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The links between handwriting and composing for Y6 children

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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 and the assumption has been made that by Y6, handwriting is a matter of presentation, unrelated to composition processes. This article reports the results of a study into the handwriting speed and orthographic motor integration of 198 Y6 children in relation to their composition and relates it to findings from an earlier paper about 179 Y2 children. The study suggests that handwriting is an important factor in the composition of Y6 children and that a proportion of children suffer from low levels of handwriting automaticity, which may be interfering with their composition.

Keywords: primary education; literacy; handwriting; composition; automaticity

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Handwriting as 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) and teachers (Wray, Medwell, Fox, & Poulson, 2002). There have also been some studies, although not a huge number, of the perceptions of young writers themselves (Wray, 1993, in the UK; Scheuer, De la Cruz, Pozo, Huarte, & Solo, 2006a, and Scheuer, De la Cruz, Pozo, & Nera, 2006b, in Argentina) and these tend to confirm a growing understanding among learners of the complexity of the writing process. Handwriting often figures prominently in descriptions of writing, particularly among young writers (e.g., United Kingdom Literacy Association & Primary National Strategy, 2004), but generally it has been seen as part of the translation of ideas, or transcription. 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 Framework for Literacy (DES & PNS, 2006) concentrate on the formation and orientation of letters in handwriting. 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 (McCutchen, 2006).

A key issue emerging from a major programme of research undertaken over the last 10 to 15 years (e.g., Berninger *et al.*, 2006; Berninger & Amtmann, 2003; Berninger & Graham, 1998) is the recognition that handwriting is far from a purely

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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, 2003). 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 (transcription, 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, Pickering, Knight, and Stegmann (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, Berninger, Abbott, Abbott, & Whitaker, 1997) in secondary school and even in the post-compulsory education years (Connelly, Campbell, MacLean, & Barnes, 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 & Wray, 2007). However, there is little evidence for this. Scardamalia, Bereiter, and Goleman (1982) suggest that handwriting is not automatic until around age 10 and that it continues to demand cognitive attention throughout the primary years. However, Berninger and Graham (1998) offer 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. UK national testing assesses handwriting speed and fluency only as post hoc measures (i.e., the length of the piece that can be written in a defined time, and the extent to which output writing is joined). There is no process assessment and thus this

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national assessment addresses only writing style and neatness. We may be failing to assess an important aspect of writing.

Lack of automaticity in letter generation can affect composition

Estimates of how many children experience handwriting difficulties range from as high as 44% (Alston, 1985; Rubin & Henderson, 1982) to as low as 5% (Barnett, Stainthorp, Henderson, & Scheib, 2006). 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. We do not have detailed information about occurrence of difficulties, but it is the impact of these difficulties on composition which is the major concern for writers, teachers and policy-makers.

Two studies undertaken in Australia (Christensen, 2005; Jones & Christensen, 1999) adapted a relatively simple alphabet writing task designed by Berninger, Mizokawa, and Bragg (1991) to measure orthographic-motor integration (the ability 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 7-year-old children 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, suggesting the possibility that performance in this area might be improved by teaching. The teaching of handwriting has been little researched, however. The survey reported by Graham *et al.* (2008) suggests that most US primary teachers do teach handwriting, but very unevenly. There are no comparable surveys of UK teachers as yet.

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 (see Hidi & Hilyard, 1984; McCutchen, 1996, 1988; Scardamalia *et al.*, 1982).

The present study

The findings of Jones and Christensen (1999) in Australia and of researchers in the US (Graham *et al.*, 1997; Berninger *et al.*, 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 US. One small study of a mixed age sample (Connelly & Hurst, 2001) has tentatively suggested that this link between handwriting automacity and composition is likely to be true for England. The present study used a larger sample involving two age groups and some results for Y6 children (age 10–11) are reported here. Parallel results for Y2 children (age 6–7) have already been reported (Medwell, Strand, & Wray, 2007).

This study also aimed to consider the extent and distribution of handwriting difficulties by looking at levels of automaticity in school pupils at the end of Y6. This would be the first step towards a screening instrument that could identify children with

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handwriting difficulties who might benefit from interventions to improve their automatic production of letters.

In this paper we address the questions of how handwriting is related to composition in English Y6 children. 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 198 Y6 pupils from four primary schools in Solihull, Coventry and Warwickshire. The sample included 101 boys (51%) and 97 girls (42%). The mean age of the sample was 11 years, 1 month (SD 3.5). The pupils were drawn from a range of economic backgrounds and 18% were entitled to a free school meal, the same as the national primary school average (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%. Forty-three pupils (21%) were recorded as having special educational needs (SEN), the same as the national proportion of pupils (DfES & Ofsted, 2006). The majority of pupils were recorded as White British, although 14% were drawn from a range of minority ethnic groups (national average 21%) (DfES & Ofsted, 2006). 78% were right handed (as reported by the children and teachers) and 22% left handed, compared to the 10–15% of the population of England who are left handed (Bentley & Stainthorp, 1993). In terms of attainment the schools were typical of the national average. In national tests at age 11 in 2006, 81% achieved Level 4 (the expected level) or above in English (national figure 79%), and 75% achieved Level 4 or above in mathematics (national figure 75%).

Measurement of composition

The writing of all the children in the sample was assessed as part of national testing (Standardised Assessment Tasks – SATs) at the end of Y6 (age 10–11). The composition task involved children in writing two pieces - a longer and a shorter piece, of two contrasting text types. These writing pieces were marked by external markers (and nationally moderated) using task specific criteria which offer 40 marks for composition, broken down as follows:

Longer task (possible 28 marks)

- Sentence structure and punctuation – up to eight marks.
- Text structure and organisation – up to eight marks.
- Composition and effect – up to 12 marks.

Shorter task (possible 12 marks)

- Sentence structure, punctuation and text organisation – up to four marks.
- Composition and effect – up to eight marks.

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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 national test and up to three marks can be awarded for handwriting using the following criteria:

- Mark: The handwriting is legible and shows some features of regularity in size and spacing. However, overall the script is disjointed and uneven.
- Marks: Overall, the handwriting is regular with some flow and movement. Letters and words are usually appropriate in size and position but there is some variation.
- Marks: The handwriting is consistent and fluent with letters and words appropriately placed. The handwriting maintains a personal style to engage the reader.

The assessment for these three marks was made on a sample of handwriting done during the longer task composition assessment. Fluency was defined as evidence of the effective joining of letters. Speed of writing or efficiency of letter generation was not included in this assessment.

Measure 2 (handwriting speed)

A copying test was used to assess handwriting speed, giving a score in letters per minute (LPM). This assessed children's ability to see, remember and reproduce a sentence containing all the letters of the alphabet, and did not assess neatness (although letters had to be correctly formed) or ability to generate letters. The Handwriting Speed Test (Wallen, Bonney, & Lennox, 1996) was designed and standardised for children in Australia. The test involves copying the sentence 'The quick brown fox jumps over the lazy dog' as many times as possible in three minutes. 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 (Pearson's product moment correlation: r=.99) was established.

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 *et al.* (1991) and adapted by Jones and Christensen (1999) for whole classes, rather than individuals. The task involved writing in lower-case as many letters of the alphabet as possible in one minute. Pupils who completed all 26 letters in lower case continued 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 (Berninger *et al*., 1991).

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The children were asked to write as quickly and as neatly as possible. 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 (r=.98).

Findings

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

The range of scores on the Alphabet Task was 1–78 alphabet letters per minute (ALPM) with a mean of 31.7 (SD=11.4). It is interesting to compare the results and distribution of this finding for Y2 children undertaking a similar test, reported in Medwell *et al*. (2007). The mean score on the Alphabet Task for Y6 children was approximately twice as that of Y2 children (mean 16.7, SD8.4) and over 95% of the Y2 children scored below the Y6 mean. This indicates that the children's performance on the alphabet task was very strongly age related. It is also notable that the Y6 results were normally distributed whereas there appeared to be a ceiling effect with the younger Y2 sample.

The range of scores for the Handwriting Speed Test was 4–113 letters per minute with a mean of 64.2 (SD=19.1).

In the Handwriting SAT for Year 6 children, 76 children (38.4%) scored 1 point, 95 (48.0%) two points and 25 (12.6%) three points. The mean was 1.7 (SD 0.67). This shows a surprisingly large number of children struggling with letter formation, orientation and regularity at Year 6 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 of composition SAT scores was 4–46, with a mean of 26.5 (SD=8.5). The sample seems to have scored a little less than the national average in their writing outcomes with 57.6 % of pupils achieving level 4 or above in writing, where the national average was 67% (DfES & Ofsted, 2006).

The relationship between handwriting and composition?

The full correlation matrix (Appendix 1) shows a high correlation between performance on the Alphabet Task and Composition (r=.46). This is higher than the correlation for speed alone (Handwriting Speed Test) at r=.32 or the correlation with neatness and letter formation (indicated by the handwriting SAT score) of r=.34. The

Table 1. Range, mean and standard deviation (SD) of writing test scores.

	N	Range	Mean	SD
Alphabet letters per minute	197	1–78	31.7	11.4
Handwriting Speed	197	4–113	64.2	19.1
Handwriting SAT score	196	1–3	1.7	.67
Composition SAT score	196	5–38	20.7	6.9
Total writing SAT marks	196	4–46	26.5	8.5
Reading SAT marks	196	2–47	30.7	9.6
Maths SAT marks	197	7–100	60.1	22.7

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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.

The Alphabet Task performance accounted for 21.5% of the variance in composition for these Y6 children, which is lower than the equivalent figure for Y2 children (34% – see Medwell *et al*., 2007). This may indicate that as writers develop, and write more sophisticated texts, there are other issues which account for more of the variance.

Interestingly, the Y6 Alphabet Task results accounted for a similar proportion of variance in composition to that reported in studies outside England. Berninger and Graham (1998), for example, reported that handwriting automaticity accounted for 25% of the variance in compositional quality in primary grades in the US.

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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 was entered first because it is the best single predictor of composition. Only scores on the Alphabet Task and Handwriting SAT score (neatness) were significant. Thus adding the SAT score for handwriting (neatness) to the regression increases the multiple r to .56, explaining an additional 10% of the variance in composition. Pure handwriting speed plays no part in predicting composition scores after automatic letter production (the Alphabet Task) and neatness (SAT Handwriting score) are accounted for. This is in contrast to the Y2 results, where handwriting speed did account for a further 10% of the variance.

These results are very interesting in relation to those children with special educational needs who qualify for test accommodation in which they are given an additional 25% time in the national tests. Such accommodation requires evidence of slow handwriting speed as the rationale for allowing extra time. This data would suggest that this rationale is inappropriate at it is not slow handwriting but orthographic–motor integration and neatness which are the relevant factors in the Y6 composition scores. Of the three tests available for handwriting speed assessment, only the DASH (Barnett, Stainthorp, Henderson, & Scheib, 2007) includes a specific letter generation element.

Table 2. Multiple regression of handwriting measures against writing composition score.

	Unstandardized coefficients (B)	Std. error	Standardized coefficients (Beta)	t	sig.
(Constant)	11.307	1.700		6.651	.000
Alphabet letters per minute	.251	.050	.384	5.060	.000
Letters per minute	.036	.028	.096	1.287	.200
handwriting score 1 (vs. 2)	−3.343	.922	−.234	−3.626	.000
handwriting score 3 (vs. 2)	3.119	1.325	.150	2.355	.020

Notes: (a) Dependent variable: KS2 composition score.

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Causal relationship between ALPM and composition

What has been demonstrated above is only a correlation between performance on the Alphabet Task and composition scores, rather than a causal role for automatic letter production. 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 and maths achievement. The measures of reading proficiency and maths achievement used were the SAT reading and maths scores for each child, assessed using the national tests. The range, mean and SD of these can be seen in Table 1.

Total reading and maths score is a good predictor of both composition (r=.63) and performance on the Alphabet Task (r=.50) so is a relevant control variable. The zero-order correlation of ALPM and composition is 0.46 (see Table 2). After controlling for maths and reading scores, the partial r drops to 0.22, but remains statistically significant ($p<.005$). Thus there is a strong relationship between ALPM and composition even when variation in reading and maths 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 or general intelligence. 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 would be very interesting 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 one letter up to those who wrote 78 letters in one minute – the extremes of our sample.

In a study by Jones and Christensen (1999) of 6- to 7-year-old children, scores of eight or below on the Alphabet Task were graded poor, 9–14 low average, 15–24 average, 25 –30 good and 31 very good, although their rationale for this was not given. However, if this grading system were used with our larger Y6 sample, this would identify only 4% of the children whereas for our Y2 sample, this identified 37% of the pupils. This evidence, and the distribution discussed above, suggests that it is not possible to specify cut off points independent of age group.

Another approach to identifying a threshold level of automaticity is to take a normative approach and look at the relationship with an external criterion. Within the Y6 sample, the Alphabet Task Scores have been grouped into 6 bands each containing approximately 17% of the sample (Table 3). This banding reduces the correlation with composition slightly, but not excessively (r drops from .46 to .45). For these Year 6 pupils, the national expectation is that the typical pupil should achieve Level 4 in writing by the end of KS2. A logistic regression was computed to identify the relationship between ALPM and the probability of achieving Level 4 or above in the national writing test. Figure 1 gives a graphical presentation of the results in Table 3 (above).

Table 3. Pupils in different score bands on ALPM.

Alphabet Task Score Band	Frequency	Valid percent	Cumulative percent	% achieving Level 4+ in writing test
1 Bottom 16% (0–22)	32	16.2	16.2	27.3
2 Low (23–25)	22	11.2	27.4	47.2
3 Low–middle (26–29)	38	19.3	46.7	52.4
4 High–middle (30–34)	37	18.8	65.5	53.7
5 High (35–42)	35	17.8	83.2	76.2
6 Top 16% (43+)	33	16.8	100.0	88.0
Total	197	100.0		58.8

Note: One case was missing for ALPM score.

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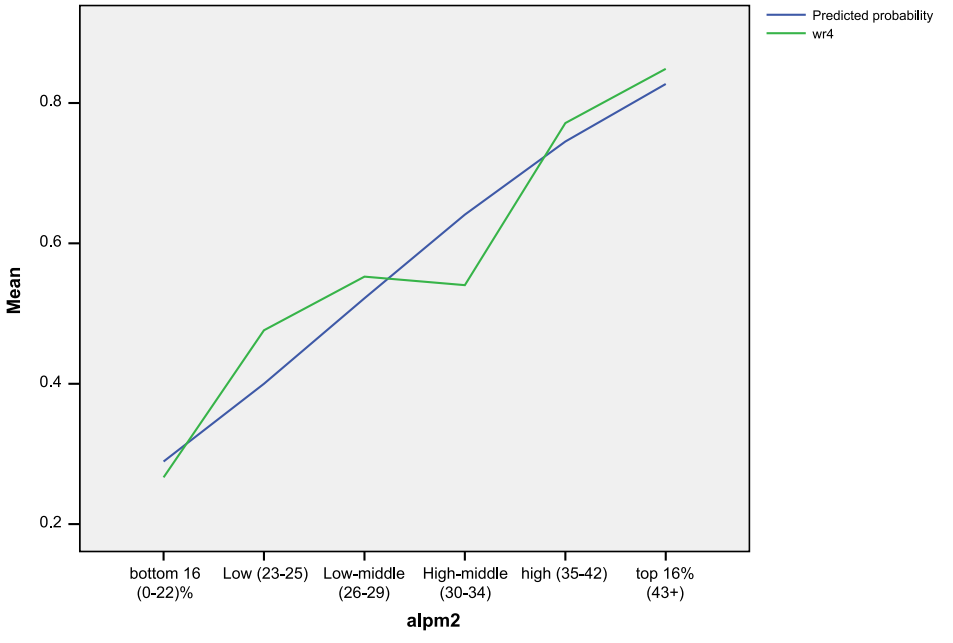

Figure 1. Logistic regression of ALPM against the probability of achieving Level 4 or above in the KS2 writing test.

For the two middle groups (Bands 3 and 4) the probability is around the sample average. However for Band 5 this rises to 76% and to 88% for Band 6. Conversely for Band 2 the probability drops to 47% and to only 27% for Band 1. This ALPM of 22 or less for an Y6 pupil indicates a significant risk of not achieving Level 4 in writing. However, overall accuracy of prediction is only 67%. If handwriting SAT score (neatness) is also included the accuracy is raised to 73%. Speed is not a significant predictor of risk when ALPM and handwriting are included, the same result described for composition in the earlier regression.

The combination of ALPM and handwriting to create risk tables shows that if handwriting is rated as good (score =3, 13% of sample) risk is very low whatever the ALPM. If handwriting is average (score=2, 48% of sample) an ALPM score <=22

gives a low (<40%) likelihood of achieving Level 4. If handwriting is rated as poor (score = 1, 39% of sample) then an ALPM score of <=25 indicates a low likelihood <40% of achieving Level 4.

It might be argued that it is inappropriate to use the handwriting score as a predictor since this also contributes to the criterion measure (KS2 writing level is based on total marks across composition, spelling and handwriting). However of the 50 marks for writing only a maximum of 3 marks (6%) can be awarded for handwriting. Also handwriting is independently correlated with spelling and composition scores, and the correlation with overall writing score largely reflects this. In this analysis of risk it is important to employ an external criterion that is recognised and relevant for practitioners, and the published KS2 writing level fulfils this requirement.

These figures do not offer sufficient predictive accuracy to make ALPM a valid screening test on its own, but the high relative 'risk' suggests that, for children with poor or average handwriting, in terms of neatness, 22 letter per minute or less is a borderline area which will benefit from further investigation and a point at which teachers should consider further diagnostic and intervention work.

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Group differences in ALPM within the sample

There are highly statistically significant differences on the Alphabet Task which relate to gender. Boys scored on average 5 letters per min lower than girls (p<.001). This is close to what Wallen *et al.* (1996) reported for the Australian Handwriting Speed Test (four letters per minute advantage for girls). This finding is interesting when compared with the gender difference for the Y2 sample we reported in Medwell *et al.* (2007). In the Y2 sample boys scored on average 3.5 letters per minute lower than girls (p<.003). The finding that the difference in ALPM on the Alphabet Task which relate to gender is greater in older children suggests that this difference may be related to the current perceived underachievement of boys in writing (UKLA & PNS, 2003).

Research in the 1980s and 1990s 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, 1993; 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.

An aspect of handwriting performance which might be important is handedness. Left-handed children represented 21% of this Y6 sample. However, handedness did not appear to be a significant factor in ALPM scores which were similar for each group at Y6 (nor was there a significant difference in Y2). Alphabet Task scores measure 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.

Free School Meals (FSM), used as an indicator of socio-economic status, also appeared to be relatively unconnected to letter generation ability. The children entitled to FSM did score significantly lower in terms of composition (p=.005). They also scored lower on the Alphabet Task, but not significantly so (p=.009), indicating that some part of their reduced composition score is due to factors other than letter generation.

A final group effect which may bear further analysis elsewhere is the school effect. There were definite school effects in the current data and if a regression analysis is

Table 4. Multiple regression of handwriting measures and school (identified as 1,2,3,4) against writing composition score.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1(a)	alpm2	.522	.126	17.130	1	.000	1.685
	hand1	−1.457	.388	14.118	1	.000	.233
	hand3	2.383	.748	10.144	1	.001	10.834
	s2	.119	.590	.040	1	.841	1.126
	s3	−.713	.470	2.307	1	.129	.490
	s4	−2.211	.578	14.623	1	.000	.110
	Constant	−.366	.564	.422	1	.516	.693

Note: (a) Variable(s) entered on step 1: alpm2, hand1, hand3, s2, s3, s4.

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repeated to include Alphabet Task score, neatness scores and school number, predictive accuracy is increased to 74% (Table 4).

This is particularly interesting when the mean scores are studied. On every measure of attainment at the end of KS2 (except neatness), including the ALPM and speed tests, School 4 was the lowest attaining school (see Table 5). However, this school had unexpectedly high neatness scores indicated by Handwriting SAT scores. 29% of pupils in School 4 were awarded a handwriting score of three compared to 13% across the sample as a whole. Unless these externally marked tests have been wrongly marked and moderated, this finding bears examination. Although the data do not identify the aspects of the school which underlie this difference, enquiries made in the schools identified a very significant difference between the handwriting teaching in School 4 and in the other three schools. School 4 had completed a two year handwriting improvement programme for all children at the time when this data was collected. This was not the case in any other school in the sample. School 4 had introduced a new handwriting script and all children (including the Y6 children in this sample) had practiced this script (using a conventional handwriting programme based on lines of letters) for 10–15 minutes each day, for two academic years. We cannot know whether this was the cause of the high neatness scores but it is interesting to speculate that, whatever had affected neatness scores, this conventional practice of writing rows of letters and the introduction of a new script did not appear to have addressed the handwriting issue which is most strongly predictive of composition success- automatic letter production. The data in this paper cannot offer answers in this area but do raise an interesting issue for future work.

Even when handwriting is not included as a predictor in the analysis, membership of School 4 still increased the risk of not achieving Level 4 relative to the other schools ($p<.015$), indicating that there were other factors at work.

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 teachers' 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 neatness and speed. Further information in both these

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Table 5. Mean, SD and sample size on key variables for each school in the sample.

school		% entitled FSM	% ethnic minority	% Left handed	% girls	%Level 4+ Writing	ALPM	speed	KS2 composition	KS2 handwriting	KS2 reading marks	KS2 maths marks
1	**Mean**	**16.1%**	**20.4%**	**23.2%**	**53.6%**	**69.8%**	**32.1**	**61.2**	**23.8**	**1.63**	**33.7**	**61.5**
	N	56	54	56	56	53	56	56	54	54	54	55
	SD	0.37	0.41	0.43	0.50	0.46	11.9	20.8	7.0	0.6	8.2	21.4
2	**Mean**	**5.9%**	**15.6%**	**35.3%**	**50.0%**	**76.5%**	**33.0**	**68.1**	**24.2**	**1.94**	**32.2**	**65.5**
	N	34	32	34	34	34	34	34	34	34	34	34
	SD	0.24	0.37	0.49	0.51	0.43	12.1	17.7	6.8	0.7	8.8	23.9
3	**Mean**	**7.1%**	**16.1%**	**21.4%**	**39.3%**	**58.9%**	**36.4**	**73.8**	**19.2**	**1.55**	**31.9**	**69.4**
	N	56	56	56	56	56	55	55	56	56	56	56
	SD	0.26	0.37	0.41	0.49	0.50	11.2	17.0	5.7	0.5	10.1	18.9
4	**Mean**	**38.5%**	**5.8%**	**11.5%**	**53.8%**	**34.6%**	**25.7**	**54.8**	**16.9**	**1.92**	**25.5**	**45.2**
	N	52	52	52	52	52	52	52	52	52	52	52
	SD	0.49	0.24	0.32	0.50	0.48	7.9	15.1	5.9	0.8	9.3	20.2
Total	**Mean**	**17.7%**	**14.4%**	**21.7%**	**49.0%**	**58.5%**	**31.8**	**64.2**	**20.7**	**1.74**	**30.8**	**60.1**
	N	198	194	198	198	195	197	197	196	196	196	197
	SD	0.38	0.35	0.41	0.50	0.49	11.5	19.2	7.0	0.7	9.7	22.8

areas would be of assistance to teachers and researchers in deciding which children might benefit from handwriting intervention.

The results discussed above replicate those of the Y2 study reported in Medwell *et al.* (2007) and suggest that a high proportion of the variance in composition for the children in this Y6 sample was 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, mentioned 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 has begun to explore a level at which Y6 children might benefit from improving their automaticity, in order to facilitate composing. Children with average or poor neatness in their handwriting, who score around 22 ALPM, or less, on the alphabet task have only a 40% chance of achieving Level 4 in the English SAT (the national target). 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 even at this age when in England they are about to go on to secondary education.

Finally, the study demonstrates that this effect is not only much 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, but also that the gap between boys and girls is wider for these Y6 children than for comparable groups in Y2. At a time when improving composition, and especially that of boys, is a national priority this suggests that intervention to improve handwriting automaticity may be of benefit to boy writers and that early intervention is desirable – this is not an issue which improves spontaneously. Further research needs to be aimed at developing and validating a simple intervention programme. The school effect in this data does not reveal the nature of school differences which affect the attainment scores but there are very tentative reasons for suspecting that application of a conventional handwriting programme may not be the answer for this issue.

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APPENDIX 1

Full Y6 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	.609**	.076	.135	.489**	.464**	.465**	.464**
	Sig. (2-tailed)		.000	.288	.059	.000	.000	.000	.000
	N	197	196	195	197	195	195	195	195
LPM (Speed)	Pearson correlation		1	−.002	.133	.366**	.414**	.370**	.321**
	Sig. (2-tailed)			.976	.063	.000	.000	.000	.000
	N		197	195	197	195	195	195	195
SAT Handwriting	Pearson correlation			1	−.065	.404**	.219**	.229**	.345**
	Sig. (2-tailed)				.363	.000	.002	.001	.000
	N			196	196	196	196	196	196
Age in months	Pearson correlation				1	.100	.038	.033	.111
	Sig. (2-tailed)					.162	.601	.642	.122
	N				198	196	196	196	196
Total writing SAT score	Pearson correlation					1	.679**	.685**	.975**
	Sig. (2-tailed)						.000	.000	.000
	N					196	196	196	196
Spelling SAT score	Pearson correlation						1	.652**	.559**
	Sig. (2-tailed)							.000	.000
	N						196	196	196
Reading SAT score	Pearson correlation							1	.637**
	Sig. (2-tailed)								.000
	N							196	196
Composition SAT score	Pearson correlation								1
	Sig. (2-tailed)								
	N								196