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The role of handwriting in composing for Y2 children

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Abstract

Although handwriting is often considered a matter of presentation, a substantial body of international research suggests that the role of handwriting in children's composing has been neglected. Automaticity in handwriting is now seen as of key importance in composing but this proposition is relatively untested in the UK. This paper reports the first results of a study into the handwriting speed and orthographic motor integration of 179 Y2 children in relation to their composition. The study suggests that handwriting is an important factor in the composition of young children and that a proportion of children suffer from low levels of handwriting automaticity, which may be interfering with their composition.

Handwriting is a language act

The complex nature of writing has been recognised not only in models of writing (Hayes, 1996) but also by policy makers (DfEE/QCA, 2000), teachers (Wray et al., 2002) and young writers themselves (Wray, 1993). Handwriting has been seen as part of the translation of ideas, or transcription. However, in pedagogic practice this has often meant that handwriting is seen not as a part of the composing process, but as a presentation skill. Both the National Curriculum for England (DfEE/QCA, 2000) and the new Framework for Literacy (DES/PNS, 2006) concentrate on the formation and orientation of letters in handwriting and speed is mentioned only for typing. Despite this, research suggests that fast, automatic handwriting may have a significant effect on children's composing. This research suggests that for writers who do not produce letters swiftly and automatically, the actual production of written letters may interfere with their ability to compose text.

A key issue emerging from a major programme of research undertaken over the last ten to fifteen years (e.g. Berninger *et al*, 2006; Berninger & Amtmann, 1994; Berninger & Graham, 1998) is the recognition that handwriting is far from a purely motor act. Berninger and Graham (1998) stress that it is "language by hand" and point out that their research suggests that orthographic and memory processes (the ability to recall letter shapes) contribute more to handwriting than do motor skills (Berninger & Amtmann, 2004). Handwriting is not just about training the hand; it is about training the memory and hand to work together to generate the correct mental images and patterns of letters and translate these into motor patterns of letters - automatically and without effort! If this is the case, then handwriting is an important part of writing, and a language act, rather than just a motor act used to record writing.

Working memory plays an important role in writing

Important models of the writing process (Kellogg, 1996, 2001; Hayes, 1996) give a central role to working memory, which temporarily stores all the information necessary for carrying out writing processes but can hold only a few items for a short time. Understanding how different writing processes (translation, planning, reviewing) are accomplished using the

same working memory space could explain how some writing processes may interfere with others.

This seems to be particularly important for children. Gathercole *et al* (2004) suggest that working memory is particularly associated with the literacy scores of younger children. If young writers have to devote large amounts of working memory to the control of lower-level processes such as handwriting, they may have little working memory capacity left for higher-level processes such as idea generation, vocabulary selection, monitoring the progress of mental plans and revising text against these plans. It may be that handwriting can "crowd out" the composing processes we value so much.

One way to manage the limited amount of working memory capacity is to make some processes, such as handwriting, automatic, in order to free up cognitive resources to deal with higher level processes. Automaticity is achieved when a process can be carried out swiftly, accurately and without the need for conscious attention (La Berge & Samuels, 1974). The development of skill in writing may require the automatization of lower-level skills so that they use less of the available working-memory resources. Amazingly, some research suggests that automatic letter writing is the single best predictor of length and quality of written composition in the primary years (Graham *et al*, 1997) in secondary school and even in the post-compulsory education years (Connelly *et al*, 2006; Jones, 2004; Peverley, 2006). However, we do not know when handwriting typically becomes automatic for children, in terms of age or of rate of letter production.

Our pedagogic theory, practice and policy in handwriting is underpinned by the assumption that handwriting becomes automatic relatively early on in writers' development (Medwell and Wray, 2007). However, there is little evidence for this. Scardamalia, Bereiter and Goleman (1982) suggest that handwriting is not automatic until around age ten and that handwriting continues to demand cognitive attention throughout the primary years. However, Berninger and Graham (1998) offer very convincing evidence that, for many children, handwriting continues to be demanding well into the secondary years, and beyond. The assumption of early automaticity unfortunately remains untested, as UK national testing does not assess handwriting speed or fluency and addresses only writing style and neatness. We may be failing to assess an important aspect of writing.

If children are not automatic in their letter generation it can affect their composition

A significant number of children experience handwriting difficulties throughout their schooling, although estimates of how many are experiencing handwriting difficulties range from as high as 44% (Alston, 1985; Rubin & Henderson, 1982) to as low as 12 - 22% (Graham and Weintraub, 1996). If any of these figures are even approximately correct, it suggests that lack of handwriting automaticity may affect a significant number of primary and secondary aged children. Boys are more likely to be identified as having handwriting problems than girls (Hamstra-Bletz & Blote, 1993; Rubin & Henderson, 1982) and a number of studies suggest that their handwriting difficulties are likely to impact upon their ability to compose written language.

Two studies undertaken in Australia (Jones & Christensen 1999; Christensen, 2005) adapted a relatively simple alphabet writing task designed by Berninger *et al* (1991) to measure orthographic-motor integration (the ablity to generate the mental patterns and motor codes necessary to write letters) and to identify children with automaticity problems. One study

measured the orthographic-motor integration, reading and written expression of 114 children in Year 2 (aged 7) before and after an eight week long handwriting programme. More than half the variance in scores on written expression could be accounted for by orthographic-motor integration, even when reading scores were controlled. Interestingly, the children undertaking the handwriting programme showed significant improvement in their composing skills. Studies in this area have experimented with the removal of some of the competing demands for children's cognitive attention during writing. De La Paz and Graham (1995), for example, found that when the children were able to dictate their texts to an adult, thus freeing them from the task of handwriting, the quality of their composition significantly improved. Other studies have confirmed this effect in primary aged children (e.g., Hidi & Hidyard, 1983; McCutchen, 1996, 1998; Scardamalia *et al*, 1982).

The present study

The findings of Jones and Christensen (1999) in Australia and of researchers in the USA (Graham *et al*, 1997; Berninger, Mitokawa and Bragg, 1991) suggest a very strong link between handwriting automaticity and composition. It is important to examine in more detail whether the findings about orthographic-motor intervention can be generalised to the British context, where the extent of handwriting difficulty is unknown and children are taught a simpler, more efficient script than those generally taught in the USA. One small study of a mixed age sample (Connelly and Hurst, 2001) has tentatively suggested that this link between handwriting automacity and composition is likely to be true for England. The present study uses a larger sample focussed on two age groups and some results for Year 2 children (age 6-7) are reported here.

This study also aims to consider the extent and distribution of handwriting difficulties by looking at levels of automaticity in school pupils at the end of Year 2. This would be the first step towards a screening instrument that could identify children with handwriting difficulties who might benefit from interventions to improve their automatic production of letters.

In this study we address the questions of how handwriting is related to composition in children in English classes at Year 2. In doing this we explore how children's handwriting speed and letter generation compares with children in other studies and whether this relates to their composing ability. To do this, the study looks at children's national test scores for composition (excluding spelling and handwriting) in relation to measures of handwriting.

The Sample

The sample was composed of 186 Year 2 pupils from four primary schools in Solihull, Coventry and Warwickshire. The sample included 108 boys (58%) and 78 girls (42%) The mean age of the sample was 7:6, and two thirds were in the range 6:8 to 7:8. 161 pupils (87%) were recorded as White British, somewhat higher than the 79% of children recorded as White British in the total primary school population of England (DfES/Ofsted, 2006). The remaining 21 pupils (13%) belonged to other ethnic groups. The children came from a range of economic backgrounds and 34 (17%) were entitled to a free school meal, close to the national average of 18% (DfES/Ofsted, 2006) (The proportion of pupils receiving free school meals is commonly used in the UK as a measure of social deprivation in a school). However, the overall figure for the sample conceals a wide difference between the four schools, where the proportion of free school meals ranged from 34% to 3%. Thirty-six children (20%) were on the special needs register within their school, close to the 21% of children with special

educational needs (SEN) nationally (DfES/Ofsted, 2006). In total 165 (89%) were right handed (as reported by the children and teachers) and 20 (11%) left handed. This is as expected when around 10-15% of the population of England is left handed (Bentley and Stainthorp, 1993)

Measurements of composition

The writing of all the children in the sample was assessed as part of the statutory end of Key Stage 1 (KS1) assessment at the end of Y2 (age 6-7). The composition task involved children in writing two pieces - a longer and a shorter piece, of two contrasting text types, which are specified in the task. The writing was assessed using the 2005 national test paper. The writing pieces were marked by teachers using task specific criteria which offer 30 marks for composition, broken down as follows:

Longer task (possible 18 marks)
Sentence structure- up to 4 marks
Punctuation - up to 4 marks
Composition and effect- up to 10 marks

Shorter Task (possible 12 marks)
Sentence structure and punctuation- up to 5 marks
Composition and effect- up to 7 marks

Marking of papers was moderated within schools and across some of the schools as part of the local arrangements for moderation of end of Key Stage assessments.

Measurement of handwriting

Three measures of handwriting were used for the study. These address different aspects of handwriting ability.

Measure 1 (Handwriting SAT)

Handwriting style and neatness in the course of composing is statutorily assessed as part of the Standard Assessment Tasks (SAT) at KS1 and up to three marks can be awarded for handwriting using the following criteria:

1 Mark: Writing is legible, letters are usually correctly formed and orientated. Generally, upper and lower case letters are not mixed within the word.
2 Marks: Letters are correctly formed and oriented. Writing may be in a controlled printed style, with letters generally neat and regular in size, and ascenders and decenders usually distinguished. Alternatively, there may be evidence of the ability to join letters, although this detracts from the overall regularity of the handwriting.
3 Marks: Letters correctly formed and orientated. Handwriting is neat and regular in size, with ascenders and decenders usually distinguished. There is evidence of fluency and the ability to join letters.

The assessment for these three marks is made on a sample of handwriting done during a composition assessment and is a product analysis. Fluency is taken to mean evidence of the

effective joining of letters. Speed of writing or efficiency of letter generation is not included in the assessment.

Measure 2 (Handwriting speed)

A copying test was used to assess handwriting speed, giving a score in letters per minute (LPM). This assesses children's ability to see, remember and reproduce a sentence containing all the letters of the alphabet, and does not assess neatness (although letters have to be correctly formed) or ability to generate letters. The Handwriting Speed Test (Wallen et al., 1996) was designed and standardised for children in Australia, although not for the English context or for children below Year 4 (8-9 year olds). The test involves copying the sentence "The quick brown fox jumps over the lazy dog." as many times as possible in three minutes on a test sheet. All letters, including crossings-out, were counted and the test rubric applied consistently. The tests were marked by two separate markers and a high level of inter- marker reliability was established. Inter-rater reliability using Pearson's product moment correlation was r=.99.

Measure 3 (Alphabet Task)

Orthographic-motor integration of handwriting involves mentally coding and rehearsing visual representations of letter patterns and integrating them with motor patterns (Berninger, 1994). This was measured using a form of the alphabet writing task described by Berninger, Mitzokawa and Bragg (1991) and adapted by Jones and Christensen (1999) for whole classes, rather than individuals. The task involves writing in lower-case as many letters of the alphabet as possible in one minute. Puils who complete all 26 letters in lower case continue the task in upper-case. Although children have plenty of opportunity to write all the letters in the course of their school work, they rarely write the whole alphabet from memory in sequence, so this task is not well rehearsed and demands organization and retrieval of letter forms in visual memory as well as the generation of the relevant motor patterns.

The children were asked to write as quickly and as neatly as possible on a test sheet. Scores were calculated by counting letters which were recognisable out of the context of the rest of the writing. Omissions, reversals, transpositions (of case) and substitutions did not count towards children's scores. Scores are given in alphabet letters per minute (ALPM). The tests were marked by two separate markers and again a high level of inter- marker reliability was established. Inter-rater reliability using Pearson's product moment correlation was r=.98.

Findings

The range, mean and SD of the writing test scores are presented in Table 1.

TABLE 1: Range, mean and standard deviation (SD) of writing test scores

Measure	**range**	**mean**	**SD**
Handwriting SAT	1 - 3	1.9	0.8
Handwriting Speed	9 - 75	33.7	11.9
Alphabet Task	3 - 44	16.7	8.4
Composition	3 - 29	17.8	6.0

The range of scores on the Alphabet Task was 3-44 alphabet letters per minute (ALPM) with a mean of 16.7 (SD=8.4). This is directly comparable with the findings of Jones and Christensen (1999) who found, for 114 Y2 children, a range of 3-32, a mean of 18.0 (SD=5.8). The English children have produced a wider range of performance on this task. Berninger, Mitzokawa and Bragg (1991) report that American children at the end of grade 1 (our Y2) were "at or near mastery" of the alphabet task in one minute and report only errors. The English children were not "at or near mastery" of the task of writing the alphabet out in one minute. Of 185, 165 (89.2%) wrote at least 26 letters but 20 (10.8%) did not. However, the American sample was small (45) and the task was administered individually.

The range of scores for the Handwriting Speed Test was 9-75 letters per minute with a mean of 33.7 (SD=11.9). In an American study Graham et al. (1997) report a mean copying speed of 19.0 letters per minute (SD=7.0) for 100 grade 1 children copying a passage. It may, of course, show that copying a passage is more demanding than repeatedly copying the test sentence.

In the Handwriting SAT, 57 children (30.6%) scored 1 point, 80 (43.0%) two points and 40 (21.5%) three points. The mean was 1.9 (SD 0.8). This shows a surprisingly large number of children still struggling with orientation and regularity of letter formation but in the absence of data about targets or teacher expectations in this area it is not possible to know whether this is a matter for concern.

The range for composition was 3-29, with a mean of 18.0 (SD=6.0). The sample seems to have been close to the national average in their writing outcomes with 69% of pupils achieving level 2b or above in writing, where the national average is 62% (DfES/Ofsted, 2006).

What is the relationship between handwriting and composition?

The full correlation matrix (Appendix 1) shows a very high correlation between performance on the Alphabet Task and Composition (r=.58). Alphabet Task performance accounts for 34% of the variance in composition for these Y2 children. This is a higher than the correlation for speed alone (Handwriting Speed Test) at r=.44 or the correlation with neatness and letter formation (indicated by the handwriting SAT score) of r=.54. The Handwriting Speed Test involves copying and is a pure measure of speed, which may well contribute to composition by allowing the child to write more in a given time. However, The Alphabet Task measures the mental generation and motor production of the letter symbols and it is automatic performance at this orthographic–motor integration which may account for its stronger prediction of composition quality because it frees up the working memory to focus on composing. Speed alone is not enough.

Interestingly, these results accounts for a different proportion of variance in composition than reported in studies outside England. Jones and Christiansen (1999) report scores on the Alphabet Task as accounting for 67% of the variance in composing scores for Y2 Australian children. Berninger and Graham (1998) report handwriting automaticity accounted for 25% of the variance in compositional quality in primary grades in the USA. This sample of English Y2 children falls between the findings in these two English-writing countries.

Stepwise multiple regression of handwriting predictors of composition

A multiple regression analysis of the three handwriting predictors of composition is presented in Table 2. The Alphabet Task is entered first because it is the best single predictor of composition. The scores on the Alphabet Task and the Handwriting Speed Test are highly correlated (r=0.60) but not synonymous. Thus adding Handwriting Speed to the regression increases the multiple r to .67, explaining an additional 10% of the variance in composition. Handwriting Speed may well contribute to composition by allowing the child to write more in a given time. Finally the Handwriting SAT makes only a minimal addition to the prediction of composition, explaining just an additional 1.2% of the variance.

TABLE 2: Stepwise multiple regression of handwriting measures against composition score

Variable	Multiple R	Adjusted R square	B	Standard error	Beta	Significance of *t*
ALPM	.58	33.8	.24	.05	.34	p<.001
Handwriting SAT	.67	44.4	2.73	.48	.36	p<.001
Handwriting Speed	.68	45.6	6.97	.04	.14	p<.05

Causal relationship between ALPM and composition

What has been demonstrated above is only a correlation between performance on the Alphabet Task and composition scores. This is not sufficient to establish a causal role for automatic letter production in relation to composition. The correlation might arise from the influence of a third factor that determines both ALPM and composition scores. For example, Graham and Weintraub (1996) have demonstrated a relationship between handwriting and reading attainment, and it may be that reading, as a measure of general literacy competence, underlies both high ALPM and high composition scores (Jones & Christensen, 1999). A partial correlation was computed to establish the relationship of ALPM with composition, independent of the influence of reading proficiency. The measure of reading proficiency used was the SAT reading levels for each child, as assessed using the SAT reading test and tasks administered at the end of KS1. Children at KS1 can achieve a level W (working towards 1), Level 1, Level 2c, Level 2b, level 2a or Level 3.The following standard scale of points used to convert the levels to scores: W=3, 1=9, 2c=13, 2b=15, 2a=17, 3=21.

Reading score is a good predictor of both composition (r=.84) and performance on the Alphabet Task (r=.55) so is a relevant control variable. The zero-order correlation of ALPM and composition is 0.58 (see Table 2). After controlling for reading score, the partial r drops slightly to 0.43, but remains highly statistically significant (p<.001). Thus there is a strong relationship between ALPM and composition even when variation in reading attainment is accounted for. This is important since it establishes that the correlation between performance on the Alphabet Task and composition is not simply mediated by both being related to good reading. It does not definitively establish that low handwriting automaticity causes poor composition, but it makes it more likely that there is some direct association in the correlation.

Identifying when lack of automaticity is a problem

It is important to establish if there is a threshold of automatic letter production for children of this age, below which a lack of automaticity has a particularly negative impact on composition quality. The children in this study show a very high level of variation of

performance on the Alphabet Task ranging from those who wrote three letters up to those who wrote 44 letters in one minute - the extremes of our sample. There are two approaches to identifying appropriate levels of automaticity. The first is to look at levels identified in other studies.

Jones & Christensen (1999) graded scores of 8 or below on ALPM poor, 9-14 low average, 15-24 average, 25-30 good and 31 very good, although their rationale for this is not given. The proportion of children in the present sample at these levels is given in Table 3.

TABLE 3: Proportion of pupils in different score bands on ALPM.

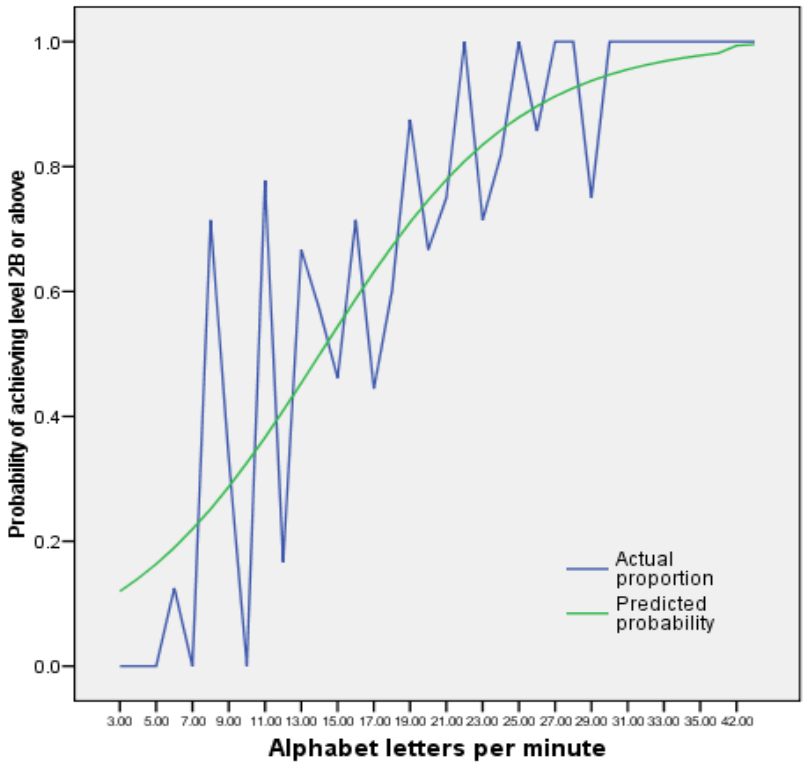
Score range	Descriptor	Percentage of Y2 sample (N=185)	Number of pupils
<=8	Poor	17.8	34
9-14	Low average	23.8	44
15-24	Average	41.1	76
25-30	Good	11.4	21
31+	Very good	1.1	11

It is interesting to note that, of the 185 pupils in the sample, 34 (18%) scored <=8. Of the pupils scoring 8 or below, 27 (79%) were boys and 14 (42%) had special educational needs of some type, although this may not have been a literacy difficulty.

Jones & Christensen (1999) used <=13 letters per minute (along with difficulties in letter formation) to select children for an intervention programme. In their sample of 114 pupils aged 6-7 years this identified 21 (18%) of the sample. In our study, this cut-off point would identify 69 pupils - over one-third (37%) of the Y2 sample.

Another approach to identifying a threshold level of automaticity is to look at the relationship with an external criterion. For these Year 2 pupils, the national expectation is that the typical pupil should achieve level 2B in writing by the end of KS1. A logistic regression was computed to identify the relationship between ALPM and the probability of achieving Level 2B or above in the national writing test. Figure 1 gives a graphical presentation of the results.

FIGURE 1: Logistic regression of ALPM against the probability of achieving Level 2B or above in the KS1 writing test



The results reveal that for a pupil achieving a score of 12 ALPM on the Alphabet Task the predicted probability of achieving Level 2B or above falls to 40%. This is a level where children in our Y2 sample may be 'at risk' of not achieving level 2B. Our sample is close to the national average in terms of their writing attainment, with 58% of pupils achieving level 2B or above compared to the 2006 national average (based on TA) of 60%. The results are therefore suggestive for the general population.

However, the overall success rate of a cut-off point of 12 ALPM in identifying who will or will not achieve writing level 2B is only 73%. Some pupils do achieve level 3 even with ALPM <10: equally some pupils with ALPM as high as 27 still only achieve level 1. Although these figures do not offer sufficient predictive accuracy to make ALPM a valid screening test on its own, the high relative 'risk' suggests that 12 letter per minute or less is a rough borderline area which will benefit from further investigation. It may be that further work to identify issues in handwriting can identify children for whom handwriting is a significant issue, possibly by including measures of neatness or accuracy as discussed above.

Group differences in ALPM within the sample

There are statistically significant differences in ALPM on the Alphabet Task which relate to gender. Boys score on average 3.5 letters per min lower than girls ($p<.003$). In standard deviation (SD) terms this is 0.4 of a SD so is a substantial difference. The authors of the Handwriting Speed Test **(**Wallen, et al., 1996**)** report a similar gender difference for speed (four letters per min advantage for girls). Research in the 1980s and 90s confirmed that girls

are generally better handwriters than boys (Graham & Miller, 1980) both on measures of overall quality and of letter formation (Hamstra-Bletz & Blote, 1990; Ziviani & Elkins, 1984). Girls also tend to write faster than boys (Berninger & Fuller, 1992; Biemiller *et al*, 1993; Ziviani, 1984). At present, there is considerable concern in Britain about boys' underachievement in writing (UKLA/PNS, 2003) but studies have not addressed specific handwriting interventions. The findings of the present study suggest that this is an area for further work.

Another aspect of handwriting performance which might be important is handedness. Left-handed children represent 11% of this Y2 sample. They score lower than right handed children in this study but not significantly so. Handedness does not appear to be a significant factor in ALPM scores, which indicate children's ability to generate mental letter patterns as well as motor patterns. A difference related to handedness might have been expected on a purely motor task.

Conclusions

The results of this study identify a very wide range of performance in handwriting measures and one of the most basic issues raised by the results is the lack of existing normative data in this area. We do not have information about teacher's expectations or targets for handwriting, nor do we have norms for children in the UK population. This is the case not only for orthographic-motor integration, the primary focus of this paper, but also for handwriting and speed. Further information in both these areas would be of assistance to teachers and researchers in deciding which children might benefit from handwriting intervention.

The results discussed above suggest that a high proportion of the variance in composition for the children in this sample is related to their handwriting and, in particular, to their ability to generate letters automatically, as measured by the Alphabet Task. This supports the idea that letter generation makes cognitive demands on children of this age and may take up working memory capacity which is, therefore, not available for higher level composing tasks. This is a very important finding, given the widespread assumption, discussed above, that handwriting is a matter of presentation. These findings support the suggestion that handwriting is indeed a language act and that orthographic-motor integration, that is automatic letter production, is not only a different measure from speed but is more significantly related to composition than speed or neatness in the present sample of English children.

This study goes some way towards identifying a level at which Y2 children might benefit from improving their automaticity, in order to facilitate composing. Children who score around 12 ALPM, or less, on the alphabet task have only a 40% chance of achieving level 2b in the writing SAT. Although this is not a foolproof screening mechanism for identifying children at risk of achieving a low SAT score, it does identify many children for whom poor handwriting automaticity may be affecting their composing. It would seem desirable to continue this research to refine further the screening mechanism, possibly including neatness or letter formation.

Finally, the study demonstrates that this effect is more pronounced for boys than girls and that boys are more likely to be in the very lowest category of performance in automatic letter generation than girls. At a time when improving composition, and especially that of boys, is a national priority this suggests that early intervention to improve handwriting automaticity

may be of benefit to many Y2 children and especially to boy writers. Further research needs to be aimed at developing and validating a simple intervention programme.

References

Alston, J. (1985) The handwriting of seven to nine year olds. *British Journal of Special Educational Needs*, 12, 68-72

Bearne, E. and Warrington, M. (2003). Boys and Writing. *Literacy Today*, 35, http://www.literacytrust.org.uk/Pubs/bearne.html [12th May, 2006]

Bentley, D. and Stainthorp, R. (1993(The needs of left handed children in the infant classroom- writing is not always right. Reading, 27, 4-9

Berninger, V. W, and Amtmann, D. (2004). Preventing written expression disabilities through early and continuing assessment and intervention for handwriting and/or spelling problems: research into practice. In L. Swanson, K. Harris, and S. Graham (Eds.), *Handbook of research on learning disabilities* (pp. 345–363). New York, Guilford Press.

Berninger, V., and Fuller, E. (1992). Gender differences in orthographic, verbal, and compositional fluency: Implications for diagnosis of writing disabilities in primary grade children. *Journal of School Psychology, 30*, 363-382.

Berninger, V. W., and Graham, S. (1998). Language by hand: A synthesis of a decade of research on handwriting. *Handwriting Review*, 12, 11–25.

Berninger, V. W., and Swanson, H. L. (1994). Modifying Hayes and Flower's model of skilled writing to explain beginning and developing writing. In E. C. Butterfield (Ed.), *Children's writing: Toward a process theory of the development of skilled writing* (pp. 57–81). Hampton Hill, UK: JAI Press.

Berninger, V. W., Mizokawa, D. T., and Bragg, R. (1991). Theory-based diagnosis and remediation of writing disabilities. *Journal of Educational Psychology*, 29, 57–59.

Berninger, V. W., Abbott, R.D, Jones, J., Wolf, B., Gould, L., Anderson-Youngstrom, M., Shimada, S. and Apel, K. (2006) Early development of language by hand: Composing, reading, listening and speaking connections; Three letter writing modes and fast mapping in spelling. *Developmental Neuropsychology*, 29 (1), 61-92

Berninger, V. W. (1994). *Reading and writing acquisition: A developmental neuropsychological perspective.* Dubuque, IA: Brown and Benchmark.

Biemiller, A., Regan, E., and Gang, B. (1993). *Studies in the development of writing speed: Age, task, and individual differences.* Unpublished manuscript, University of Toronto, Ontario, Canada.

Bourdin, B.; Fayol, M. (2002) Even in adults, written production is still more costly than oral production. *International Journal of Psychology* 37 (4), 219-227

Christensen, C. A. (2005) The role of orthographic-motor integration in the production of creative and well structured written text for students in secondary school, *Educational Psychology.* 25 (5), 441-453

Connelly, V., and Hurst, G. (2001) The influence on handwriting fluency on writing quality in later primary and early secondary education. *Handwriting Today* 2, 5–57.

Connelly, V., Campbell, S., MacLean, M., and Barnes, J. (2006). Contribution of lower order skills to the written composition of college students with and without dyslexia. *Developmental Neuropsychology*, 29, 175–196.

De La Paz, S., and Graham, S. (1995). Dictation: Applications to writing for students with learning disabilities. In T. Scruggs and M. Mastropieri (Eds.), *Advances in learning and behavioral disorders* (Vol. 9, pp. 227–247). Greenwich, CT: JAI Press.

DfEE/QCA (Department for Education and Employment/Qualifications and Curriculum Authority) (2000) *The National Curriculum Handbook for Primary Teachers in England: Key Stages 1 and 2*. London: HMSO

Department for Education and Skills\Primary National Strategy(2006) Primary framework for literacy and mathematics London: DES

Department for Education and Skills/ Office For Standards in Education (2006) National School Improvement Summary Report for maintained Primary Schools. London: DES/Ofsted

Gathercole, S. E., Pickering, S. J., Knight, C. and Stegmann, Z. (2004) Working memory skills and educational attainment: Evidence from national curriculum assessments at 7 and 14 years of age. *Applied Cognitive Psychology*, 18, 1-16.

Graham, S., and Miller, L. (1980). Handwriting research and practice: A unified approach. *Focus on Exceptional Children* 13, 1-16.

Graham, S., and Weintraub, N. (1996). A review of handwriting research: Progress and prospects from 1980 to 1994. *Educational Psychology Review*, 8, 7-87.

Graham, S. (1990). The role of production factors in learning disabled students' compositions. *Journal of Educational Psychology*, 82, 781–791.

Graham, S., Berninger, V., Abbott, R., Abbott, S., and Whitaker, D. (1997). The role of mechanics in composing of elementary school students: A new methodological approach. *Journal of Educational Psychology* 89 (1), 170–182.

Hamstra-Bletz, L. and Blote, A., (1993). A longitudinal study on dysgraphic handwriting in primary school. *Journal of Learning Disability* 26, 689–699.

Hayes, J. R. (1996). A new model of cognition and affect in writing. In C. Levy and S. Ransdell (Eds.) *The science of writing* (pp. 1-30). Hillsdale, NJ: Erlbaum.

Hidi, S. and Hilyard, A. (1984) The comparison of oral and written productions in two discourse modes,' in *Discourse Processes*, 6, 2, 91-105.

Jones, D., and Christensen, C. (1999). The relationship between automaticity in handwriting and students' ability to generate written text. *Journal of Educational Psychology*, 91, 44-49.

Jones, D. (2004) *Automaticity of the transcription process in the production of written text.* Unpublished Doctor of Philosophy Thesis, University of Queensland, Australia.

Kellogg, R. T. (1996). A model of working memory in writing. In C. Levy and S. Ransdell (Eds.). *The science of writing: Theories, methods, individual differences, and applications* (pp. 57-71). Mahwah, NJ: Lawrence Erlbaum.

Kellogg, R. T. (2001) Competition for working memory among writing processes, *American Journal of Psychology*, 114, pp. 175-191.

La Berge, D., and Samuels, S. J. (1974) Toward a theory of automatic information processing. *Cognitive Psychology*, 6, 283–323.

McCutchen, D. (1988) "Functional automaticity" in children's writing: A problem in metacognitive control. *Written Communication*, 5, 306-324.

McCutchen, D. (1996) A capacity theory of writing: Working memory in composition. *Educational Psychology Review*, 8, 299–325.

Medwell, J. & Wray, D. (2007) Handwriting: what do we know and what do we need to know? *Literacy* 41, 1, 10-16

Peverley, S. (2006). The importance of handwriting speed in adult writing. *Developmental Neuropsychology*, 29, 197– 216.

Rubin, N. and. Henderson S.E (1982). Two sides of the same coin: Variation in teaching methods and failure to learn to write. *Special Education: Forward Trends*, 9, 17–24.

Saada-Robert, M. (1999) Effective means for learning to manage cognitive load in second grade school writing: a case study. *Learning and Instruction*, 9, 189-208

Scardamalia, M., Bereiter, C., and Goleman, H. (1982). The role of production factors in writing ability. In Nystrand, M. (Ed.), *What writers know: The language, process, and structure of written discourse* (pp. 173–210). New York: Academic Press.

Sweller, J. (1988) Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12,* 247–285.

United Kingdom Literacy Association/ Primary National Strategy (2004) *Raising boys' achievements in writing* Hertfordshire: UKLA

Wallen, M., Bonney M., Lennox, L. (1996) *The Handwriting Speed Test* Australia: Helios Art and Book Co.

Wray, D. (1993) 'What do children think about writing?' in *Educational Review*, Vol. 45 (1), pp. 67-77

Wray, D., Medwell, J., Fox, R. & Poulson, L. (2002) *Teaching Literacy Effectively* London: RoutledgeFalmer

Ziviani, J. and Elkins, J. (1984). An evaluation of handwriting performance. *Educational Review*, 36, 249–261.

Ziviani, J., (1984) Some elaborations on handwriting speed in 7- to 14-year-olds. *Perceptual and Motor Skills* 58, 535-539.

APPENDIX 1

Full Y2 correlation matrix

		ALPM (Alphabet task)	LPM (Speed)	SAT Handwriting	Age in months	Total writing SAT score	Spelling SAT score	Reading SAT score	Composition SAT score
ALPM (Alphabet task)	Pearson correlation	1	.599**	.427**	.075	.618**	.561**	.546**	.581**
	Sig. (2-tailed)		.000	.000	.312	.000	.000	.000	.000
	N	185	184	178	184	178	178	59	179
LPM (Speed)	Pearson correlation		1	.282**	.046	.498**	.473**	.324**	.440**
	Sig. (2-tailed)			.000	.537	.000	.000	.013	.000
	N		185	178	184	178	178	58	179
SAT Handwriting	Pearson correlation			1	.109	.636**	.425**	.430**	.540**
	Sig. (2-tailed)				.149	.000	.000	.001	.000
	N			179	178	178	179	59	178
Age in months	Pearson correlation				1	.091	-.043	-.037	.136
	Sig. (2-tailed)					.228	.573	.785	.070
	N				185	178	178	58	179
Total writing SAT score	Pearson correlation					1	.785**	.798**	.967**
	Sig. (2-tailed)						.000	.000	.000
	N					179	179	59	179
Spelling SAT score	Pearson correlation						1	.632**	.664**
	Sig. (2-tailed)							.000	.000
	N						179	59	178
Reading SAT score	Pearson correlation							1	.814**
	Sig. (2-tailed)								.000
	N							59	59
Composition SAT score	Pearson correlation								1
	Sig. (2-tailed)								
	N								180