

Handwriting in the middle years

A strategy for academic & professional success

The latest research in handwriting for
middle childhood and adolescence

ZB Zaner-Bloser

Producing Agile Writers

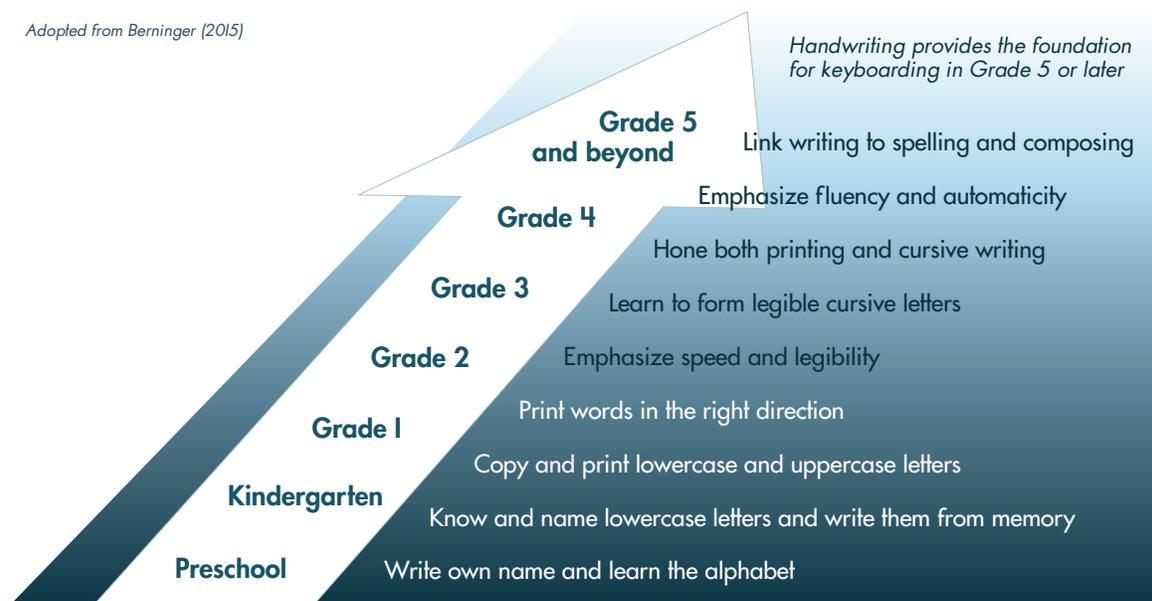
In the course of a day, an elementary or adolescent student may take notes on a lecture, complete written examinations, text on a smartphone, and write their papers and homework at home. By providing handwriting practice and instruction, we produce students whose ideas flow from their hands freely.

Intuitively, teachers understand that handwriting practice reflects not only their students' motor skills but also their cognitive development. Who hasn't witnessed a student's frustration that his pencil can't keep up with his story ideas? Or a student whose writing skills are undermined by illegible handwriting?

Thanks to recent, sophisticated research, we now know that learning to form letters by hand is a critical foundation for students' literacy and academic success. Yet in the Common Core State Standard for English Language Arts, handwriting standards do not appear after Grade 1 and cursive does not appear as a subject of instruction at all. The decision to ignore this foundational literacy skill isn't evidence based. Research results support handwriting instruction starting in the early grades with printing, transitioning to cursive in the second or third grade, and continuing checkups and practice through the middle school years.

The goal of handwriting instruction is not rote practice or busywork for students. Its goal is to produce **agile writers**: students who can fluently compose in manuscript and cursive for their schoolwork and beyond.

Adopted from Berninger (2015)



Why continue handwriting instruction past Grade 3?

Older students still write by hand in school

Speed, legibility, and automaticity in handwriting are still important skills in the 21st century classroom, even in the era of keyboards and smartphones. Letter formation is a key component in reading and writing skills: independently writing by hand helps students learn and memorize letters much more efficiently than does simply tracing, copying, or typing them (Longcamp, Zerbato-Poudou, & Velay, 2005). According to the National Reading Panel, letter knowledge is one of the two best predictors of reading proficiency: the coordinated physical movements required to form letters help students memorize and recognize them when they read. In fact, some researchers suggest the slight variations students make in forming letters help them learn to read the wide range of print styles they encounter in their schoolwork and at home (James & Englehardt, 2012). Clearly, handwriting is proven important for the early years of literacy. It is also important in the later grades.

In the 21st century, students continue to write most assignments and tests by hand—and the Common Core State Standards' emphasis on writing has brought the conversation about writing into language arts classrooms at every level. A 2008 study showed that older students produce at least half of their writing for school by hand, and younger students handwrite nearly 90 percent of their schoolwork. Even in the Common Core State Standards (http://www.corestandards.org/assets/Appendix_C.pdf) document, for example, almost half of the sample K–8 student essays are hand written (Denton, Cope, & Moser, 2006; Cutler & Graham, 2008). The recent report on Grade 8 and Grade 12 writing scores for the National Assessment of Educational Progress found that 61% of eighth grade students reported spending more than 15 minutes each class period writing (National Center for Education Statistics, 2012).

In addition, teachers reported in a recent survey that 24.4% of a student's total grade in middle school and 41.1% of it in high school would be based on writing of at least paragraph length in an end-of-course exam. Fifty-one percent also reported frequent practice in timed, on-demand writing to prepare students for high-stakes tests (Applebee & Langer, 2011). Not only are students still writing by hand for most of their schoolwork, regardless of the availability of computers (one study found that teachers use most of the technology in the classrooms and students use it mostly for finding resources online; Applebee & Langer, 2011)—they also do more writing in preparation for assessment.

Handwriting continues to develop beyond the early elementary years

Handwriting fluency continues to develop past the early grades. Studies show that direct instruction measurably improves students' handwriting legibility and fluency through Grade 9; in addition, the overall quality of writing and the length of writing passages also increase (Graham & Santangelo, 2012; Pontart et al., 2013). Handwriting skills develop over time; one recent research study suggests that older students' handwriting is more related to their orthographic knowledge

[H]andwriting, when reassessed throughout elementary school, was found to be variable from year to year, especially after third grade when formal handwriting instruction ceases

—Alstad et al., 2015

rather than their fine motor writing skills because their knowledge of how to produce letterforms has become automatic (Pontart et al., 2013). This automaticity is important for students' continuing academic success: they can use the stored memory of how words look in order to write them fluently (as well as recognize new words as they encounter them). In the upper elementary grades, phonological skills continue to underlie both reading and writing; students aren't "finished" with language learning in Grade 2 or 3 (Del Campo, Buchanan, Abbott, & Berninger, 2015; Berninger & Abbott, 2010). Research results show that fluency in handwriting is strongly

related to the quality and quantity of students' complex written text as late as Grade 8 (Christensen & Jones, 2013).

Developing greater automaticity in producing text can be especially helpful during the ages of 8 to 18 when a student's prefrontal cortex—which houses the executive functions of judgment, critical analysis, induction, deduction, prioritizing, organization, and creative problem solving—develops rapidly (Willis, 2011). Some evidence suggests that students' increasing sophistication in processing language can be harnessed to augment handwriting fluency. For instance, typically developing middle elementary students process words in units of syllables, rather than a sequence of letters, and the syllable structure of words can affect handwriting in both students and adults (Lambert, Sausset, & Rigalleau, 2015). Generally, adults handwrite with a pattern that suggests the words are processed as groups of writing-specific syllables, often called the "ortho-syllable": they tend to pause slightly in between groups of these ortho-syllables. These results suggest that as a student develops writing skills, he or she is composing with writing-specific units rather than series of letters: automaticity in handwriting (especially cursive) bolsters the production (and therefore the recognition) of these groups.

Handwriting supports academic achievement

Because they are writing in school, handwriting difficulties can affect students' academic work in myriad ways in the later elementary grades and middle school. Students who struggle with writing by hand will avoid writing tasks; this avoidance means that they do not enjoy the same results from composing, they compose less, and they struggle with spelling because of a lack of practice (Montgomery, 2012). They may also suffer a loss of self-esteem because they are seemingly outpaced by their peers who complete classroom written work more quickly (Feder & Majnemer, 2007). In addition, the demonstrated educational benefits of using writing to understand, remember, and reflect on what they've learned are less available as an academic strategy to students who struggle to match the speed of their writing to the speed of their thoughts.

Lacking handwriting fluency can leave students with poorer composing skills when they express themselves in written text (Longcamp, Zerbato-Poudou, & Velay, 2005), and handwriting fluency strongly predicts students' ability to produce more complex written text (Christensen & Jones, 2013). Many studies also show that strengthening students' handwriting skills leads to an increased quality of their written compositions (Graham, Harris, & Fink, 2013). When students write automatically, without having to stop and think about the specific letters they form, they can focus instead on constructing sentences and getting their ideas on paper. They produce more writing and longer compositions (Medwell, Strand, & Wray, 2009). Researchers surmise that this fluency decreases students' cognitive load, freeing up their short-term working memory for higher level composing tasks.

As students advance in school, test-taking and note-taking increase in most academic subjects

Legible, fluent handwriting is important to attaining academic success for all students. Nowhere is handwriting fluency more consequential than in timed-writing assignments and tests, where students may feel they are caught between completing the task and making their results legible.

The quality of students' handwriting affects the evaluations of students' written work in high-stakes tests and class assignments throughout their career. Poor or illegible handwriting influences standardized test scores: solid research

Your essay must be written on the lines provided on your answer sheet—you will receive no other paper on which to write. You will have enough space if you write on every line, avoid wide margins, and keep your handwriting to a reasonable size. Remember that people who are not familiar with your handwriting will read what you write. Try to write or print so that what you are writing is legible to those readers.

—College Board SAT Writing Practice

finds that handwritten essays are graded differently based on the legibility of the handwriting (Graham & Harris, 2002; Conti, 2012; Vander Hart, Fitzpatrick, & Cortesa, 2010). Poor handwriting can drop a paper from the 50th percentile to the 10th or 22nd percentile even when the essay contains the same content (Graham, Harris, & Herbert, 2011). Essay graders of handwritten standardized tests read more than 100 essays an hour, making legibility even more important for these high-stakes tests (ACT, 2011).

The impact is felt beyond language arts writing assignments; students' poor handwriting can also affect their scores in mathematics and computer science courses throughout their secondary and postsecondary careers (Awasekar & Halkude, 2015). In one study, engineering essays demonstrating legible handwriting

If students cannot write mathematical signs well, it may ultimately result in their inability to copy information legibly in their notebooks and this could possibly slow down their academic progress.

—Oche, 2014

resulted in better test scores—even though the content of the answers was exactly the same (Awasekar & Halkude, 2015). Students' mathematics tests can be compromised if they cannot form mathematical signs legibly or communicate with their teacher by showing their reasoning (Oche, 2014). The results of timed tests in particular are subject to students' handwriting according to both

teachers and students themselves, especially if slow writing speed compromises students' ability to complete a test (Oche, 2014).

Taking notes on teacher presentations is a complex task, and a student's handwriting fluency is necessary for successful note-taking. A series of research studies on student note-taking found important links between transcription speed and the quality of written notes—and the quality of written notes was a clear predictor of students' test scores (Peverly, Garner, & Vekaria, 2013a; Peverly et al., 2013b). In addition, some research shows that taking notes by hand, compared to typing them, results in better conceptual understanding of the lecture material even if the total length of the notes themselves is shorter. (Mueller & Oppenheimer, 2014).



Adopted from Peverly et al. (2013)

As with composing written essays, note-taking requires students to harness an assortment of cognitive processes. Even copying notes from the whiteboard in any subject area such as mathematics or history can be difficult for students with poor handwriting.

Fluency in cursive writing continues to be important

Cursive writing is typically taught in Grades 2 or 3 in U.S. schools, and in many school districts formal handwriting instruction stops in the early elementary grades. But research shows that handwriting is variable from year to year, especially when handwriting instruction is no longer part of the curriculum in the later grades (Alstad et al., 2015). By fourth grade, many students have mastered manuscript and are well on their way to being fluent in cursive letters; cursive allows students to take notes more efficiently, and some research shows that cursive is speedier than printing (Ziviano and Watson-Will, 1998).

Fluent cursive writing consistently predicts higher level spelling and composing skills at every grade from 4 to 7.

—Alstad et. al, 2015

In one recent study, researchers compared three modes of written language production by students in Grades 4 to 7: printing, cursive, and typing. The study showed that, first, handwriting skills continue to develop through these grades: without formal instruction, students' manuscript and cursive skills both continue to increase. Second, the researchers also supported including assessing handwriting skills in older students for the purposes of supporting writing instruction. Finally, for developmentally typical students in these grades, fluent cursive writing consistently predicted both higher level spelling and composing skills at each grade (Alstad et al., 2015). The authors conclude that students need continuing handwriting instruction in the form of warm up handwriting practice before writing cognitively demanding schoolwork. They also show that students with language difficulties need explicit continued instruction in multiple handwriting modes.

As students become acquainted with both manuscript and cursive handwriting, they are better able to determine the handwriting style (manuscript, cursive, or manuscript-cursive hybrid) that best serves them in terms of speed, automaticity, and output for note taking, in-class assignments, and high-stakes tests (Alstad et al., 2015). In later elementary grades and middle school, cursive handwriting practice can be coupled with note-taking instruction to prepare students for high school and beyond.

Students with learning difficulties spend as much time thinking about handwriting and what their papers look like as they do on the content of their papers.

—Cahill, 2013

Handwriting instruction supports special populations and uses

Some popular interventions for at-risk students rely on writing, such as writing about stressful events or how they feel through journal writing and sharing. Although writing about emotional events can help process those events (Bernstein, Ablow, Maloney, & Nigg, 2014), the benefits could be compromised if students have difficulty writing by hand; research shows mixed results for adolescents writing about emotional situations (Travagin, Margola, & Revenson, 2015), and handwriting difficulties may be one (as yet unexplored) explanation for their varying effects. Writing-based interventions for at-risk youth have a greater chance for success when the physical production of writing itself is not a cause of anxiety or stress.

Handwriting instruction improves legibility and supports cognitive development—and therefore it sets students up for later academic achievement. Direct

Assessing handwriting beyond the earliest school years can help identify learning difficulties that may manifest in different developmental stages, and systematic handwriting instruction can reduce the number of children needing special education services

— Berninger, 2015

handwriting instruction can improve reading and writing skills, and students with language-related specific learning disabilities can especially benefit from deliberate instruction (Cahill, 2013). Handwriting problems can signal a student's need for additional instructional supports that will strengthen her work in the classroom and chances for success.

Recent research shows a link between autism spectrum disorders (ASDs) and handwriting;

elementary-age children with ASD have lower overall quality of handwriting compared to their peers. Ten-year-old children with ASD, for example, scored below the average scores of typically developing 6- and 7-year-old students in letter formation skills (Fuentes, Mostofsky, & Bastian, 2009). Adolescents with Asperger's syndrome report difficulties with shaping letters, avoid composing long essays, and resist starting to write at all (Breiviki & Hemmingsson, 2013), all of which slow down academic achievement. Eleven-year-old students with specific language impairments were shown in one study to have produced less text of lower quality because of their lack of handwriting fluency as well as spelling knowledge; the researchers support more practice in transcription skills for these students (Connelly, Dockrell, Walter, & Critten, 2012).

Given the unique coordination of different systems of the brain needed to produce handwriting, slow or untidy handwriting can be a marker for coordination disorders (Scordella et al., 2015). Children with these difficulties pause longer when writing and write larger letters and, as a result, produce less written text (Prunty, Barnett, Wilmut, & Plumb, 2013, 2014). Motor difficulties are also

often associated with learning and language difficulties and attention deficit hyperactivity disorder (Kaiser, Shoemaker, Albaret, & Geuze, 2015; Brossard-Racine, Majnemer, Shevell, Snider, & Belanger, 2011) as well. Assessing handwriting beyond the earliest school years can help identify learning difficulties that may manifest in different developmental stages, and systematic handwriting instruction can reduce the number of children needing special education services (Berninger, 2015).

Formal, ongoing handwriting instruction can help students develop better writing skills no matter the underlying cause of their struggles (Cahill, 2013; Berninger & Neido, 2014; Graham, Harris, & Fink, 2013; Richards, et al., 2015). For instance, new research suggests dyslexia may be helped with handwriting instruction more effectively than remedial reading interventions (Montgomery, 2012). An analysis of this research suggests that instruction in cursive can be particularly helpful for middle elementary and adolescent students because the likelihood of reversals and inversions is reduced, cursive writing increases speed and left-to-right flow, and spacing is made automatic (Montgomery, 2012). Without intervention, handwriting difficulties can persist into adulthood among populations with learning or motor coordination disabilities (Barnett, Henderson, Scheib, & Schulz, 2011).

Writing by hand is a lifetime skill

Fluency, speed, and automaticity in handwriting supports later postsecondary success: even in undergraduate students, handwriting fluency is directly and significantly related to writing quality and test scores (Connelly, Dockrell, & Barnett, 2005). Acknowledging that many educational and employment opportunities will require typing and keyboarding skills does not mean that handwriting is not important: contemporary research supports the idea that fluency in writing by hand actually leads to better keyboarding and touch-typing (Cahill, 2013). In adults, faster handwriting has been correlated to faster typing speeds, likely because they rely on similar linguistic processes developed over time (Weintraub, Gilmour-Grill, & Weis, 2010).

The effects of poor handwriting can carry over into adulthood in job applications or materials for admission to college or trade school. Illegible handwriting continues to be a source of judgment: sloppy handwriting is often interpreted as sloppy thinking. Providing frequent, regular “tune ups” for students in the upper elementary grades and in middle school make sense for their cognitive and academic development. Direct instruction and practice in handwriting for later elementary age students can provide lifelong skills to support their academic and professional success.

Bibliography

- Alstad Z., Sanders, E., Abbott, R. D., Barnett, A. L., Henderson, S. E., Connelly, V., & Berninger, V. W. (2015). Modes of alphabet letter production during middle childhood and adolescence: Interrelationships with each other and other writing skills. *Journal of Writing Research, 6*(3), 199–231.
- American College Testing (ACT). (2011). Scoring guidelines. Accessed April 19, 2012, <http://www.actstudent.org/writing/scores/guidelines.html>
- Alves, R. A., Branco, M., Castro, S. L., & Olive, T. (2011). Children of high transcription skill compose using bigger language bursts. In V. Berninger (Ed.), *Cognitive psychology of writing handbook: Past, present, and future contributions of cognitive writing research to cognitive psychology* (pp. 415–428). East Sussex, UK: Psychology Press.
- Awasekar, D. D., & Halkude, S. A. (2015). An analysis of assessment bias influenced by presentation and writing technique in undergraduate engineering examination. *Journal of Engineering Education Transformations (special issue)*(January), 93–98.
- Barnett, A. L., Henderson, S. E., Scheib, B., & Schulz, J. (2011). Handwriting difficulties and their assessment in young adults with DCD: Extension of the DASH for 17-to 25-year-olds. *Journal of Adult Development, 18*, 114–121.
- Berninger, V.W. (2012). *Evidence-based, developmentally appropriate writing skills K to 5: Teaching the orthographic loop of working memory to write letters so developing writers can spell words and express ideas*. Paper presented at Handwriting in the 21st Century? An Educational Summit, Washington, DC, January 23, 2012.
- Berninger, V. (2015). Research support for Ohio HB 146. Manuscript, June 20.
- Berninger, V. W., & Abbott, R. D. (2010). Listening comprehension, oral expression, reading comprehension, and written expression: related yet unique language systems in grades 1, 3, 5, and 7. *Journal of Educational Psychology, 102*, 635–651.
- Berninger, V., & Niedo, J. (2014). Individualizing instruction for students with oral and written language difficulties. In J. Mascolo, D. Flanagan, & V. Alfonso (Eds.), *Essentials of planning, selecting and tailoring intervention: Addressing the needs of unique learners* (pp. 231–264). New York: Wiley.
- Bernstein, R. E., Ablow, J. C., Maloney, K. C., & Nigg, J. T. (2014). Piloting PlayWrite: Feasibility and efficacy of a playwriting intervention for at-risk adolescents. *Journal of Creativity in Mental Health, 9*(4), 446–467.
- Breiviki, I., & Hemmingsson, H. (2013). Experiences of handwriting and using a computerized ATD in school: Adolescents with Asperger's syndrome. *Scandinavian Journal of Occupational Therapy, 20*, 349–356.
- Brossard-Racine, M., Majnemer, A., Shevell, M., Snider, L., & Belanger, S. A. (2011). Handwriting capacity in children newly diagnosed with attention deficit hyperactivity disorder. *Research in Developmental Disabilities, 32*(6), 2927–2934.
- Cahill, S. (2013). Where does handwriting fit in? Strategies to support academic achievement. In *Handwriting Research: Impact on the Brain and Literacy Development* (pp. 20–31). Columbus, OH: Zaner-Bloser.
- Chetail, F. (2014). Effect of number of syllables in visual word recognition: New insights from the lexical decision task. *Language, Cognition and Neuroscience*. doi: 10.1080/23273798.2013.876504
- Christensen, C. A., & Jones, D. (2013). Handwriting: An underestimated skill in the development of written language. In *Handwriting Research: Impact on the Brain and Literacy Development* (pp. 148–158). Columbus, OH: Zaner-Bloser.
- Connelly, V., Dockrell, J.E., & Barnett, J. (2005). The slow handwriting of undergraduate students constrains overall performance in exam essays. *Educational Psychology, 25*(1), 97–105.
- Connelly, V., Dockrell, J.E., Walter, K., & Critten, S. (2012). Predicting the quality of composition and written language bursts from oral language, spelling, and handwriting skills in children with and without specific language impairment. *Written Communication 29*(3) 278–302.
- Conti, G. E. *Handwriting characteristics and the prediction of illegibility in 3rd and 5th grade students*. Paper presented at Handwriting in the 21st Century? An Educational Summit, Washington, DC, January 23, 2012.
- Cutler, L., & Graham, S. (2008). Primary grade writing instruction: A national survey. *Journal of Educational Psychology, 100*(4), 907–919.
- Del Campo, R., Buchanan, W. R., Abbott, R. D., & Berninger, V. W. (2015). Levels of phonology related to reading and writing in middle childhood. *Reading and Writing, 28*, 183–198.
- Denton, P.L., Cope, S., & Moser, C. (2006). The effects of sensorimotorbased intervention versus therapeutic practice on improving handwriting performance in 6- to 11-year-old children. *American Journal of Occupational Therapy, 60*, 16–27.
- Eric, L., Solen, S., & François, R. (2015). The ortho-syllable as a processing unit in handwriting: the mute e effect. *Reading and Writing, 28*(5), 683–698.
- Feder, K. P., & Majnemer, A. (2007). Handwriting development, competency, and intervention. *Developmental Medicine & Child Neurology, 49*, 312–317.
- Fuentes, C. T., Mostofsky, S. H., & Bastian, A. J. (2009). Children with autism show specific handwriting impairments. *Neurology, 73*, 1532–1537.
- Graham, S., & Harris, K. (2002). Prevention and intervention for struggling writers. In M. R. Shinn (Ed.), *Interventions for academic and behavior problems II: Preventative and remedial approaches* (pp. 589–610). Washington, DC: National Association of School Psychologists.
- Graham, S., & Santangelo, T. (2012, January). *A meta-analysis of the effectiveness of teaching handwriting*. Paper presented at Handwriting in the 21st Century? An Educational Summit, co-sponsored by American Association of School Administrators and Zaner-Bloser, Washington, DC.
- Graham, S., Harris, K. R., & Fink, B. (2013). Is handwriting causally related to learning to write? Treatment of handwriting problems in beginning writers. In *Handwriting Research: Impact on the Brain and Literacy Development* (pp. 159–166). Columbus, OH: Zaner-Bloser.
- Graham, S., Harris, K., and Hebert, M. A. (2011). *Informing writing: The benefits of formative assessment*. A Carnegie Corporation Time to Act report. Washington, DC: Alliance for Excellent Education.
- James, K. H., & Englehardt, L. (2012). The effects of handwriting on functional brain development in pre-literate children. *Trends in Neuroscience and Education, 1*(1), 32–42.

- Kaiser, M.-L., Shoemaker, M. M., Albaret, J.-M., & Geuze, R. H. (2015). What is the evidence of impaired motor skills and motor control among children with attention deficit hyperactivity disorder (ADHD)? Systematic review of the literature. *Research in Developmental Disabilities, 36*, 338–357.
- Kandel, S., & Perret, C. (2015). How does the interaction between spelling and motor processes build up during writing acquisition? *Cognition, 136*, 325–336.
- Kandel, S., Héroult, L., Grosjacques, G., Lambert, E., & Fayol, M. (2009). Orthographic vs. phonologic syllables in handwriting production. *Cognition, 110*(3), 440–444.
- Lambert, E., Sausset, S., & Rigalleau, F. (2015). The ortho-syllable as a processing unit in handwriting: The mute e effect. *Reading and Writing, 28*, 683–698.
- Longcamp, M., Boucard, C., Gilhodes, J., Anton, J., Roth, M., Nazarian, B., & Smith, J. (2008). Learning through hand- or typewriting influences visual recognition of new graphic shapes: Behavioral and functional imaging evidence. *Journal of Cognitive Neuroscience, 20*(5), 802–815.
- Longcamp, M., Lagarrigue, A., Nazarian, B., Roth, M., Anton, J.-L., Alario, F.-X., & Velay, J.-L. (2014). Functional specificity in the motor system: Evidence from coupled fMRI and kinematic recordings during letter and digit writing. *Human Brain Mapping, 35*, 6077–6087.
- Longcamp, M., Zerbato-Poudou, M., & Velay, J. (2005). The influence of writing practice on letter recognition in preschool children: A comparison between handwriting and typing. *Acta Psychologica, 119*, 67–79.
- Medwell, J., Strand, S., & Wray, D. (2009). The links between handwriting and composing for Y6 children. *Cambridge Journal of Education, 39*, 329–344. doi: 10.1080/0305764090310372
- Montgomery, D. (2012). The contribution of handwriting and spelling remediation to overcoming dyslexia. In T. Wydell (Ed.), *Dyslexia—A Comprehensive and International Approach* (pp. 109–146). InTech. Retrieved from <http://www.intechopen.com/books/dyslexia-a-comprehensive-and-international-approach/the-contribution-of-handwriting-and-spelling-remediation-to-overcoming-dyslexia>
- Mueller, P. A., & Oppenheimer, D. M. (2014). The pen is mightier than the keyboard: Advantages of longhand over laptop note taking. *Psychological Science, 25*(6), 1159–1168.
- National Center for Education Statistics (2012). *The nation's report card: Writing 2011* (NCES 2012–470). Institute of Education Sciences, U.S. Department of Education, Washington, D.C.
- Oche, E. (2014). The influence of poor handwriting on students' score reliability in mathematics. *Mathematics Education Trends and Research, 1–15*. doi:doi:10.5899/2014/metr-00035
- O'Mahony, P., Dempsey, M., & Killeen, H. (2008). Handwriting speed: Duration of testing period and relation to socio-economic disadvantage and handedness. *Occupational Therapy International, 15*, 165–177. doi: 10.1002/oti.255
- Peverly, S. T., Garner, J. K., & Vekaria, P. C. (2013a). Both handwriting speed and selective attention are important to lecture note-taking. *Reading and Writing*, Published online March 7. doi:DOI 10.1007/s11145-013-9431-x
- Peverly, S. T., Vekaria, P. C., Reddington, L. A., Sumowski, J. F., Johnson, K. R., & Ramsay, C. M. (2013b). 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*, 115–126.
- Pontart, V., Bidel-Ideï, Lambert, E., Morisset, P., Flouret, L., & Alamargot, D. (2013). Influence of handwriting skills during spelling in the primary and lower secondary grades. *Frontiers in Psychology, 4*(818). doi: 10.3389/fpsyg.2013.00818
- Prunty, M. M., Barnett, A. L., Wilmot, K., & Plumb, M. (2013). Handwriting speed in children with Developmental Coordination Disorder: Are they really slower? *Research in Developmental Disabilities, 34*(9), 2927–2936.
- Prunty, M. M., Barnett, A. L., Wilmot, K., & Plumb, M. S. (2014). An examination of writing pauses in the handwriting of children with Developmental Coordination Disorder. *Research in Developmental Disabilities, 35*, 2894–2905.
- Richards, T. D., Grabowski, T. J., Boord, P., Yagle, K., Askren, M., Mestre, Z., . . . Berninger, V. (2015). Contrasting brain patterns of writing-related DTI parameters, fMRI connectivity, and DTI–fMRI connectivity correlations in children with and without dysgraphia or dyslexia. *Neuroimage: Clinical, 8*, 408–421.
- Schlagal, B. (2013). Best practices in spelling and handwriting. In *Handwriting Research: Impact on the Brain and Literacy Development* (pp. 32–38). Columbus, OH: Zaner-Bloser.
- Scordella, A., Di Sano, S., Aureli, T., Cerratti, P., Verratti, V., Fanò-Illic, G., & Pietrangelo, T. (2015). The role of general dynamic coordination in the handwriting skills of children. *Frontiers in Psychology, 6*(580). doi: 10.3389/fpsyg.2015.00580
- Travagin, G., Margola, D., & Revenson, T. A. (2015). How effective are expressive writing interventions for adolescents? A meta-analytic review. *Clinical Psychology Review, 36*, 42–55.
- Vander Hart, N., Fitzpatrick, P., & Cortesa, C. (2010). In-depth analysis of handwriting curriculum and instruction in four kindergarten classrooms. *Reading and Writing, 23*, 673–399.
- Weintraub, W., Gilmour-Grill, N., & Weis, P. L. (2010). Relationship between handwriting and keyboarding performance among fast and slow adult keyboarders. *American Journal of Occupational Therapy, 64*, 123–132.
- Willis, J. (2011, July 11). The brain-based benefits of writing for math and science learning. Retrieved from Edutopia: <http://www.edutopia.org/blog/writing-executive-function-brain-research-judy-willis>
- Ziviano, J., & Watson-Will, A. (1998). Writing speed and legibility of 7–14 year old school students using modern cursive script. *Australian Occupational Therapy Journal, 45*, 59–64.

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