

Cursive over typeface: the importance of teaching handwriting instead of typing

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Abstract

It has been argued that handwriting is slowly becoming less prominent in favour of typing. This is because handwriting seems to take up more time and effort than typing does. The objective of this study is to examine the importance of handwriting. The aim of this study is to determine what factors play a key role in the acquisition and further practice of handwriting and to provide further evidence for the importance of handwriting as opposed to typing.

This study covers four main topics in order to examine the importance of handwriting. This is done by looking at whether handwriting practice and the teaching of handwriting is deteriorating in schools, the different learning processes involved in writing and typing and the connections that handwriting has with literacy.

In order to examine these topics, a multitude of sources were examined and consulted. These ranged from neurological research articles, in which test results are reported and analysed, to literature organizations testing general literacy of children and adults, to websites that report concerns voiced by educators. This dissertation aims to give an accurate representation of these sources by citing them appropriately. Taken together, these sources provided an overview of the main topic of the importance of handwriting. From this study it became clear that cursive handwriting is no longer an obligatory part of the curriculum in neither the United Kingdom nor the United States, and that there is a decrease in those with eligible handwriting. In addition it also identifies that bad handwriting can have disastrous consequences in professional fields. It has become clear that handwriting has a significant influence on character recognition that typing lacks. Furthermore, handwriting promotes memory retention, helps build more complicated sentences than with typing, and leads to a better composition of a written text. Finally it describes that handwriting and literacy are connected and a better handwriting performance leads to a better reading performance.

It is concluded in the dissertation that handwriting continues to take up an important position in education, and should not be given a secondary place next to typing. Handwriting contributes to academic success and higher literacy rates and bad handwriting could lead to a worse literacy rate. The study indicates that a further

education in handwriting should always be present in order to sustain the future for literacy, readability of text, and memorization of characters.

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Declaration

I hereby certify that this dissertation is my original research work. When contributions of others are involved, there will be due reference given to the literature, and an acknowledgement will be given to these authors.

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Introduction

The rise of personal computers has eased the life of many people universally and has become a part of everyday life. Written communication, administration but also researching has become easier with the help of a personal computer. However, while some of these changes have been met with enthusiasm, they have also given cause for concern regarding the negative effects of these new technologies. One of the concerns is that typing, due to its speed, ease and agility, will cause handwriting to disappear.

Even though keyboarding is becoming increasingly important for schoolchildren worldwide, handwriting remains an important skill that children should be expected to learn presently. Recently, many more children are receiving keyboarding instruction.¹ Even though children of the age of seven have barely mastered written script, educators seem eager to teach these children how to type on a computer. According to the Common Core standards, a set of high-quality academic standards in mathematics and English language arts/literacy,² children should develop the capability to use digital tools for their future scholarly research. This leads to schools instructing children in the use of computers from a young age. While computer skills seem essential in a world full of electronics, this educational policy risks handwriting to lose ground in the future. According to educator Kathy Libby some educators believe that the computer has made handwriting take a secondary position following typing.³ Associate professor Anne Mangen of the University of Stavanger mentions that the natural learning process that is strengthened by writing, may be disrupted by typing.⁴ As such, they see the risks should handwriting disappear in favour of typing in the future. This is reflected in the same Common Core standards that have already abolished the teaching of the cursive script in primary school.⁵ While this does not indicate the abolishment of teaching handwriting

¹ L. Layton, 'Elementary students learn keyboard typing ahead of new Common Core tests', *The Washington Post*, 13 October 2013 <http://www.washingtonpost.com/local/education/elementary-students-learn-keyboard-typing-ahead-of-new-common-core-tests/2013/10/13/d329ba66-3289-11e3-9c68-1cf643210300_story.html> (15 June 2014).

² <<http://www.corestandards.org/about-the-standards/>> (23 June 2014).

³ R. Francis, 'Have computers forced handwriting out of the picture?', *Education World*, 26 June 2008, <http://www.educationworld.com/a_curr/curr241.shtml> (4 July 2014).

⁴ The University of Stavanger. "Better learning through handwriting", *ScienceDaily*, 24 January 2011. <www.sciencedaily.com/releases/2011/01/110119095458.htm> (29 May 2014).

⁵ 'The Importance of Teaching Handwriting in the 21st Century', *Hanover Research*, February 2012, p. 2. <http://www.zaner-bloser.com/media/zb/zaner-bloser/pdf/hw_hanover.pdf> (19 May 2014).

altogether, it is cause for worry for the future, as handwriting achievement has been shown to correlate with reading comprehension and doing better in school than peers who have lesser handwriting skills.⁶ Should handwriting disappear, reading comprehension will likely suffer with its disappearance. The possible abolishment of teaching handwriting should therefore always be a concern. The main topic that this thesis will explore is why handwriting remains important and why it should not be discontinued as both practice and teaching.

Neurological researcher Longcamp has, for instance, identified how handwriting movement plays a key role in letter recognition. Previous research into this direction has also been done by Puranik and Nakamura on the recognition of characters and they have argued how handwriting plays a key role in this. The research that this dissertation will use is based on neurological research on the premotor cortex, which investigates the way in which movement is involved in handwriting. Many tests from research involve the significance of the reported differences in brain activity between handwriting and typing. More recently, Timothy Smoker has identified that the memory-retention for words works better when they are being written out, rather than typed down. However, other researchers⁷ found that typing has more benefits than handwriting does. Therefore this thesis will also examine both claims and verify whether the argument made for typing is legitimate.

This dissertation will look at the importance of handwriting, to support its continued teaching in the near future. It will further look at research based on pedagogical, neurological and social research on literacy and typing versus handwriting. From this analysis it should become clear that handwriting is important, and its importance serves as a support for its continued teaching in schools. Combined with a decreasing literacy in both adults and children, this thesis will assess whether the continued teaching of handwriting is required in order to improve reading abilities.

This thesis will assess whether there is a cause for concern, and provide a foundation for a continued existence of handwriting generally. It will therefore not only assess whether a continued instruction is needed, but also look at whether or not people

⁶ F. Kirmizi, 'The relationship between writing achievement and the use of reading comprehension strategies in the 4th and 5th grades of primary schools', *Procedia Social and Behavioral Sciences*, 1 (2009), p. 233.

⁷ Genlott et al.

should continue to write by hand after the crucial years in primary school in order to improve their own essay writing and literacy skills.

LIST OF TERMS

Agraphia: The inability and the loss of the ability to write and spell when writing.

Behavioural studies: The analysis of human and/or animal behaviour through observation.

Cognitive production of speech: The mental processes involved in the brain that are responsible for speech.

Comparative analysis: The comparison of two or more similar sets of data.

Cortical motor system/motor cortex: The region of the brain that is responsible for the initiation of movement. This region contains the premotor cortex, which most of the neurological research in this thesis is based on.

Cursive handwriting: A style of handwriting that connects its letters and therefore conjoins the word itself.

Developmental dyslexia: Reading disorder that is characterized by a difficulty in reading and not recognising letters accurately.

Discourse: In this dissertation used as in the definition of Foucault “to assign relations to objects”. It investigates the relationship between language and the cultural and social meaning that this language acquired.

Embodiment Theory: The theory that the human mind is largely shaped by the actions and aspects of the human body.

Hiragana: One of the three Japanese scripts. It refers to the syllabic components used for Japanese verbs.

Kanji: The main script of Chinese, and one of the three scripts of Japanese. It refers to the orthographic images that represent words.

Katakana: One of the three Japanese scripts. It refers to the syllabic components used for foreign words.

Literacy: The simplest description of it is the ability to read and write. However, this thesis also takes into account the ability to understand text beyond reading the words, and to be able to grasp the meaning of a text. Presently, while most people in western society can read and write, some are not able to go anywhere beyond that though this skill is also becoming increasingly important. That is also what this thesis takes into account.

Logographic writing systems: Writing systems which use graphemes that represent words of a language, instead of building up words by letters that represent units of sound. In this way it is impossible to tell how a word is pronounced because only its meaning is made clear. Examples include: Chinese (Kanji) and Ancient Egyptian (Hieroglyphs).

Neuroimaging: The process of producing images of the structure and activity of the brain by for instance an MRI. In this dissertation it refers to studies which have looked at brain activity while a subject was performing particular tasks.

Neurolinguistics: The study of mechanisms in the brain involved in linguistic activities and language acquisition.

Orthography: The rules of the writing system of a language such as those concerning spelling, hyphens, and capitalization.

Phoneme: A unit of sound in a language.

Print: A style of handwriting that uses unconnected block letters.

Writing Acquisition: The process involved in the learning of writing.

1. Death of handwriting

Writing is the only way to communicate through written linguistic messages, and therefore it would be beneficial for children to spend quite a few years learning how to write. Historians classify anything predating written sources as prehistory even though written history has been referred to history. This shows that handwriting, at least in terms of history, signifies a certain form of credibility.⁸ However, computer ownership is on the rise. While only 8 percent of American households owned a computer in 1984, that number went up to 75 percent in 2011.⁹ This increased use of computers is certainly accompanied by an increased use of typing, which means that there are fewer people handwriting than there were thirty years ago. This rise of computers, combined with a rise in typing, does give cause for concern. Even though handwriting has prestige, due to its long history of use and years of being included in school curriculum, this question remains whether typing will soon replace it and if that is possible. After all, typed sources are able to record written language just as well as handwritten sources do. This chapter will therefore examine whether the 'death' of handwriting is a legitimate concern and whether handwriting is being threatened by technology, or whether the concerns are ungrounded.

1.1 The rise of laptops and technology in classrooms

Schools worldwide are beginning to implement laptops and iPads into their classrooms. In the Netherlands, for example, ten so-called 'iPad-schools' opened their doors in August 2013, at which all students were supplied with an iPad and educated differently from other primary schools.¹⁰ The difference lies in the fact that students no longer need to be present for the entire day, and even a standard classroom and a teacher are now becoming optional, alongside a difference in teaching due to the iPads being used. According to the organization, these students will acquire skills that will include the assets of the digital age. These assets include innovativity, creativity, flexibility and teamwork. However this initiative is not solely supported by just the creator of these

⁸ A. van der Weel. *Memory and the Reading Substrate* (uncorrected draft), p. 2.

⁹ <<http://www.census.gov/prod/2013pubs/p20-569.pdf>> (6 June 2014).

¹⁰ C. van Hoek, 'Tien iPad scholen openen in augustus deuren', *Nu.nl*, 8 April 2013
<<http://www.nu.nl/internet/3391863/tien-ipad-scholen-openen-in-augustus-deuren.html>>.

schools, it has also gained the support of the Dutch parliament. One of its parties claimed that education could not remain idle when the world around us changes rapidly.¹¹ These schools will therefore centre around the iPads and the skills required to use them, and children from the age of four will be able to have their own iPad. De Hond, the creator of these schools, went so far as to claim that only 4 percent of all written material was written by hand, so it would be more useful for children to learn how to type blind than it would be to write by hand.¹²

Not only the Netherlands have expressed interest when it comes to involving more computers and laptops in schools. According to a survey held by EACEA, The Education, Audiovisual and Culture Executive Agency of the European Commission, which was filled out by teachers and headmasters in 26 European countries, most of them regard the impact of ICT on learning as positive.¹³ The Rose report, an independent review of the teaching of early reading in primary schools, set out recommendations to modernize learning from 2011, which have also been accepted by the British government.¹⁴ The report, as said by head teacher Len Peach, recognizes that ICT is part of children's lives and it is therefore a positive development for computers and typing to be incorporated in schools. Technology budgets for UK schools are also increasing,¹⁵ and while that does not indicate that primary schools mean to use ICT as a leading means of teaching, it does show that more schools will incorporate the use of computers and technology in the nearby future. The most notable example is the "One Laptop per Child Project" which aims to provide a low-cost connected laptop for the poorest children of the world, and thereby giving them educational opportunities.¹⁶

¹¹ 'Tweede Kamer Steunt iPadscholen', *De Telegraaf*, 8 June 2013
<http://www.telegraaf.nl/digitaal/21633266/___Kamer_steunt_iPadscholen__.html>.

¹² T. Mudde, 'Het nieuwe leren', *De Volkskrant*, 8 June 2013
<<http://www.volkskrant.nl/vk/nl/2844/Archief/archief/article/detail/3454909/2013/06/08/Het-nieuwe-leren.dhtml>>.

¹³ A. Balanskat, 'Study of the impact of technology in primary schools: synthesis report', *Steps EACEA*, 2009, pp. 1-54
<http://eacea.ec.europa.eu/llp/studies/documents/study_impact_technology_primary_school/02_synthesis_report_steps_en.pdf>.

¹⁴ G. Cole, 'Rose Report places technology centre stage in primary curriculum', *The Guardian*
<<http://www.theguardian.com/resource/rose-report-technology-primary-curriculum>>.

¹⁵ 'Schools increase technology spend', *ICT for Education*, 5 October 2012
<<http://www.ictforeducation.co.uk/article/schools-increase-technology-spend.html>>.

¹⁶ <<http://one.laptop.org/about/mission>>.

While this particular project is mostly meant for developing countries, its approach is one that many schools in Europe and North-America apply to their own classrooms.

However, this provision of laptops and tablets leave more traditional arrangements, such as note-taking and even the computer lab, in the dust. In spite of the enthusiasm of teachers many studies have shown that a large number of teachers still fail to take full advantage of the ICT programme in their teaching, and that most of their enthusiasm stems from intuitive arguments, rather than their own experience.¹⁷

1.2 The lost art of handwriting

But then what about handwriting? Alongside these technological changes in schools, handwriting too seems to be taking a hit. The cursive handwriting, which was an obligatory part of the American elementary education, seems to have been disappearing for years says the Washington Post.¹⁸ Both the teaching of cursive handwriting and the use of the script itself have been slowly declining in the United States since the 1970s,¹⁹ is now no longer part of an obligatory curriculum. This is due to the revision of the Common Core State Standards in 2011, which abolished the obligatory teaching of cursive handwriting. Even though only cursive handwriting is no longer obligatory, other handwriting instruction could also be abolished. According to these same Common Core Standards even regular handwriting instructions could no longer be considered necessary after the first grade.²⁰ While schools have the choice to teach either cursive or manuscript writing, they now also have the choice to abolish instructions in handwriting completely after the first grade. Because educators find themselves with too little time already to teach a variety of courses, some of them may

¹⁷ T. Karsenti and S. Collin, 'Benefits and challenges of using laptops in primary and secondary schools: Results of the second investigation at the Eastern Townships School Board. Summary of main results', 2012, p. 6.

¹⁸ T. Shapiro and S. Voisin, 'Cursive handwriting disappearing from public schools; With new federal standards not requiring cursive handwriting, instruction in it is increasingly rare', *The Washington Post*, 8 April 2013, p. 1.

¹⁹ N. Borges, 'Cursive Handwriting Is Just One Casualty Of Common Core And Modern Education', *WLRN*, 17 February 2014 < <http://wlrn.org/post/cursive-writing-just-one-casualty-common-core-and-modern-education>>.

²⁰ 'Handwriting in the 21st century?', *Saperstein Associates*, winter 2012, pp. 1-7. <https://www.hw21summit.com/media/zb/hw21/files/H2948_HW_Summit_White_Paper_eVersion.pdf> (20 June 2014).

opt not to teach handwriting instruction any longer beyond the first grade.²¹ Since the Common Core State Standards of 2011, the importance of handwriting in elementary schools has diminished significantly²². Especially now that schools have to prepare students for a future that seems to usurp penmanship in favour of typing. The preference for typing and computers does not come as a surprise when, as previously stated, laptops and computers are on the rise in classrooms.

The optional teaching of cursive, however, does not mean the abolishment of handwriting altogether. Surprisingly, a survey done by the Vanderbilt University in 2007 revealed that many teachers were in favour of teaching cursive. Ninety percent of the correspondents said that their schools required instruction in handwriting, and another ninety percent offered cursive in the third grade.²³ Even though teachers are optimistic about the use of handwriting, educators in the United States have already mentioned that they do not have students practise handwriting as a daily exercise, possibly because it is now no longer obligatory. This, according to educators such as Kathy Simmons-O'Neal, is damaging for the children's motor skills and their proficiency in handwriting in general.²⁴ Even with the best intentions, teachers do not spend enough time on handwriting and are often not equipped with the proper methods to teach it.

The now optional need for cursive does however pose a problem. Handwriting in general already becomes optional to teach after the first grade, and cursive is optional altogether. Some educators are already equating writing with typing, and consider typing an adequate replacement in the present age. Steve Graham, an education professor at Arizona State University, mentions that the cursive script is gone except for those in their sixties and seventies²⁵. He goes on to say however that "in the 1950s everything was written by hand. Paper and pencil. Right now, it's a hybrid world".

²¹ M. Downs, 'Schools debate: Is cursive writing worth teaching?', *Florida Today*, 23 January 2009 <http://usatoday30.usatoday.com/news/education/2009-01-23-cursive-handwriting_N.htm>

²² L. Dinehart, 'Handwriting in early childhood education: Current research and future implications', *Journal of Early Childhood Literacy*, (2014), p. 2.

²³ 'The Importance of Teaching Handwriting in the 21st Century', *Hanover Research*, February 2012 <http://www.zaner-bloser.com/media/zb/zaner-bloser/pdf/hw_hanover.pdf>

²⁴ J. Zubrzycki, 'Experts Fear Handwriting Will Become a Lost Art', *Education Week*, 31:18 (2012), p. 2.

²⁵ T. Shapiro and S. Voisin, 'Cursive handwriting disappearing from public schools; With new federal standards not requiring cursive handwriting, instruction in it is increasingly rare', *The Washington Post*, 8 April 2013, p. 2.

Another educator named Carl Brown, the principal of Manatee Elementary, says that parents would be upset if children were sent to handwriting camp in this day and age. He also mentions that children no longer write letters, but use email and text messages instead which he follows up by mentioning that a lot of those old ways are going away.²⁶ Both these statements could imply that handwriting might be deemed unnecessary in the future, and that some educators are already thinking about excluding it from the curriculum. This is, after all, what Maurice de Hond is doing with the iPad-schools while mentioning that typing is done on a bigger scale than handwriting.

Even cursive handwriting is important for the development of children, however. Being able to write in cursive leaves students with a choice on the particular writing style that they want to develop, and cursive especially comes in handy for signatures and bills, according to a study done by Hanover Research.²⁷ Cursive is more difficult to imitate and is at a lesser risk of identity theft. But children are also more capable to develop their own handwriting style which they are comfortable with, with a full arsenal of letters at their disposal. Besides being able to develop a personal writing style, opponents of the optional teaching of cursive also argue that some documents are written in cursive such as the American Constitution. Should cursive no longer be taught presently, children of this age might not be able to read certain documents in the future. Of course, this argument can be simply by looking at Gothic scripts that researchers are still able to decode presently.

1.3 Decreasing proficiency in handwriting

Recent findings by the Early Childhood Longitudinal Study have shown a snapshot of today's children and youth's literacy skills, while focussing primarily on writing. Children were assessed whether they had a below basic, basic, proficient or advanced level in writing. These levels were assigned by a writing score between 0 and 300, 276,000 students participated in the experiment. The students were tested on their own input with writing, how informative their writing was and how persuasive the text

²⁶ M. Downs, 'Schools debate: Is cursive writing worth teaching?', *Florida Today*, 23 January 2009 <http://usatoday30.usatoday.com/news/education/2009-01-23-cursive-handwriting_N.htm>

²⁷ 'The Importance of Teaching Handwriting in the 21st Century', *Hanover Research*, February 2012 <http://www.zaner-bloser.com/media/zb/zaner-bloser/pdf/hw_hanover.pdf>

appeared.²⁸ These results determined their literacy skills. The same results showed that at age ten, 72 percent of children performed at or even below the basic level of proficiency in writing.²⁹ Even though this 72 percent included the basic level of proficiency, it did show that students simply did not perform at the best of their abilities when most of what they could do was at a basic level. Only 2 percent of all children manages to score at an advanced level of proficiency. In the case of minorities, as well as children who come from a lower socio-economical background, a total of 85 percent performed at a basic or below basic level of writing literacy. The trend of performing at a basic or low level of proficiency continues to stay high in the eighth and up until the twelfth grade, the highest grade level that this study researched. While there was a slight improvement in the eighth grade of 67 percent performing at a basic or below basic level of writing proficiency, this number was 76 percent in the twelfth grade. These numbers show that children do not perform well when it comes to writing. A switch to keyboards and typing in primary schools instead of learning proper handwriting, when children's handwriting skills are not up to par yet, might not be a proper solution to this continuing problem.

Regarding people's own perception of their handwriting, Docmail, a UK-based printing and mailing company, conducted a poll in 2012. In this poll they asked respondents how they judged their own handwriting, in which 33 percent of the respondents admitted to having difficulties when reading their own handwriting.³⁰ The fact that one in three people had not written anything by hand in over half a year, may have played a part in this. Even simpler tasks such as updating phone books and calendars are now more likely than ever to be supported by technology, rather than pen and paper. This problem with handwriting could pose serious problems in the future.

In the worst-case scenario, poor handwriting does not only lead to mail addresses on letters not being read correctly, but it also causes mistakes in professional fields. Doctors' poor handwriting is responsible for over 7,000 deaths each year in the

²⁸ <<http://nces.ed.gov/nationsreportcard/pdf/main2002/2003529.pdf>> (25 May 2014).

²⁹ B. Miller and P. McCaule, 'Reflections on the need for the continued research on writing', *Reading and Writing*, 24 (2011), p. 123.

³⁰ M. Casey, 'Has technology ruined handwriting?', *CNN*, 28 July 2013
<<http://edition.cnn.com/2013/07/26/tech/web/impact-technology-handwriting/>> .

United States.³¹ The reason why these deaths occur is because the dosage cannot be read, or some abbreviations remain unclear. In the medical world especially, these details can mean life or death for some patients and this field demands clear instructions.

Even though typing has become much more important, bad handwriting is still weighing in on grades and even future jobs. While teachers exclaim they would never deduct points for bad handwriting, university professor Steve Graham says that research has shown a different outcome. When teachers are presented with the exact same composition, one written in good handwriting and the other in poor handwriting, they will give lower grades to the one that has poor handwriting.³² In schools, poor handwriting may lead to a lower self-esteem when children are unable to keep up with the amount of written material. This, in turn, makes it more common for these children to be classified as lazy or lacking motivation.³³ Even when it comes to hand-written job applications, those hiring will judge applicants on their handwriting. After all, it makes more sense to hire someone who has better skills in handwriting than one who does not, for much the same reasons that teachers grade those students better. The handwriting is easier to read and appears more professional. These provide a good argument for the preference of typing over handwriting.

However, students who typically struggle with handwriting may face the same problems when they are put behind a computer to type. Virginia Berninger, a professor of educational psychology at the University of Washington, mentions that handwriting has both cognitive and motor benefits. It is these benefits that contribute to good handwriting, but eventually also good keyboarding. Children who face difficulties with their handwriting, she argues, may face those same difficulties when they use a keyboard.³⁴

The common belief is that those who use computers more often have a decreased use of handwriting in daily life but also that they are faster when it comes to writing. In

³¹ C. Blazer, 'Should Cursive Handwriting Still Be Taught in Schools?', *Information Capsule Research Devices*, 0916 (2010), p. 3.
<<http://drs.dadeschools.net/InformationCapsules/IC0916.pdf>>.

³² M. Pressler, 'The Handwriting Is on the Wall', *The Washington Post*, 11 October 2006
<<http://www.washingtonpost.com/wp-dyn/content/article/2006/10/10/AR2006101001475.html>>

³³ K. Feder and A. Majnemer, 'Handwriting development, competency, and intervention', *Developmental Medicine & Child Neurology*, 49.4 (March 2007), p. 312.

³⁴ J. Zubrzycki, 'Experts Fear Handwriting Will Become a Lost Art', *Education Week*, 31.18 (2012), p. 1.

a research concerning the time required to copy lines in order to research basic fine motor skills, conducted by the Leibniz Research Centre, the researchers classified people as non-computer users and computer-users. While there was no difference in speed when tracing these lines between older non-computer users and older computer-users, there was a significant difference in writing speed between the younger generation that used computers and those who did not.³⁵ This could indicate that the older generation, no matter if they use computers or not, have been handwriting longer than the younger generation who is used to using a computer.

1.4 Conclusion

When looking at the slow decrease of handwriting over the past few years, it has become clear that handwriting is no longer considered to be as important as it used to be. The Common Core Standards in America seem to imply that the teaching of handwriting decreases. The Netherlands has taken the first few steps into the direction of a fully computerised school, instead of one that traditionally teaches by pen and paper. Even though some educators are trying to keep handwriting practice in place, it has become more difficult for these educators to teach handwriting when faced with other subjects to teach, and because it is no longer obligatory. Moreover, even teachers who do still dedicate themselves to teaching handwriting do not necessarily have a good grasp on how to properly teach it. Alongside the rise of laptops and computers, both in school and at home, handwriting no longer seems to be as relevant as it was thirty years ago. Keyboards may be considered as an adequate replacement for writing, which would mean that handwriting is no longer considered necessary.

A frequent use of computers goes hand-in-hand with a decrease in speed in handwriting, as well as a lesser proficiency in handwriting. Whether the accompanied use of computers is a coincidence or not, it is clear that children are increasingly struggling with handwriting. Not only are students suffering from bad handwriting by getting worse grades and possibly being classified as lazy, but adults too suffer from bad handwriting. One of the major consequences is that some professions simply cannot

³⁵ S. Sülzenbrück, M. Hegele, G. Rinkenauer and H. Heuer, 'The Death of Handwriting: Secondary Effects of Frequent Computer Use on Basic Motor Skills', *Journal of Motor Behaviour*, 43:3 (2011), p. 248.

afford to have bad handwriting, such as the medical field. Combined with a more dismissive attitude towards handwriting as its importance is decreasing, this could have disastrous consequences for the teaching of handwriting in the future.

Chapter 2. The differences between writing by hand and typing on a computer

In this discussion of handwriting, typing has come up as possible replacement of handwriting with the rise of computers. This chapter discusses whether typing can be a suitable replacement for handwriting, and questions how the two are different when it comes to the movement involved. Handwriting seems to take more effort than typing on a computer does. Handwriting is also commonly thought of as slower, requiring more effort, and requiring more eligibility, whereas keyboarding makes things easier on people by being quicker to do, and by being easy to read whether or not a person is fast at typing. The different fonts make it easier for authors to pick the one that they like, instead of developing their own style in handwriting. Italics is now an option in every word processing program, and deletion is simply done by a backspace button on the keyboard instead of crossing everything out. There is a possibility that handwriting makes people write more carefully, as it takes more effort to write something down, and because erasing words would take up both paper and time. However, what are some other differences between keyboarding and handwriting besides the ones mentioned above? As the previous chapter explained that instruction and proficiency in handwriting is decreasing, this chapter will examine whether these differences are significant enough to signify the importance of handwriting.

2.1 Recognising characters and letters when learning how to type versus handwriting

Computers, as well as tablets and smartphones, are now being used by an increasingly younger group all over the world. A preschooler using a laptop no longer seems strange, and a child learning how to type is encouraged to keep it up. After all, in the present day typing is becoming increasingly important alongside handwriting.

As previously discussed, computers make up for a great deal of writing at present. Typing has become as much a part of writing as handwriting has been in all the years before. However, there are more differences between handwriting and typing than the use of paper versus electronics. It should not come as a surprise that one of the major differences between handwriting and typing is the movement involved. Handwriting involves a different type of motor movement than typing, and the

increasing use of computers begs the question what kind of effects this drastic change in hand movement will have on children. What would be the effect if children would learn how to type before they are taught handwriting, if they are taught that at all?

Movement generally organises the perception of the world by attributing properties to it.³⁶ This is seen in touch, where a subject will be able to determine the size, structure and temperature of an object. Movement is therefore associated with perception in order to make up the presentation of the object. Yet, even when no movement is involved, such as the viewing of pictures, a premotor cortical area is activated.³⁷ The area in the brain involved in movement helps recognising these images, which shows that movement, perception and even images are related to one another. This is where handwriting comes in: while characters, or letters, are not objects in the sense that a person can touch them, they work in a similar manner. By moving a hand and writing the letter down physically, a person is able to memorise the structure of the character.

In the light of these discoveries, it has become increasingly difficult to ignore the differences between typing on a computer and writing by hand. In both types of writing, the recognition of letters remains important in the writing process. However, it is the research in motor movement that shows handwriting may prove to be of paramount importance when it comes to the recognition of letters. Both alphabetic characters and other characters such as those of the Asian or Arabic scripts are associated with particular handwriting movements. Studies on patients with brain damage have shown that the cortical motor system which controls movements still corresponds to viewing visual representation of letters, helping the patient recognise these characters.³⁸ Even when the brain is damaged, these functions still work to help recognise letters even if they are only viewed here and not written down. This is possibly because the brain has previously connected these characters with the movement of the hand when the person

³⁶ M. Longcamp, M. Zerbato-Poudou, and J. Velay, 'The influence of writing practice on letter recognition in preschool children: A comparison between handwriting and typing', *Acta Psychologica*, 119 (2005), p. 68.

³⁷ Longcamp, Zerbato-Poudou, & Velay, 'The influence of writing practice on letter recognition in preschool children', p. 68.

³⁸ Longcamp, Zerbato-Poudou, & Velay, 'The influence of writing practice on letter recognition in preschool children', p. 68.

had written these characters down in the past.³⁹ In spite of the part of the brain involved with movement corresponding to recognition of letters, this does not fully prove that movement is needed for recognition. However, it does provide evidence in that direction. This is further supplied by the Japanese who, in their childhood, must write down their characters repeatedly in order to memorise them. As adults, they memorise these characters by writing them in the air,⁴⁰ providing evidence that movement is involved in memorization. Neither of these movements have anything to do with typing, but rather with handwriting. Handwriting apparently attributes to memorising characters more than typing does.

The difference between handwriting and typing showed again in another experiment on the connections between writing instruction method and letter memorisation, which tested character writing acquisition in young children. The children were not obligated to learn words, they were only instructed to write down the letters themselves. Handwriting requires the test-subject to define the letter by movement of the hand, and it therefore establishes a link between the written product and the movement involved. Typing also involved a complex form of learning: while the typing form also required movement, the memorisation of the letter usually involved finding the location on the keyboard instead. In turn, there was no connection between the representation of the letter and the movement involved in writing it.⁴¹ Cognitive neuroscientist Longcamp investigated, the same methods in adults of 26 years of age. Because the subjects were already familiar with existing English alphabetic characters, they were introduced to ones that they were unfamiliar with: Bengali and Gujarati.⁴² The subjects were tested on their knowledge after learning the characters by handwriting or typing, for three weeks. Handwritten characters were better recognised

³⁹ Longcamp, Zerbato-Poudou, & Velay, 'The influence of writing practice on letter recognition in preschool children', p. 69.

⁴⁰ Longcamp, Zerbato-Poudou, & J. Velay, 'The influence of writing practice on letter recognition in preschool children', p. 69.

⁴¹ Longcamp, M. Zerbato-Poudou, & J. Velay, 'The influence of writing practice on letter recognition in preschool children', p. 77.

⁴² M. Longcamp, C. Boucard, J. Gilhodes, J. Anton, M. Roth, B. Nazarian, and J. Velay, 'Learning through Hand- or Typewriting Influences Visual Recognition of New Graphic Shapes: Behavioral and Functional Imaging Evidence', *Journal of Cognitive Neuroscience*, 20:5 (2008), p. 803.

than the characters that had been learned by typing.⁴³ Both handwritten and typed characters had been learned in the exact same span of time, so familiarity with the character was not part of a subject's ability to recognise it. Yet, overall, handwritten characters were better recognised. When learning how to read, some of the movements involved in writing the character remain with a person and therefore trigger a response to remember them. A feature that was solely part of the handwritten characters was that the subjects were actually able to write them. Even if subjects could remember the appearance of the typed character, they were not able to write the character itself.⁴⁴

There is another question that remains of interest in the acquisition of handwriting; whether this type of learning also applies to logographic languages. This is of interest because logographic languages and the characters depend on stroke-order and not on individual letter learning, could the same therefore apply to these languages? Logographic languages are composed of graphemes that represent words in itself. It is easier to identify them as 'pictures'. The Ancient Egyptian language was one of these logographic languages and today the most common examples are Japanese, Chinese, Korean, and other East-Asian languages. It is Chinese that depends heavily on the motor memory when it comes to the acquisition of the language and its characters, possibly because these characters require more strokes of the hand when writing them. A Chinese character may have up to eight different strokes leading to its completion.⁴⁵ The characters are also more complex compared to alphabetic characters as the Chinese do not have single letters, but their characters represent complete words or word components.

Different from alphabet characters is that Chinese does not build on phonemes at all. Whereas several phonemes together will form words, the Chinese characters are already words on their own. The ability required to connect letters to words and phonemes to orthography is not the same in Chinese.⁴⁶ It is therefore of great importance that Chinese learners become familiar with the characters in order to read. If

⁴³ Longcamp, Boucard, Gilhodes, Anton, Roth, Nazarian, & Velay, 'Learning through Hand- or Typewriting Influences Visual Recognition of New Graphic Shapes: Behavioral and Functional Imaging Evidence', p. 806.

⁴⁴ M. Longcamp, C. Boucard, J. Gilhodes, J. Anton, M. Roth, B. Nazarian, and J. Velay, (2008), p. 812.

⁴⁵ C. Guan, Y. Liu, D. Chan, F. Ye, and C. Perfetti, ' Writing Strengthens Orthography and Alphabetic-Coding Strengthens Phonology in Learning to Read Chinese', *Journal of Educational Psychology*, 103:3 (2011), p. 110.

⁴⁶ C. Guan, Y. Liu, D. Chan, F. Ye, and C. Perfetti, (2011), p. 509.

other research already suggests that alphabetic learners must write in order to recognise 26 characters when reading, it is only logical to assume that learners of Chinese must write by hand in order to memorise a set of characters that can go up into the thousands. While it is possible to learn how to type these, a learner of Chinese must be familiar with its components before the character will show up in a word processing program. In other words, different Chinese characters start with the same component, and only precise knowledge of all components of the character will enable a user to pick the correct character in a word processing programme. These characters also cannot be altered in any shape or form, whereas the alphabetical characters can be stylised to the writer's own needs. In fact, the heavy cursive styles from the past may not be practised or even read at all anymore.⁴⁷

In a research article by Nakamura et al., it is suggested that the same part of the brain responsible for writing and recognising alphabetic characters is a great deal more involved when it comes to logographic languages such as Chinese.⁴⁸ If one stroke is inaccurate in a Chinese character, the character may either not exist or not have the meaning that the writer intended. As a result, writing these characters relies heavily on both the visual and the motor systems. Chinese children therefore learn reading Chinese characters at the same time that they are writing these characters, in order for them to become better acquainted with them. In this way, the repetitive movement of the hand will be remembered visually as well. Once this character has been memorised, it will be remembered for a much longer time than when simply learning how to read the character. Motor memory lasts for a long time without needing further practice, which would be another argument when it comes to primarily teaching handwriting as opposed to typing. It would also explain why those who have learned handwriting in their childhood are still able to write decades later and read well. A neuroimaging study done by Guan et al. on brain activation patterns after handwriting Chinese characters found that characters which had been learned by writing produced more brain activity than learned by studying or reading them. Not only that but these areas in the brain were

⁴⁷ K. Nakamura, W. Kuo, F. Pegado, L. Cohen, O. J. L. Tzeng, and S. Dehaene, 'Universal brain systems for recognizing word shapes and handwriting gestures during reading', *Psychological and Cognitive Sciences*, 109:50 (2012), p.5.

⁴⁸ K. Nakamura, W. Kuo, F. Pegado, L. Cohen, O. J. L. Tzeng, and S. Dehaene, , 109:50 (2012), p. 1

typically associated with motor activity and semantic processing. The learning of Chinese is therefore enhanced by handwriting.⁴⁹

When it comes to people who have solely forgotten how to write, the underlying problem appears to be an impairment of the motor programmes that contain information about the hand movements which are needed to form the letters in question.⁵⁰ Because the motor programmes required to handwrite appear impaired, a person is unable to recall the appearance of the letters and how to write them. Individuals with lexical agraphia have trouble with spelling irregular words, but these problems are also typically associated with damage to the part of the brain that is involved in the movements required for handwriting. This signals a connection between the fine motor movement and the ability to write, but also with the ability to recall letters and spell accurately. If these movements are involved in a better performance, it is arguable that the implementation of handwriting should be a big priority. If this evidence signals that the movements required in handwriting lead to a better spelling and writing performance, it means that typing will lead to a lesser performance. In support of this argument a research by Longcamp et al. showed that alphabetic characters which are learned through typing were recognised less accurately than characters which were learned by hand.⁵¹ Ironically so, children who have started to write by hand will develop the finer motor skills that will aid them in keyboard typing.⁵²

2.2 Conclusion

This chapter set out to determine whether the differences between handwriting and are significant and would therefore deserve more credit than it is currently being given. Even though the use of computers continues to increase and typing has become much more prominent in recent years, handwriting and typing are different enough for the former to remain important. Handwriting has a more significant influence on the recognition of characters than typing, due to the movements involved when hand

⁴⁹ C. Guan, Y. Liu, D. Chan, F. Ye, and C. Perfetti, (2011), p. 514.

⁵⁰ P. Beeson, S. Rapsak, E. Plante, J. Chargualaf, A. Chung, S. Johnson, and T. Trouard, 'The neural substrates of writing: A functional magnetic resonance imaging study', *Aphasiology*, 17:6 (2003), p. 650.

⁵¹ M. Longcamp, M. Zerbato-Poudou, and J. Velay, 119 (2005), p. 70.

⁵² 'Waarom kan en mag typen schrijven niet vervangen', *Platform Handschrift Ontwikkeling*, 22 December 2010

<<http://members.upc.nl/m.otter7/handschriftontwikkeling/Artikelen/Waarom%20typen%20schrijven%20niet%20mag.pdf>>.

writing these characters. While typing also teaches the memorization of characters, these characters will mostly be remembered by their position on the keyboard instead of their appearance and typing does not aid in learning how to write them.

The finer motor movement that handwriting teaches will also be helpful when it comes to typing. Not only does the research support the continued teaching of handwriting alphabetic characters, it also supports different orthographic systems such as the Chinese orthographic system. The findings of this chapter support the hypothesis that handwriting must continue to be taught, as its importance proves much bigger than typing when it comes to the memorisation of letters and characters for writing especially.

Chapter 3. The importance and added benefits of handwriting

The previous chapter discussed how the movement involved in handwriting have a significant effect on the working memory of the brain. It further explained how these movements were different from writing by keyboard. This chapter will aim to explain the differences in execution and style, memory and the average success in school between handwriting and typing. It will also signify the importance of handwriting generally while still comparing it the importance of typing.

3.1 Differences in execution, planning and revising in handwriting and typewriting

When discussing the difference between handwriting and typing, it is important to look at the difference in execution. Handwriting clearly involves writing the ideas down on paper as opposed to typing words on a screen, but in what way do students write differently when it comes to their ideas and thoughts between these two types of writing? Having discussed motor movement and its connection to writing and reading legibly, this section will discuss the cognitive processes involved in handwriting as opposed to typewriting.

Typing is usually regarded as a faster method to write essays, letters, and letters in the form of emails. For people with dyslexia, and those suffering from other learning disabilities, the keyboard can serve as a relief, as students will no longer struggle with complicated words and will require less time when it comes to completing tests. Typing after all, is easier on those suffering from dyslexia. According to Genlott and Grönlund, children improve their writing considerably when working on a computer with programmes developed for their writing development.⁵³ iPads and computers are a sociocultural way of learning, provided that they link up to the rest of the classroom activities so students will not work in isolation. Children in this project were provided with iPads and worked in pairs when writing texts, before publishing them on a website and subjecting them to discussion. iPads worked well in the classroom and stimulated writing which was without faults or without words crammed into corners after correcting, which often happens when writing on paper. Genlott and Grönlund show

⁵³ A. Genlott, A. Grönlund, 'Improving literacy skills through learning reading by writing: The iWTR method presented and tested', *Computers & Education*, 67 (2013), p. 99.

that the writing of children who used these programmes improved considerably, even though these results were not compared to similar handwriting exercises. These digital programmes were, in their opinion, the best way to teach children how to write. After all, their literacy improved, they were better equipped to assess the work of their peers, and they were more familiar with technology and the internet than people in the eighties and nineties. Genlott et al. also argue for the incorporation of writing instruction through computers, because children write better and longer pieces, take less time in writing them, and the written pieces are more legible. Additionally, by using a computer, they can use a software feature where they can put their work online so that classmates are able to read their pieces and comment on it. In doing so this creates an improved cooperation between classmates and stimulates students' critical thinking.

However, upon investigating the differences between students with learning disabilities and those without, researchers Connelly, Gee, and Wash found that there was no difference in the total time required for the completion of the writing tasks assigned.⁵⁴ In fact, both groups of students took longer to write essays by typing than by writing them by hand. And this is not merely for the reasons that Genlott et. al give in their research; that children in the eighties and nineties were simply not used to using computers yet and were therefore slow when typing. This research was conducted in 2009, only four years prior to the article written by Genlott and Grönlund. These children have grown up with technology, and yet from the second grade to the sixth grade onwards their writing continuously improved when they were using handwriting. They wrote longer essays at a quicker pace than they did with typewriting. Age and experience with computers did not seem to matter in terms of the students' writing. Even though handwriting makes it harder for students to erase their mistakes, this did not deter students in writing longer and more complex sentences, contrary to typing.

The fact that handwriting is quick, even though typing might appear quicker at first glance, is not that strange. As reported by Salthouse, there is no correlation between typing speed and comprehension of the material. Meaning that whether or not someone can type fast, it has no impact on their reading comprehension. Those who

⁵⁴ V. Beminger, R. Abbott, A. Augsburger, and N. Garcia, 'Comparison of Pen and Keyboard Transcription Modes in Children With and Without Learning Disabilities', *Learning Disability Quarterly*, 32:3 (2009), p. 123.

typed quickly typically read over their material very briefly, which made incomplete sentences more likely to occur in typing than in handwriting. An implication of these results is that reading and typing may involve different processes. When someone reads through their text, his typing skill is no different from one who does not read through his written text. However, as soon as it comes to comprehension of their text, those who were asked to think about their typed text scored higher than peers who did not read through their text. This means that while their typing skills were not affected by flimsy reading, their reading skills were impacted.⁵⁵

When it comes to writing itself, an influential paper written by Hayes and Flower identified three cognitive processes which aid good writing. These processes are: planning (generating ideas and setting goals), translating (turning ideas into written text); and revising (recreating the text to improve clarity of idea expression)⁵⁶. It is transcription however, the ability to express thoughts into written symbols of language, that is especially important when it comes to writing. Transcription is more important for handwriting and spelling in written language than for typing. A keyboard presents a user with all possible characters, but in handwritten language a writer would need the knowledge of these characters or he would not be able to write at all. Previously, children who struggled with handwriting and spelling were given more instructions in order to improve their transcription. These problems can be overcome in the early years if students are given such instructions in order to improve their handwriting. But if typing is done on a computer, it remains a concern how children will be able to improve. Of course, there are writing programs such as described by Genlott et al. but research has shown that these only have a modest effect; students will primarily improve their ability to edit their text, without solving the problems related to spelling, where children learn the exact characters that make up the words, and transcription, the act of putting the words to paper.⁵⁷ In an attempt to compare writing by keyboard and writing by hand for students with learning disabilities, including children without these disabilities, a research Berninger concluded that keyboards are not a substitute for

⁵⁵ T. Salthouse, 'Perceptual, Cognitive, and Motoric Aspects of Transcription Typing', *Psychological Bulletin*, 99:3 (1986), p. 305.

⁵⁶ V. Berninger et al, 'Comparison of Pen and Keyboard Transcription Modes in Children With and Without Learning Disabilities', p. 124.

⁵⁷ G. MacArthur, 'The effects of new technologies on writing and writing processes', in G. MacArthur, S. Graham, & J.Fitzgerald (Eds.), *Handbook of writing research* (New York: Guilford Press, 2006), p. 150.

explicit instruction.⁵⁸ This showed that both groups benefited more from handwriting instruction than they did from typing. Furthermore, children with learning disabilities may fare better with handwriting, and the keyboarding should be an addition to instruction as opposed to being a replacement. It is the scholar Galbraith who mentions another benefit to the transcription of writing: that text translation is a way to generate more ideas.⁵⁹ By writing the text down, the author will generate more sentences and more ideas, which would lead to a better text.

Handwriting is more than the motor acts described in the previous section. In fact, the ability to recall the letter shapes and spelling of words has more to do with the orthographic processes in the brain.⁶⁰ These contribute more to handwriting than motor processes will, as they involve the words and their spelling being written on paper as opposed to the movement of the hand, which has less to do with the words being used. But they also occur without taking up too much 'thinking' involved in the writing process as a whole. It must be said however, that these processes are linked to the motor movements involved when handwriting.

In an experiment carried out by Jean-Luc Velay of the University of Marseille it has become clear that different parts of the brain are activated when reading letters that were taught by handwriting, than the letters that were learned by the use of a keyboard.⁶¹ This would mean that the part of the brain pertaining to writing does not seem to correlate a letter that was written by hand with one that was written on a keyboard. By continuously repeating words on paper, handwriting influences the motor-orthographic processes needed to remember words, and use them in written pieces. When children gain a good grasp of handwriting and write words down more or less automatically, they will have more room to focus on their own ideas and composition of the text without struggling with the words and spelling. If children are not able to use

⁵⁸ V. Beminger et al, 'Comparison of Pen and Keyboard Transcription Modes in Children With and Without Learning Disabilities', p. 138.

⁵⁹ V. Baaijen, 'The development of understanding through writing', *Groningen Dissertations in Linguistics 107*, (2012), p. 109.

⁶⁰ J. Medwell and D. Wray, 'Handwriting: what do we know, and what do we need to know', *Literacy*, 41 (2007), p. 12.

⁶¹ The University of Stavanger. "Better learning through handwriting." ScienceDaily. ScienceDaily, 24 January 2011. <www.sciencedaily.com/releases/2011/01/110119095458.htm>.

handwriting automatically, they spend much time thinking of the way their writing is perceived, which hinders their time spent thinking on the content of their papers.⁶²

The speed of handwriting is, therefore, not just an advantage in terms of time, but should be taken into consideration when it comes to word production, which will lessen the burden on the working memory of the brain. The working memory is a fundamental cognitive process in the brain, often conceived as a limited-capacity system that is responsible for the processes such as planning, reasoning, comprehension and problem solving.⁶³ As practice eases early processes of writing such as the aforementioned words and spelling, the speed in writing should increase when practice frees the working memory. This speed in writing is also related to quality in writing.⁶⁴

Peeverly, in his article 'The Importance of Handwriting Speed in Adults', argues that handwriting will continue to be important in adulthood when adults are no longer practicing their handwriting daily. While the motor processes of hand movement require more effort for children in primary and even secondary school, and therefore take up more of their time, the speed of transcription continues to slow in older writers. It is this speed that affects the quality and length of the written piece. Even though it is not the motor movement that requires effort in adults, there is another cause that is slowing down their transcription speed. While adult writers are not affected by motor movement, they are affected by their lack of automatism. This automatism is achieved by the daily practice of younger writers. Both speed, length, and quality are stronger in younger students.⁶⁵

As a result of inefficient practice, even college and university students may suffer from the same problems that beginning writers around the age of seven face, such as struggling with composing a written piece and reading comprehension. Students and adults alike who do not practice their handwriting may become stuck on ideas and the composition of their piece, as writing itself takes too long. Continuous practice clears working memory space, improving the speed. By freeing up this working memory,

⁶² S. Cahill, 'Where Does Handwriting Fit In?: Strategies to Support Academic Achievement', *Intervention in School and Clinic*, 44 (2009), p. 224.

⁶³ K. Klein and A. Boals, 'Expressive Writing Can Increase Working Memory Capacity', *Journal of Experimental Psychology*, 130:3 (2001), p. 520.

⁶⁴ S. Peeverly, 'The Importance of Handwriting Speed in Adult Writing', *Developmental Neuropsychology*, 29:1 (2006), p. 200.

⁶⁵ S. Peeverly, (2006), p. 200.

writers are able to work goals like analysing their text and its composition, leading to a better quality of the text. The only difference is that adults are at a much greater risk of decreased writing skills, as children are able to overcome their issues more easily. Children, unlike adults, benefit from the aid of teachers and solve their issues with writing early on by practice. For adults, it will be more difficult to overcome their decreased writing skills as a result of little practice, with writing difficulties as a result.

In comparison with ordinary hand movements, such as drawing a circle, handwriting movements involving characters activate different parts of the brain. Writing the alphabet activates the left superior parietal region, which is responsible for writing, whereas this activation was greatly reduced when drawing a simple circle.⁶⁶ This proves that it is not merely movement that is responsible for the improvement of handwriting, spelling and the memorization of letters, but the particular letter-shape of the movement itself. This makes it seem more plausible that typing cannot replace handwriting, because the same movements are not involved in typing. As only handwriting movement is responsible for the improvement of character recognition and writing, it is therefore considered to be more important than typing.

3.2 Working memory in handwriting

Repeated handwriting is not an uncommon tool for studying. Repeating words on paper is a common strategy for studying when it comes to tests. Students write summaries by hand, or repeat the words required for the test on paper, in order to memorize them. The previous sections discussed the motor movements involved in handwriting, and the added benefits of handwriting as opposed to typing, this section will expand on those topics by discussing how handwriting is associated with memory and memorizing written forms and better than typing.

In the previous chapter on character recognition it was discussed that the motor knowledge acquired from handwriting significantly contributes to the recognition of letters. This supports the argument that the physical act of writing provides an additional layer of memory which is not found in typing.⁶⁷ Handwriting, as opposed to

⁶⁶ P. Beeson, S et al, (2003), p. 657.

⁶⁷ T. J. Smoker, C. E. Murphy, and A. Rockwell, 'Comparing Memory for Handwriting versus Typing', *Proceedings of the Human Factors and Ergonomics Society 53rd Annual Meeting*, 2009, p. 1744.

typing, requires a different set of movements. And it is not just letters, but the recognition of words too that may be affected. Writing by hand involves unique movements for each letter, whereas typing will be mostly repetitive. When a writer is typing he is mostly reading the letters on screen, as he is not physically involved in writing the letter and all the characters in typing involve the same tapping movement. On a keyboard, there are no different movements required for different letters. Naka and Naoi found that undergraduate students, both Japanese and American, learned characters better by writing them than by reading them.⁶⁸ Furthermore, the memory for typed words is relatively poor in comparison to that for those which were written by hand. Smoker et al. tested whether remembering words was different from recalling letters when it came to handwriting versus typing. Participants were distracted before the test was taken, so they could not rehearse the words or influence the results in any way. They were also required to learn words that were not semantically related, in order to improve the results of the test. Their research concluded that those learning words through typing recalled words incorrectly more frequently than those who wrote them down by hand. It also showed that performance on the recognition of words was significantly better in handwriting than it was in typing. While being by no means conclusive, and requiring further evidence for the claims proposed, handwriting did not only improve the recollection of letters, but also of entire words.⁶⁹

A traditional way for Japanese children to learn both their kanji and hiragana is to repeat writing characters over and over. In a research by Naka, young subjects were required to test whether the ability to memorize words was due to the stroke-order in kanji, or whether it came from the repetition in writing. The experiment had them write down Arabic words, which would be difficult to replicate in a similar manner as kanji. The results showed that it was the repetition of writing, and not simply remembering the stroke order of particular letters and words, that made the memorization of these possible.⁷⁰

⁶⁸ M. Naka, 'Repeated writing facilitates children's memory for pseudocharacters and foreign letters', *Memory & Cognition*, 26:4 (1998), p. 804.

⁶⁹ T. J. Smoker, C. E. Murphy, and A. Rockwell, 2009, p. 1746.

⁷⁰ M. Naka, (1998), p. 808.

Note-taking, a common memory aid when listening to lectures, has until now mostly been done by handwriting.⁷¹ The same is true when it comes to written summaries, which are mostly written by hand in order to memorize the words. While held true for many students, is there any value to writing by hand instead of typing when it comes to memorizing? According to linguists Boch and Piolat, note-taking is primarily used to record information but also retain this information whether those written notes are diaries, grocery lists, or lecture notes. The most common feature of note-taking is that it is used as a way to store information and remember it for later use.⁷² Much like the speed of writing will free up the working space of the brain, note-taking also makes memorization easier by freeing up this working space. In this way writers can focus on other aspects of studying or writing. Note-taking itself is already part of the memorization process, according to Boch and Piolat. Highlighting is more important than skimming over a text, and re-writing, in turn, is better than highlighting. Both these actions require movement of the hand. When it comes to typing, this becomes more difficult. Highlighting then becomes a simple click of the mouse, and rewriting can simply be copied onto a screen. Judging by the previous sections on memory, even if a person would repeatedly type characters and words on screen, it would be remembered less well.

Comparing typing to handwriting continues to show that handwriting is involved in a memorization process that is less apparent when it comes to typing. Typing involves singular movements which are the same for each letter, whereas the movement involved in handwriting shows more retention when it comes to letters and word memorization. It both frees up the working memory, but also helps in remembering the words written down.

3.3 Success in school

Having discussed the importance of handwriting when it comes to the differences in writing execution from typing and the importance of memory involved in handwriting,

⁷¹ S. Peeverly, P. Vekaria, L. Reddington, J. Sumowski, K. Johnson, and C. Ramsay, 'The Relationship of Handwriting Speed, Working Memory, Language Comprehension and Outlines to Lecture Note-taking and Test-taking among College Students', *Applied Cognitive Psychology*, 27 (2013), p. 115.

⁷² F. Boch and A. Piolat, 'Note Taking and Learning: A Summary of Research', *The WAC Journal*, 16 (2005), p. 102. <<http://wac.colostate.edu/journal/vol16/boch.pdf>>

this section will discuss whether these differences have an impact on schools. It will discuss the average success of children and students who have poor handwriting, and those who are good at handwriting.

It has been made clear that handwriting is important for the memory, and that it is harder for adults to rectify a lack of practice and mistakes as a result, much harder than it is for children. But how do children who write badly differ from their peers? On average between ten and thirty percent of all children struggle with handwriting.⁷³ Children with poor handwriting skills do less well in schools than peers with good handwriting skills. Not only do they make errors in the composition or spelling in childhood, but these mistakes also predict their later academic ability in both reading and handwriting.⁷⁴ This lesser performance may also include a low verbal IQ, lower mathematical skills and increased attention difficulties compared to their peers. Though learning difficulties are usually assumed to be the underlying cause of both bad handwriting and other tasks, it is problems with handwriting that are partially causing these issues. Children who struggle with handwriting will struggle to keep up with the written work required of them and therefore perform badly in other areas. Additionally, work written in eligible handwriting will be graded higher than unintelligible handwriting, no matter the content as said in chapter 2. This reflects badly in a student's performance overall, even though it is largely the bad handwriting that leads to a bad performance overall.

In an experiment to discover which finer motor skills were involved in a child's academic success, Grissmer et al. noted that of all the finer motor skills tested in kindergartners, copying an image and utilizing a writing utensil proved to be a stronger predictor than any other motor skill.⁷⁵ Handwriting boosts writing, spelling, reading and math. In a study conducted by Laura Dineheart, four-year-old children who did well in finer motor tasks such as handwriting, later also showed higher scores in reading and math tests.⁷⁶ Not only did reading and math improve in children who were good at handwriting, but another study also found that only proper instruction in handwriting

⁷³ K. Feder and A. Majnemer, 'Handwriting development, competency, and intervention', *Developmental Medicine & Child Neurology*, 49:4 (March 2007), p. 313

⁷⁴ Feder and Majnemer, 'Handwriting development, competency, and intervention', p. 313.

⁷⁵ L. Dinehart, 'Handwriting in early childhood education: Current research and future implications', *Journal of Early Childhood Literacy*, (2014), p. 6.

⁷⁶ B. Harris, 'Handwriting skill enhances all learning', *The Commercial Appeal*, 2014.

could boost children's academic success. This success is partially attributed to a higher quality of written texts by children who do well in handwriting, amongst the subjects mentioned earlier. Unlike adults, clear writing instruction could benefit children in the long run and improve on their struggles with handwriting as well as their future academic success.

3.4 Conclusion

Students who write by hand appear to benefit from more advantages compared to those who type. By handwriting students are able to comprehend texts better but are also able to compose better texts by writing longer and more extensive sentences. The automaticity of handwriting also ensures that a student spends less time worrying about spelling and grammar, and can spend more time on their piece alone. Speed in handwriting therefore also frees up the working space of the brain. Along with the advantages when it comes to text-composing, note-taking by hand proved to be beneficial when studying as it stimulated the retention of the information learned.

Students who had better handwriting than their peers did better academically, because handwriting also stimulated a better performance in other subjects. Those who struggled with handwriting also struggled with their homework, leading to a worse performance and a lower self-esteem. Practising handwriting could therefore be beneficial in order to achieve better school results. Memory especially seemed to do better in handwriting than it did in typing: students were able to pick up on new characters better when they were taught by handwriting than when they learned them by typing. Not only were students able to remember their characters, but they were also able to write them down, a feat that was not accomplished by typing alone.

Learning characters by repeatedly writing them by hand is still a method practised by younger students and not without good reason. Whereas typing seems to benefit students when it comes to speed and easy deletion, it is handwriting that provides an additional layer of memory and stimulates students' motor movement and working memory. Handwriting remains important for purposes of execution when it comes to writing essays and assignments, but also for academic achievement and memory purposes.

4. The connection between handwriting and literacy

Having discussed the importance of handwriting in the previous chapter, this chapter will expand on the importance of handwriting by looking at the connection between literacy and handwriting. In this chapter it will become clear how handwriting specifically relates to the ability to both read and write, and make clear that typing or other methods of writing are not a replacement for handwriting.

4.1 How are reading and writing related?

First is it important to establish the connection between reading and writing in general. Because both reading and writing are language processes it assumed that they are logically connected. However it is only recent research done by Giovanni Parodi on the relationship between reading and writing in 2006, and the 2013 research by Debra McCarney et al. on how poor handwriting relates to poor literacy, among others, that have contributed to determining the exact nature of this relationship which will be explained further into this chapter.

As mentioned in the first chapter on the slow decline of handwriting, there is a decline in the both reading proficiency and writing proficiency. Both students' comprehension and production levels are below standard, which sparked a concern for current reading and writing trends.⁷⁷ Taking England as an example, a major study by the OECD in 2013 showed that the literacy levels of England's young adults were falling, and they were doing worse in comparison to their European and Asian peers.⁷⁸ The results are going backwards, young people are doing worse than their elders presently and there has been no improvement. Even though it signifies that literacy for some countries is improving, it also shows that the literacy is declining in western countries such as the United Kingdom, which has always been thought of as one of the leading countries in Europe. The report concluded that the stock of skills available in

⁷⁷ G. Parodi, 'Reading-writing connections: Discourse-oriented research', *Reading and Writing*, 20 (2007), p. 226.

⁷⁸ S. Coughlan, 'England's young adults trail world in literacy and maths', *BBC News*, 9 October 2013 <<http://www.bbc.com/news/education-24433320>>.

England is bound to decline unless considerable action is taken.⁷⁹ While extensive research elucidates the causes behind this underachievement, many questions remain unanswered. While previously the understanding and production of written texts were treated as separate processes, recently most of the research pertaining to these subjects concerns their underlying relationship. Reading was treated as a receptive skill, whereas writing was treated as an active skill, a producing skill. As a result, both of these processes were taught separately.⁸⁰

While much of the research came out in the late nineties, there is one study produced by Stotsky in 1983 that provided significant results. Stotsky presented a variety of case studies where reading and handwriting were correlated, particularly those carried out even in the sixties and seventies, which came out of with highly significant correlations. Stotsky was one of the first researchers who provided evidence that better writers tend to read more than poor writers do, and that those well-read typically produce better texts.⁸¹ Even though he was one of the earliest researchers in this field, his research was still considered highly experimental even fifteen years later. As a result, most of the research pertaining to this subject was limited in its form.

It is because the concepts of discourse, comprehension, and production have greatly changed these last few years that they have allowed for the possibility of research into the correlations between reading and writing. Today there is little doubt amongst researchers that reading and writing are related. In a study conducted by Parodi in 2007 the main focus was to assess these correlations between reading and writing. Four hundred thirty nine students, all fourteen years of age, were required to write argumentative texts, following certain guidelines pertaining to the nature of the text, and to read argumentative texts in turn. The texts were based on subjects that the students were familiar with. A first result of the research was that reading and writing were both perceived to be equally difficult: 59.9 percent of the students found problems with the

⁷⁹ R. Garner, 'British education in crisis? Literacy and numeracy skills of young people in UK among lowest in developed world', *The Independent*, 8 October 2013
<<http://www.independent.co.uk/student/news/british-education-in-crisis-literacy-and-numeracy-skills-of-young-people-in-uk-among-lowest-in-developed-world-8866117.html>> (20 June 2014).

⁸⁰ G. Parodi, pp. 227.

⁸¹ G. Bas, 'Correlation Between Elementary Students' Reading Attitudes and Their Writing Dispositions', *International Journal of Global Education*, 1:2 (2012), p. 1
<<http://www.ijseg.org/ojs/index.php/ijge/article/viewFile/40/80>>

reading, whereas 60.3 percent had difficulties with the production of the texts. While these results did not prove the correlation yet, it did show that many students struggled with reading and writing. However this particular correlation of difficulty appeared in different forms. If handwriting shows a connection to reading, this is a good argument as to why it would be better for children to learn handwriting than it would be for them to learn typing.

When texts became more abstract, there was a drop in achievement for both comprehension and composition, a likely result of students having a better short-term memory at this age. Because of the difficulty of the text students remembered even less. So when the students had to write about a more difficult text, they simply forgot their main idea and quickly jumped from one thought to the next. The same is true for reading, where the information was not retained long enough for students to answer questions about the text correctly. The more abstract the text, the more difficult it was for the students to retain the information and they forgot about most of the text. Both of these results are helpful when it comes to understanding the connection between writing and reading. Poor readers generally have not practised the retention of information well and focus only on a few ideas, much like poor writers do and which result in poor composition skills. In contrast, good readers who have practised better reading strategies and trained their memory capacity are more capable of composing texts and hold a better overview of their ideas. Those who practise with handwriting and reading, will soon be able to read more difficult texts and write more difficult pieces. Good reading and good writing correlate on this scale, which would therefore suggest that teachers should provide lessons on reading and writing both.

4.2 Emergent literacy skills as a foundation for handwriting

One of the first words that children can write is their own name. Name writing has shown to be a strong indicator of a child's early literary skills, by showing their early knowledge of the alphabet and their phonological awareness.⁸² A child's early literacy skills include alphabet knowledge, phonological awareness, recognition of print

⁸² C. S Puranik, C. J. Lonigan, and Young-Suk Kim, 'Contributions of emergent literacy skills to name writing, letter writing, and spelling in preschool children', *Early Childhood Research Quarterly*, 26 (2011), p. 466.

characters and name writing. Some literacy researchers therefore consider name writing to be the first step into a child's literacy development. Reading may begin with a purely visual stage, where children copy the letters that they see on paper.⁸³ This is also their first attempt at writing.

Children appear to read words in the pre-reading stage by trying to determine the context. The context is not restricted to the text itself, but may also involve a social context. Think, for instance, of a parent rewarding the child for connecting the picture in a book to the matching sentence. Children begin to associate the pictures in books with the sentences their parent reads, and consequently repeat them to earn their reward. While this gives the impression that children are able to read, they have simply learned to connect the picture to an utterance. In this way, children are only able to read words by knowing what they mean contextually.

In order for children to be able to recognize words out of context, they need to focus on the letters of the words themselves. This requires them to develop an awareness of individual letters and to recognize their shapes. Both of these are also included in handwriting, where children are becoming aware of the shape of the letters themselves. Before this process, children are not able to detect spelling errors in words, which seems to get significantly easier after children are learning each letter individually. Spelling is therefore also connected to reading. The reason for the relationship between spelling and reading is that they both share a phonological awareness.⁸⁴ Because English is typically not a language that translates well to script, as the sounds of words do not always correlate with the spelling, an improvement in spelling would also mean an improvement of this phonological awareness. Spelling is improved by repeating to write a word by hand repeatedly, in order to familiarize children with the letters but also with the spelling of words. Early reading skills, including knowledge of the alphabet and letter shapes but also letter-sound knowledge, contribute to writing ability in English.⁸⁵

⁸³ R. Blair and R. Savage, 'Name Writing but not environmental print recognition is related to letter-sound knowledge and phonological awareness in pre-readers', *Reading and Writing: An Interdisciplinary Journal*, 19 (2006), p. 992.

⁸⁴ K. Ritchey, 'The building blocks of writing: Learning to write letters and spell words', *Reading and Writing*, 21:1-2 (2008), p. 29.

⁸⁵ K. Ritchey, p. 42.

This discovery resonates with other research, conducted with Chinese children. As has been previously mentioned, the copying of words in writing makes it easier for a person to master it. This process is especially true when it comes to Chinese. What is interesting however is that copying in Chinese was uniquely associated with being able to read.⁸⁶ Tan et al. researched this by having Chinese children of the ages 7 and 8 years of age copy written characters from samples as quickly as possible, but also being asked to name printed digits.⁸⁷ It demonstrated as a result that writing performance was strongly associated with Chinese reading in both beginning and intermediate readers. In other words, children who are less familiar with print, and therefore written words, are poor readers in comparison to those who do practise with print. Children who write normally but have a reading disability are very rare, but children who read normally and still make spelling errors are much more frequent.⁸⁸ This only goes to show that those who have practised their writing well will find fewer difficulties in reading than those who only focus on reading by itself. While those who read well are doing fine in reading, they may find themselves having difficulties with writing. Difficulties in writing can be enhanced with practice in writing, just as much as the research above seems to suggest that reading too can be improved by writing.

4.3 Impact on reading through the use of electronics

According to research done by Martin et al. in 2003, the reading ability of children in Sweden in the age category of 9 and 10 years old has gone down between 1991 and 2001. In ten years time, the reading ability of children had significantly decreased by three percent, meaning that three percent less than ten years before is able to read well.⁸⁹ The same is true for the United States, where there has been a decline in reading

⁸⁶ C. McBride-Chang, K. Chung, and X. Tong, 'Copying skills in relation to word reading and writing in Chinese children with and without dyslexia', *Journal of Experimental Child Psychology*, 110 (2011), p. 423.

⁸⁷ L. Tan, J. Spinks, G. Eden, C. Perfetti, and W. Siok, 'Reading depends on writing, in Chinese', *Proceedings of the National Academy of Sciences of the United States of America*, 102:24 (2005), p. 8781.

⁸⁸ G. Pinto, L. Bigozzi, B. Gamannossi, and C. Vezanni, 'Emergent Literacy and Early Writing Skills', *The Journal of Psychology*, 173:3 (2012), p. 349.

⁸⁹ A. Folkesson and L. Swalander, 'Self-regulated learning through writing on computers: Consequences for reading comprehension', *Computers in Human Behavior*, 23 (2007), p. 2489.

between 1982 and 2002.⁹⁰ While this alone may not be convincing, and does not evidently name a cause, it does show that literacy may actually be going down in the present age. While it is expected that literacy will only increase, this era too faces challenges that may impact the literacy of people.

Recently, in a study conducted by the UK National Literacy Trust in 2011, researchers found that 52 percent of children preferred to read books on an iPad or tablet whereas only 32 percent would rather read a physical book and the remaining numbers do not have a preference.⁹¹ While children generally mentioned that they enjoyed reading as an activity, over 50 percent, this number decreased as children got older. The same was true for enjoyment in writing.⁹² If this is combined with an increasing need for typing, which has been shown to have a lesser effect on a child's ability to read letters, the consequences for the future literacy of children could be perilous.

The problem of a decreasing literacy does not solely lie with children because approximately 50 percent of the United States' adults proved to score on the two lowest out of four categories of literacy and only 13 percent scored at the highest level of literacy, the National Assessment of Literacy reported in 2003.⁹³ These categories included below basic, basic, intermediate and proficient. However, proficient meant that adults were able to perform more complex activities, possibly by being able to analyse a text. With the current research showing that children and adults need to be able to do more with their texts than basic reading, the fact that only 13 percent of American adults is able to do this is alarming. When only 50 percent of adults are able to read at a very basic level, this means that they are very literate by today's standards. It shows that, should children continue not being able to read or write well, their literacy will simply worsen or stay at a low level. This is therefore a nationwide problem that could be

⁹⁰ 'Reading At Risk: A Survey of Literary Reading in America', *The National Endowment for the Arts*, 2004, p. x. <<http://arts.gov/sites/default/files/ReadingAtRisk.pdf>>

⁹¹ <http://www.literacytrust.org.uk/media/5371_children_s_on-screen_reading_overtakes_reading_in_print> (4 August 2014).

⁹² C. Clarke and J. Douglas, 'Young People's Reading and Writing An in-depth study focusing on enjoyment, behaviour, attitudes and attainment,' 2011, p.15 <http://www.literacytrust.org.uk/assets/0001/0177/Attitudes_towards_Reading_Writing_Final_2011.pdf> (August 4 2014).

⁹³ <<http://nces.ed.gov/fastfacts/display.asp?id=69>> (25 June 2014).

solved by improving a child's literacy early on so that they will not experience this issue when they are adults.

4.4 Improving literacy

Much like the discussion of children and their low performance when it comes to writing, the international benchmark on literacy states four levels: low (locate and retrieve information), intermediate (make straightforward references), high (make inferences and interpretations with text-based support), and advanced (integrate ideas and information across texts to provide reasons and explanations).⁹⁴ In first world countries, only twenty percent of the population ranks in the advanced literacy state, which is a good indication that both countries and individuals should always strive for a better literacy rate.

Primary school seems to be essential when it comes to learning how to write and read. These are the years that a child's linguistic abilities develop. A connection between handwriting fluency and reading has been repeatedly established by teachers in the first grade and kindergarten.⁹⁵ Those students who were able to mimic the alphabet and write down all 26 characters were the same students that were able to follow up on reading instructions and scored higher than their fellows who could not. Conversely, those students who could not write those characters down, were perceived to be slow in reading and their reading development was found to be lagging. So in order to prevent adults from having trouble reading, it is in one's primary school years that this can be prevented. These first years will be effective on students' life-long literacy.⁹⁶

4.5 Neurological connections between reading and handwriting

Handwriting occupies 30 to 60 percent of a child's day in elementary school. This would make it seem that, in order for them to do well in school, they will have to write well and adequately. However, the truth is not as positive as that. Between 10 and 30 percent

⁹⁴ A. Genlott, A. Grönlund, 'Improving literacy skills through learning reading by writing: The iWTR method presented and tested', *Computers & Education*, 67 (2013), pp. 98-104.

⁹⁵ R. Nelson, 'Handwriting Fluency for Literacy', *Peterson Directed Handwriting*, 2012, <http://www.peterson-handwriting.com/Publications/FluencyProject_Print.pdf>

⁹⁶ F. Kirmizi, 'The relationship between writing achievement and the use of reading comprehension strategies in the 4th and 5th grades of primary schools', *Procedia Social and Behavioral Sciences*, 1 (2009), p. 233.

of all children struggle with handwriting, this can increase the difficulty of homework and negatively influence their attitude towards writing in general. However, studies have shown that learning how to write can improve letter perception and reading. So having difficulties with handwriting will affect more than just students' handwriting. It will also influence their reading abilities.

While handwriting can improve a child's academic abilities, while those with poor handwriting take longer to complete tasks, the quality of a child's handwriting also shows connections to other language-related skills.⁹⁷ Such skills include the improvement of letter perception, and in turn therefore also improves word reading.. But this is still applicable when it comes to unfamiliar characters, such as those from a different character system like Chinese or Korean. Western children are still able to pick up on these languages more easily when learning its characters by repeatedly writing them on paper. These findings correspond with those found in children with developmental dyslexia. In a study done by McBride-Chang et al. all Chinese children were tested on their copying skills of Chinese characters. They had difficulties with writing the characters down, as had been expected, but they also experienced problems with reading. Those without dyslexia encountered no difficulties when reading a text, as much as they had no difficulties copying the Chinese characters. The research showed that those with slower handwriting, and in this case dyslectic children, had difficulties in the visual-motor integration. These difficulties also affected their ability to read well⁹⁸.

Even though typing has become as much part of daily life as reading has always been, studies, such as the one by Cunningham,⁹⁹ have shown that typing does not support reading acquisition as much as handwriting practice does.¹⁰⁰ Because the movement involved in letter writing helps children establish the properties attached to a

⁹⁷P. Gimenez, N. Bugescu, J. M. Black, R. Hancock, K. Pugh, M. Nagamine, E. Kutner, P. Mazaika, R. Hendren, B. D. McCandliss, and F. Hoeft, 'Neuroimaging correlates of handwriting quality as children learn to read and write', *Frontiers in Human Neuroscience*, 2014, p.1
<<http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00155/abstract>>

⁹⁸ C. McBride-Chang, K. Chung, and X. Tong, 'Copying skills in relation to word reading and writing in Chinese children with and without dyslexia', *Journal of Experimental Child Psychology*, 110 (2011), pp. 431.

⁹⁹ A. Cunningham and K. Stanovich, 'Early spelling acquisition: Writing beats the computer', *Journal of Educational Psychology*, 82 (1990), pp. 159–162.

¹⁰⁰ M. Longcamp, M. Zerbato-Poudou, and J. Velay, 'The influence of writing practice on letter recognition in preschool children: A comparison between handwriting and typing', *Acta Psychologica*, 119 (2005), p.70.

letter, these will aid children in recognizing these letters when reading. The speed and accuracy with which pre-schoolers name letters is a better indication of reading abilities later on than phonological knowledge of the relationship between letters and sound.¹⁰¹ This resonates with the theory of Ferdinand de Saussure in which he argued that words primarily consist of sound images and meaning and are identified by their contrasting meaning from other words. Sound images are the sensory impression that the words, or in this case letters, have left on the user such as by writing them down. In other words, when children name letters they are aware of the differences with other letters but not of their phonological properties.¹⁰²

Recent studies by Longcamp et al. and James et al., which have investigated the role of motor practice on letter recognition, suggest that adults benefit from handwriting practice when it comes to letter recognition.¹⁰³ In this way, when a child reaches adulthood, there will be few difficulties in recognizing letters. When adults write or read their letter recognition is little to not affected by font, type, or size because in childhood they will have made these letters their own with handwriting. In this same line, neuroimaging studies showed that visual recognition of letters only activated motor regions of the brain when letters were trained by handwriting, but not when they were trained by typewriting.¹⁰⁴

Learning how to write on a computer, which has a limitless set of fonts and sizes, may prove to be detrimental to the developing pre-literate brain. Handwriting is different for each person; it is an individual, personal style. When it comes to writing on a computer, these letters are no longer individual, making it more difficult in theory for a person to recognize different shapes when they are used to a particular font type. In other words, letter recognition and reading benefit from handwriting practice.

Skilled reading, in part, relies on the representation of words that are accessed through written forms. In Chinese, the strokes of characters are heavily associated with the word-meaning, as these characters are associated with word meaning and not word units. Chinese characters are not broken up into parts like the alphabet but broken up

¹⁰¹ K. James and L. Engelhardt, 'The effects of handwriting experience on functional brain development in pre-literate children', *Trends in Neuroscience and Education*, 1 (2012), p. 32.

¹⁰² <<http://faculty.smu.edu/nschwartz/seminar/Saussure.htm>> (21 June 2014).

¹⁰³ K. James and L. Engelhardt, p. 33

¹⁰⁴ M. Kiefer and N. Trumpp, 'Embodiment theory and education: The foundations of cognition in perception and action', *Trends in Neuroscience and Education*, 1 (2012), p. 16

into strokes.¹⁰⁵ As Chinese children learn character reading alongside character writing, they will associate the stroke sequences and therefore the movement involved with the word being written. Repetition will serve the character recognition for a long period of time . An experiment with adult learners of Chinese, who would learn the language as a second language, has shown once more that instruction through writing provided better results than typing. But also that those who participated in even one session of handwriting, improved their recognition of Chinese characters.¹⁰⁶

Handwriting is also assumed to be closely related to reading because the embodiment theory mentions that both movement and sensory experiences, which are both activated during handwriting, are assumed to be implicitly activated during reading.¹⁰⁷ The same part of the brain that is activated during handwriting is also activated when reading. This is because of the letters involved in reading, which have been learned through handwriting, and can therefore be retrieved from memory.

Even though handwriting is a good foundation for reading, the opposite also appears to be true. In a survey by F. Kirmizi, it tested the connection between writing abilities and reading by having students use reading comprehension strategies. Such strategies included summarizing, raising questions and concluding the text. The success of the students' writing ended up depending on their comprehensive reading skills. The better students read texts and understood them, the better they were at writing itself. If a student is not an effective reader, they will most likely encounter problems with reading and writing later on, because reading is more than simply seeing characters on page. In order to increase students' success in writing, and improving their literacy, students should learn how to read effectively and understand the text well.

4.6 Conclusion

Literacy appears to be declining, whether this has to do with the use of electronics or not. Both children in the United States and the United Kingdom appear to read less and have a worse literacy level compared to their international peers. Most of the research of

¹⁰⁵ C. Guan, Y. Liu, D. Chan, F. Ye, and C. Perfetti, 'Writing Strengthens Orthography and Alphabetic-Coding Strengthens Phonology in Learning to Read Chinese', *Journal of Educational Psychology*, 103:3 (2011), p. 510.

¹⁰⁶ C. Guan, Y. Liu, D. Chan, F. Ye, and C. Perfetti, p. 517.

¹⁰⁷ M. Kiefer and N. Trumpp, p. 16.

this study was conducted in either of these countries, and showed that they did not perform well enough. Both of these countries also have a large population, and their decreasing literacy rates are a cause for concern. Children prefer to read on iPads even though a lesser percentage of those children enjoy reading as activity, as opposed to those who prefer the physical book. While it does not prove a correlation with a decline in literacy, it is significant to mention. Literacy is not simply low among children but adults as well. In order to improve the literacy of children, it is essential that they work on their handwriting. Handwriting and reading have been proven to be connected to each other and those who write well, also typically tend to read well. The same is true for those who read more often, and therefore produce better texts.

Practice with handwriting will improve a student's reading and writing and will enable them to handle more difficult texts as they progress. Handwriting stimulates being able to read, and is both linked to character recognition and better reading in general. A child's first attempt at reading is done by copying characters on a piece of paper, which seems to resonate with Chinese children where copying characters is associated with reading in general. Copying characters by handwriting stimulates the ability to read.

Primary school is essential when it comes to learning how to write and read, as these are the earliest years in which linguistic skills develop. Should students cease to learn handwriting, or should schools opt for primarily teaching typing instead, their reading ability will suffer. But even adults benefit from handwriting practice, which in turn stimulates their reading. Reading and writing are therefore connected and in order to improve literacy, children should be taught handwriting from an early age onwards.

5. Conclusion

This thesis set out to explore the importance of handwriting and the need for its continued existence in the future. The decline in handwriting triggered the research for this thesis and it has aimed to explore this by looking at different aspects such as the differences between handwriting and typing, and the connection of handwriting to reading. It was designed to determine whether a continued teaching of handwriting was necessary.

The results of this study indicate that handwriting has become less important than it has been in the past; certain countries have already taken steps in the direction of typing and others have abolished the obligatory learning of cursive handwriting. So the concern that teaching handwriting might disappear in the future is certainly legitimate because negative consequences are attached to worse handwriting, such as a worse academic performance.

Handwriting is also a key factor in the recognition of characters and letters, which will aid people in their reading abilities. Even when subjects are not actively writing, the same area that controls motor movement still lights up when they are being shown a picture of a character, further proving that handwriting aids the memory in character recognition. Handwriting therefore supports the ability to remember characters much better than keyboarding does. Handwriting also stimulates a better performance in typing due to the fine motor skills it helps develop. Those who handwrite also have better composition skills and they tend to write more extensive sentences. Both lead to better texts as the automaticity of handwriting improves the working memory of the brain. When studying, handwriting stimulates the memory in order to retain information. This again shows a link to reading abilities and memorization. Finally handwriting is linked to early literacy skills and to both better reading and writing, and it is best if children learn this as early on as possible.

The expectations in this thesis were that handwriting would certainly not be replaced with typing, but that it was in decline and that handwriting had more advantages when compared to typing practice. The result indicates a continued need for handwriting and signify that handwriting remains very important for both young people and adults.

The evidence from this study suggests that handwriting is both more beneficial to literacy, memory and reading than typing is, even though handwriting is considered less important as a skill in its own right. Handwriting should therefore continue to be taught, and typing should not take a primary place in a child's education. Should handwriting cease to be taught, this evidence suggests that it will have major consequences on a child's literacy.

The present study provides a framework for future discussions in the field of handwriting and literacy. While the current study has only looked at the memorization in handwriting and the connection between handwriting and reading, it has provided a groundwork for further investigation and hopefully demonstrated that handwriting should not be an optional part of the curriculum in schools.

Works Cited List

<<http://one.laptop.org/about/mission>> (15 May 2014).

<<http://nces.ed.gov/nationsreportcard/pdf/main2002/2003529.pdf>> (25 May 2014).

<<http://www.textfugu.com/kanji/how-to-learn-kanji/>> (1 June 2014).

< <http://www.dailymail.co.uk/news/article-2325378/Children-read-iPads-Kindles-weaker-literacy-skills-charity-warns.html>> (5 June 2014).

<<http://nces.ed.gov/fastfacts/display.asp?id=69>> (5 June 2014).

<<http://www.census.gov/prod/2013pubs/p20-569.pdf>> (6 June 2014)

<<http://faculty.smu.edu/nschwart/seminar/Saussure.htm>> (21 June 2014).

<<http://www.corestandards.org/about-the-standards/>> (23 June 2014).

<<http://nces.ed.gov/fastfacts/display.asp?id=69>> (25 June 2014).

<http://www.literacytrust.org.uk/media/5371_children_s_on-screen_reading_overtakes_reading_in_print> (4 August 2014).

'Handwriting in the 21st century?', *Saperstein Associates*, winter 2012, pp. 1-7.

<https://www.hw21summit.com/media/zb/hw21/files/H2948_HW_Summit_White_Paper_eVersion.pdf> (20 June 2014).

'Handwriting is beneficial to Children's Cognitive Development', *FYI Living*, 22 February 2011 < <http://fyiliving.com/research/handwriting-is-beneficial-to-childrens-cognitive-development/>> (21 May 2014).

'Handwriting without tears', *HW Tears*, 2013, pp. 1-16.

'Reading At Risk: A Survey of Literary Reading in America', *The National Endowment for the Arts*, 2004, pp. 1-47. <<http://arts.gov/sites/default/files/ReadingAtRisk.pdf>>

'Schools increase technology spend', *ICT for Education*, 5 October 2012
<<http://www.ictforeducation.co.uk/article/schools-increase-technology-spend.html>> (15 May 2014).

'The Importance of Teaching Handwriting in the 21st Century', *Hanover Research*, February 2012 <http://www.zaner-bloser.com/media/zb/zaner-bloser/pdf/hw_hanover.pdf> (19 May 2014).

'Tweede Kamer Steunt iPadscholen', *De Telegraaf*, 8 June 2013
<http://www.telegraaf.nl/digitaal/21633266/_Kamer_steunt_iPadscholen_.html> (15 May 2014).

'Waarom kan en mag typen schrijven niet vervangen', *Platform Handschrift Ontwikkeling*, 22 December 2010
<<http://members.upc.nl/m.otter7/handschriftontwikkeling/Artikelen/Waarom%20typen%20schrijven%20niet%20mag.pdf>> (27 May 2014)

V. Baaijen, 'The development of understanding through writing', *Groningen Dissertations in Linguistics 107*, (2012), pp. 1-262.

V. Baaijen, D. Galbraith, K. de Glopper, 'Effects of writing beliefs and planning on writing performance', *Learning and Instruction*, 33 (2014), pp. 81-91.

A. Balanskat, 'Study of the impact of technology in primary schools: synthesis report', *Steps EACEA*, 2009, pp. 1-54

<http://eacea.ec.europa.eu/llp/studies/documents/study_impact_technology_primary_school/02_synthesis_report_steps_en.pdf> (15 May 2014).

P. Beeson, S. Rapcsak, E. Plante, J. Chargualaf, A. Chung, S. Johnson, and T. Trouard, 'The neural substrates of writing: A functional magnetic resonance imaging study', *Aphasiology*, 17:6 (2003), pp. 647-665.

V. Beminger, R. Abbott, A. Augsburg, and N. Garcia, 'Comparison of Pen and Keyboard Transcription Modes in Children With and Without Learning Disabilities', *Learning Disability Quarterly*, 32:3 (2009), pp. 123-141.

Y. Bi, Z. Han, and Y. Zhang, 'Reading does not depend on writing, even in Chinese', *Neuropsychologia*, 47 (2009), pp. 1193 -1199.

R. Blair and R. Savage, 'Name Writing but not environmental print recognition is related to letter-sound knowledge and phonological awareness in pre-readers', *Reading and Writing: An Interdisciplinary Journal*, 19 (2006), pp. 991-1016.

C. Blazer, 'Should Cursive Handwriting Still Be Taught in Schools?', *Information Capsule Research Devices*, 09:16 (2010), pp. 1-8.

<<http://drs.dadeschools.net/InformationCapsules/IC0916.pdf>> (20 May 2014).

F. Boch and A. Piolat, 'Note Taking and Learning: A Summary of Research', *The WAC Journal*, 16 (2005), pp. 101-113.

<<http://wac.colostate.edu/journal/vol16/boch.pdf>> (6 June 2014).

N. Borges, 'Cursive Handwriting Is Just One Casualty Of Common Core And Modern Education', *WLRN*, 17 February 2014 < <http://wlrn.org/post/cursive-writing-just-one-casualty-common-core-and-modern-education>> (16 May 2014).

- M. Casey, 'Has technology ruined handwriting?', *CNN*, 28 July 2013
<<http://edition.cnn.com/2013/07/26/tech/web/impact-technology-handwriting/>> (20 May 2014).
- S. Cahill, 'Where Does Handwriting Fit In?: Strategies to Support Academic Achievement', *Intervention in School and Clinic*, 44 (2009), pp. 223-228.
- G. Clark, 'The relationship between handwriting, reading, fine motor and visual-motor skills in kindergarteners', *Iowa State University Theses and Dissertations*, 2010, pp. 1-84.
- C. Clarke, 'Children and Young People's Reading Today', *National Literacy Trust*, 2012, pp. 1-60.
<http://www.literacytrust.org.uk/assets/0001/4543/Young_people_s_reading_FINAL_REPORT.pdf> (20 June 2014).
- C. Clarke and J. Douglas, 'Young People's Reading and Writing An in-depth study focusing on enjoyment, behaviour, attitudes and attainment,' 2011, pp. 1-123.
<http://www.literacytrust.org.uk/assets/0001/0177/Attitudes_towards_Reading_Writing_Final_2011.pdf> (August 4 2014).
- S. Coughlan, 'England's young adults trail world in literacy and maths', *BBC News*, 9 October 2013 <<http://www.bbc.com/news/education-24433320>> (20 June 2014).
- G. Cole, 'Rose Report places technology centre stage in primary curriculum', *The Guardian* <<http://www.theguardian.com/resource/rose-report-technology-primary-curriculum>> (15 May 2014).
- A. Cunningham and K. Stanovich, 'Early spelling acquisition: Writing beats the computer', *Journal of Educational Psychology*, 82 (1990), pp. 159–162.

M. Damian, D. Dorjee, and H. Stadthagen-Gonzalez, 'long-Term Repetition Priming in Spoken and Written Word Production: Evidence for a Contribution of Phonology to Handwriting', *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 37:4, pp. 813-826.

S. DeWitt, 'The Effects of Note Taking and Mental Rehearsal on Memory', *Journal of Undergraduate Psychology Research*, 2 (2007), pp. 46-49.

L. Dinehart, 'Handwriting in early childhood education: Current research and future implications', *Journal of Early Childhood Literacy*, (2014), pp. 1-22.

M. Downs, 'Schools debate: Is cursive writing worth teaching?', *Florida Today*, 23 January 2009 <http://usatoday30.usatoday.com/news/education/2009-01-23-cursive-handwriting_N.htm> (19 May 2014).

C. Guan, Y. Liu, D. Chan, F. Ye, and C. Perfetti, 'Writing Strengthens Orthography and Alphabetic-Coding Strengthens Phonology in Learning to Read Chinese', *Journal of Educational Psychology*, 103:3 (2011), pp. 509-522.

K. James and L. Engelhardt, 'The effects of handwriting experience on functional brain development in pre-literate children', *Trends in Neuroscience and Education*, 1:1 (2012), pp. 32-42.

K. Feder and A. Majnemer, 'Handwriting development, competency, and intervention', *Developmental Medicine & Child Neurology*, 49:4 (March 2007), pp. 312-317.

J. Fischer and Y. Tazouti, 'Unraveling the Mystery of Mirror Writing in Typically Developing Children', *Journal of Educational Psychology*, 104:1 (2012), pp. 193-205.

A. Folkesson and L. Swalander, 'Self-regulated learning through writing on computers: Consequences for reading comprehension', *Computers in Human Behavior*, 23 (2007), pp. 2488-2508.

L. Fortunati and J. Vincent, 'Sociological insights on the comparison of writing/reading on paper with writing/reading digitally', *Telematics and Infomatics*, 31 (2014), pp. 39-51.

R. Francis, 'Have computers forced handwriting out of the picture?', *Education World*, 26 June 2008, <http://www.educationworld.com/a_curr/curr241.shtml> (4 July 2014).

J. Francken, 'Schrijven versus typen: wat zegt de neurowetenschap?', *4W*, 15 October 2014, <<http://4w.kennisnet.nl/artikelen/2013/10/15/schrijven-versus-typen-wat-zegt-de-neurowetenschap/>> (21 May 2014).

C. Fried, 'In-class laptop use and its effects on student learning', *Computers & Education*, 50 (2008), pp. 906-914.

R. Garner, 'British education in crisis? Literacy and numeracy skills of young people in UK among lowest in developed world', *The Independent*, 8 October 2013 <<http://www.independent.co.uk/student/news/british-education-in-crisis-literacy-and-numeracy-skills-of-young-people-in-uk-among-lowest-in-developed-world-8866117.html>> (20 June 2014).

A. Genlott, A. Grönlund, 'Improving literacy skills through learning reading by writing: The iWTR method presented and tested', *Computers & Education*, 67 (2013), pp. 98-104.

P. Gimenez, N. Bugescu, J. M. Black, R. Hancock, K. Pugh, M. Nagamine, E. Kutner, P. Mazaika, R. Hendren, B. D. McCandliss, and F. Hoeft, 'Neuroimaging correlates of handwriting quality as children learn to read and write', *Frontiers in Human Neuroscience*, 2014, pp. 1-15 <<http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00155/abstract>>

G. Bas, 'Correlation Between Elementary Students' Reading Attitudes and Their Writing Dispositions', *International Journal of Global Education*, 1:2 (2012), pp. 1-6

<<http://www.ijseg.org/ojs/index.php/ijge/article/viewFile/40/80>>

S. Graham, K. Harris, and B. Fink, 'Is Handwriting Causally Related to Learning to Write? Treatment of Handwriting Problems in Beginning Writers', *Journal of Educational Psychology*, 92:4 (2000), pp. 620-633.

C. Guan, Y. Liu, D. Chan, F. Ye, and C. Perfetti, 'Writing Strengthens Orthography and Alphabetic-Coding Strengthens Phonology in Learning to Read Chinese', *Journal of Educational Psychology*, 103:3 (2011), pp. 509-522.

B. Harris, 'Handwriting skill enhances all learning', *The Commercial Appeal*, 2014.

C. van Hoek, 'Tien iPad scholen openen in augustus deuren', *Nu.nl*, 8 April 2013

<<http://www.nu.nl/internet/3391863/tien-ipad-scholen-openen-in-augustus-deuren.html>> (15 May 2014).

M. Hoskyn and H. Swanson, 'The relationship between working memory and writing in younger and older adults', *Reading and Writing: An Interdisciplinary Journal*, 16 (2003), pp. 759-784.

R. Ivanić, 'Discourses of Writing and Learning to Write', *Language and Education*, 18:3 (2004), pp. 220-245.

K. James and L. Engelhardt, 'The effects of handwriting experience on functional brain development in pre-literate children', *Trends in Neuroscience and Education*, 1 (2012), pp. 32-42.

T. Karsenti and S. Collin, 'Benefits and challenges of using laptops in primary and secondary schools: Results of the second investigation at the Eastern Townships School Board. Summary of main results', 2012, pp. 1-41, Montreal, QC: CRIFPE.

M. Kiefer and N. Trumpp, 'Embodiment theory and education: The foundations of cognition in perception and action', *Trends in Neuroscience and Education*, 1 (2012), pp. 15-20.

F. Kirmizi, 'The relationship between writing achievement and the use of reading comprehension strategies in the 4th and 5th grades of primary schools', *Procedia Social and Behavioral Sciences*, 1 (2009), pp. 230-234.

K. Klein and A. Boals, 'Expressive Writing Can Increase Working Memory Capacity', *Journal of Experimental Psychology*, 130:3 (2001), pp. 520-533.

L. Layton, 'Elementary students learn keyboard typing ahead of new Common Core tests', *The Washington Post*, 13 October 2013
<http://www.washingtonpost.com/local/education/elementary-students-learn-keyboard-typing-ahead-of-new-common-core-tests/2013/10/13/d329ba66-3289-11e3-9c68-1cf643210300_story.html> (15 June 2014).

Y. Lee and J. Wu, 'The indirect effects of online social entertainment and information seeking activities on reading literacy', *Computers & Education*, 67 (2013), pp. 168-177.

M. Longcamp, C. Boucard, J. Gilhodes, J. Anton, M. Roth, B. Nazarian, and J. Velay, 'Learning through Hand- or Typewriting Influences Visual Recognition of New Graphic Shapes: Behavioral and Functional Imaging Evidence', *Journal of Cognitive Neuroscience*, 20:5 (2008), pp. 802-815.

M. Longcamp, M. Zerbato-Poudou, and J. Velay, 'The influence of writing practice on letter recognition in preschool children: A comparison between handwriting and typing', *Acta Psychologica*, 119 (2005), pp. 67-79.

- M. Longcamp, J. Anton, M. Roth, J. Velay. 'Premotor activations in response to visually presented single letters depends on the hand used to write: a study on left-handers.', *Neuropsychologia*, 43:12 (2005) pp. 1801–1809.
- M. Longcamp, C. Boucard, J. Gilhodes, and J. Velay, 'Remembering the orientation of newly learned characters depends on the associated writing knowledge: A comparison between handwriting and typing', *Human Movement Science*, 25 (2006), pp. 646-656.
- G. MacArthur, 'The effects of new technologies on writing and writing processes', in G. MacArthur, S. Graham, & J. Fitzgerald (Eds.), *Handbook of writing research* (New York: Guilford Press, 2006), pp. 248-262.
- D. McCarney, L. Peters, S. Jackson, M. Thomas, A. Kirby, 'Does Poor Handwriting Conceal Literacy Potential in Primary School Children?', *International Journal of Disability, Development and Education*, 60:2 (2013), pp. 105-118.
- A. Mangen and J. Velay, 'Digitizing literacy: reflections on the haptics of writing', *Intech Open*, (2010) <<http://www.intechopen.com/books/advances-in-haptics/digitizing-literacy-reflections-on-the-haptics-of-writing>>
- C. McBride-Chang, K. Chung, and X. Tong, ' Copying skills in relation to word reading and writing in Chinese children with and without dyslexia', *Journal of Experimental Child Psychology*, 110 (2011), pp. 422-433.
- J. Medwell and D. Wray, 'Handwriting: what do we know, and what do we need to know', *Literacy*, 41 (2007), pp. 10-15.
- J. Medwell and D. Wray, 'Handwriting - A Forgotten Language Skill?', *Language and Education*, 22:1 (2008), pp. 34-47.

V. Menon and J.E. Desmond, 'Left superior parietal cortex involvement in writing: integrating fMRI with lesion evidence', *Cognitive Brain Research*, 12 (2001), pp. 337-340.

K. de Medeiros, A. Mosby, K. Hanley, M. Pedraza, and J. Brandt, 'A randomized clinical trial of a writing workshop intervention to improve autobiographical memory and well-being in older adults', *International Journal of Geriatric Psychiatry*, 26 (2011), pp. 803-811.

B. Miller and P. McCaule, 'Reflections on the need for the continued research on writing', *Reading and Writing*, 24 (2011), pp. 121-132.

T. Mudde, 'Het nieuwe leren', *De Volkskrant*, 8 June 2013
<<http://www.volkskrant.nl/vk/nl/2844/Archief/archief/article/detail/3454909/2013/06/08/Het-nieuwe-leren.dhtml>> (15 May 2013).

M. Naka, 'Repeated writing facilitates children's memory for pseudocharacters and foreign letters', *Memory & Cognition*, 26:4 (1998), pp. 804-809.

M. Naka and H. Naoi, 'The effect of repeated writing on memory', *Memory & Cognition*, 23:2 (1995), pp. 201-212.

K. Nakamura, W. Kuo, F. Pegado, L. Cohen, O. J. L. Tzeng, and S. Dehaene, 'Universal brain systems for recognizing word shapes and handwriting gestures during reading', *Psychological and Cognitive Sciences*, 109:50 (2012), pp. 1-6.

S. Neef, J. van Dijck, and E. Ketelaar, *Handwriting in the Age of New Media*, (Amsterdam: Amsterdam University Press, 2006).

R. Nelson, 'Handwriting Fluency for Literacy', *Peterson Directed Handwriting*, 2012,
<http://www.peterson-handwriting.com/Publications/FluencyProject_Print.pdf>

G. Parodi, 'Reading-writing connections: Discourse-oriented research', *Reading and Writing*, 20 (2007), pp. 225-250.

C. Perfetti and L. Harris, 'Universal Reading Processes Are Modulated by Language and Writing System', *Language Learning and Development*, 9:4 (2013), pp. 296-316.

S. Peverly, 'The Importance of Handwriting Speed in Adult Writing', *Developmental Neuropsychology*, 29:1 (2006), pp. 197-216.

S. Peverly, P. Vekaria, L. Reddington, J. Sumowski, K. Johnson, and C. Ramsay, 'The Relationship of Handwriting Speed, Working Memory, Language Comprehension and Outlines to Lecture Note-taking and Test-taking among College Students', *Applied Cognitive Psychology*, 27 (2013), pp. 115-126.

G. Pinto, L. Bigozzi, B. Gamannossi, and C. Vezanni, 'Emergent Literacy and Early Writing Skills', *The Journal of Psychology*, 173:3 (2012), pp. 330-354.

S. Planton, M. Jucla, F. Roux and J. Démonet, 'The “handwriting brain”: A meta-analysis of neuroimaging studies of motor versus orthographic processes', *Cortex*, 49:10 (2013), pp. 2772-2787.

M. Pressler, 'The Handwriting Is on the Wall', *The Washington Post*, 11 October 2006 <<http://www.washingtonpost.com/wp-dyn/content/article/2006/10/10/AR2006101001475.html>> (20 May 2014).

C. S Puranik, C. J. Lonigan, and Young-Suk Kim, 'Contributions of emergent literacy skills to name writing, letter writing, and spelling in preschool children', *Early Childhood Research Quarterly*, 26 (2011), pp. 465-475.

K. Ritchey, 'The building blocks of writing: Learning to write letters and spell words', *Reading and Writing*, 21:1-2 (2008), pp. 27-47.

M. Robinson, 'Children who read on iPads or Kindles have weaker literacy skills and are less likely to enjoy it as a pastime, charity warns', *The Daily Mail*, 16 May 2013. <<http://www.dailymail.co.uk/news/article-2325378/Children-read-iPads-Kindles-weaker-literacy-skills-charity-warns.html>> (4 August 2014).

S. Rosenblum, B. Engel-Yeger, and Y. Fogel, 'Age-related changes in executive control and their relationships with activity performance in handwriting', *Human Movement Science*, 32:2 (2013), pp. 363-376.

F. Roux, J. Durand, E. Réhault, S. Plantona, L. Draper, and J. Démonet, 'The neural basis for writing from dictation in the temporoparietal cortex', *Cortex*, 50 (2014), pp. 64-75.

T. Salthouse, 'Perceptual, Cognitive, and Motoric Aspects of Transcription Typing', *Psychological Bulletin*, 99:3 (1986), pp. 303-319.

I. Schoen, 'Effects of Method and Context of Note-taking on Memory: Handwriting versus Typing in Lecture and Textbook-Reading Contexts', *Pitzer Senior Theses*, (2012), pp. 1-28.

T. Shapiro and S. Voisin, 'Cursive handwriting disappearing from public schools; With new federal standards not requiring cursive handwriting, instruction in it is increasingly rare', *The Washington Post*, 8 April 2013, pp. 1-3.

T. J. Smoker, C. E. Murphy, and A. Rockwell, 'Comparing Memory for Handwriting versus Typing', *Proceedings of the Human Factors and Ergonomics Society 53rd Annual Meeting*, 2009, pp. 1744-1747.

J. Smyth, 'Keep cursive in the classroom? Handwriting has taken back seat to keyboarding, but some states are going "back to basics"', *Associated Press*, (2013), pp. 1-2.

N. Stevenson and C. Just, 'In Early Education, Why Teach Handwriting Before Keyboarding?', *Early Childhood Education Journal*, 42:1 (2014), pp. 49-56.

S. Sülzenbrück, M. Hegele, G. Rinkenauer and H. Heuer, 'The Death of Handwriting: Secondary Effects of Frequent Computer Use on Basic Motor Skills', *Journal of Motor Behaviour*, 43:3 (2011), pp. 247-251.

S. Taipale, 'The affordances of reading/writing on paper and digitally in Finland', *Telematics and Infomatics*, 31 (2014), pp. 532-542.

L. Tan, J. Spinks, G. Eden, C. Perfetti, and W. Siok, 'Reading depends on writing, in Chinese', *Proceedings of the National Academy of Sciences of the United States of America*, 102:24 (2005), pp. 8781-8785.

The University of Stavanger. "Better learning through handwriting", *ScienceDaily*, 24 January 2011. <www.sciencedaily.com/releases/2011/01/110119095458.htm> (29 May 2014).

A. van der Weel, Memory and the Reading Substrate (uncorrected draft), pp. 1-5.

G. Williams and R. Larkin, 'Narrative writing, reading and cognitive processes in middle childhood: What are the links?', *Learning and Individual Differences*, 28 (2013), pp. 142-150.

J. Zubrzycki, 'Experts Fear Handwriting Will Become a Lost Art', *Education Week*, 31:18 (2012), pp. 1-3.