)

The woman likes to buy things.

Yesterday this is what she _____. (bought)

The woman falls on a banana skin.

This is the banana skin that she _____ on yesterday. (fell)

The girl keeps puppies.

Yesterday this is the puppy that she _____. (kept)