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The Role of Orthographic–Motor Integration in the Production of Creative and Well-Structured Written Text for Students in Secondary School

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There is a strong relationship between orthographic–motor integration related to handwriting and students' ability to produce creative and well-structured written text. This relationship is thought to be due to the cognitive load which results when attention is required by writers to write letters and words on the page. Lack of automaticity in orthographic–motor integration means that writers do not have sufficient cognitive resources to accomplish the more demanding aspects of text production such as ideation, text monitoring, and pragmatic awareness. A systematic handwriting program can significantly improve the quality of written text by young children experiencing problems with orthographic–motor integration. This study investigated the effectiveness of a handwriting program in remediating older students' problems in orthographic–motor integration and consequently enhancing their written language skills. Two groups of students in Grades 8 and 9 were provided with either practice in handwriting or daily completion of a written journal. There were no differences between the two groups at pre-test. However, at post-test, the handwriting group had significantly higher scores in orthographic–motor integration as well as for the length and quality of the text they wrote.

Orthographic–motor integration refers to the way in which orthographic knowledge is integrated with the motor demands of handwriting in order to produce letters and words. A focus on handwriting for students in secondary schools may appear unnecessary. Handwriting is often regarded as a low-level skill which is easily mastered at early elementary levels. From this perspective, the curriculum for adolescents should focus on generation of complex ideas that are logically organized and well articulated in written text.

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The production of written text is an intellectually demanding task. It requires the writer to translate ideas into written form through various language-specific processes. These processes of ideation and translation require a complex array of cognitive and metacognitive processes. Examples of these processes include accessing lexical knowledge, semantic coding, phonological coding, and monitoring of syntactic structures (Bain, 1991; Berninger, 1994; Levine, 1987). As students become older and written tasks increase in length and complexity, higher-order processes become more critical in producing text (Hooper et al., 1993). In addition, self-monitoring, revising, and editing skills are necessary for students to detect errors, check for semantic content and syntactic expression, and modify text appropriately (Beal, 1993; Butterfield, Douglas, & Plumb, 1994). Effective writers need to evaluate information and analyze issues in order to organize and plan their text selectively (Bellanca & Fogarty, 1992; Gleason, 1995; Graham, MacArthur, Schwartz, & Page-Voth, 1992; Harris & Pressley, 1991). At the same time, writers need to identify their audience and the purpose of writing so that they communicate clearly.

As a result of the importance of this complex array of processes, many studies of students' writing have focused on the cognitive and metacognitive skills involved in the planning and generation of ideas, and the monitoring and revision of text (Hayes & Flowers, 1980). Relatively little attention has been paid to the question of whether the number and complexity of these processes may place an excessive cognitive load on the writer's intellectual resources. Cognitive resources available for conscious processing are extremely limited; individuals can accomplish only one intellectual task requiring attention at a time (Sweller, 1988; Sweller & Chandler, 1994). Thus, in addition to the nature of the processes that underpin writing, the way in which an individual manages his or her cognitive resources is also critical for successful writing (Saada-Robert, 1999).

Individuals can manage the cognitive load of writing in two basic ways. First, they can automate the basic sub-components of the task. Second, they can sequence cognitive activities, so that only one attention-consuming process is executed at a time. For example, writers can focus on ideation in the first draft of text, then monitor and revise for syntactic, semantic, and pragmatic adequacy in second and subsequent drafts. Many approaches utilized to teach written language focus on the role of sequencing tasks to manage cognitive load.

Less frequently recognized in teaching written language is the critical role of automaticity of sub-component skills in reduction of cognitive load and effective management of cognitive resources. Automaticity refers to the execution of cognitive tasks quickly, accurately, efficiently, and without the need for attention to be allocated to the task (La Berge & Samuels, 1974). Automaticity allows the execution of a skill without conscious thought so that other important aspects of the task requiring conscious thought can be undertaken.

For writers, sequencing of component skills is an effective way of managing resource limitations when the task of writing does not require the simultaneous execution of component sub-skills. However, some sub-skills are essential to writing and cannot be sequenced. Handwriting is a necessary and unavoidable aspect of

generating written text. In order to generate creative and well-structured written text, students must have the mechanical aspects of getting letters, words, and sentences onto the page at a level of automaticity. Unless handwriting is automated, the cognitive load required for the physical act of writing can overwhelm the system and interfere with more complex processes that require conscious thought for ideation, sequencing ideas, and monitoring of accuracy and communicative clarity.

Handwriting is not purely a physical act. Berninger and Graham (1998) refer to handwriting as "language by hand." It requires the integration of orthographic knowledge and fine-motor skills related to formation of letters on the page. In fact, orthographic and memory processes may contribute more to handwriting than motor skills (Berninger & Amtmann, 2004).

Handwriting is often seen as a minor aspect of writing and irrelevant to the generation of complex text. Thus, teaching of handwriting is sometimes seen as exemplifying the worst aspects of educational practices that focused on rote learning of fragmented skills. However, there is a growing body of evidence to suggest that orthographic–motor integration related to handwriting is critical to the generation of creative and well-structured written text. Lack of automaticity in orthographic–motor integration can seriously impact on young children's ability to express ideas in text. For example, De La Paz and Graham (1995) investigated the impact of removing competing attentional demands, required by the mechanics of writing, through the use of dictation. They found that when the children used dictation the quality of written text improved for children at primary school age.

Scardamalia, Bereiter, and Goleman (1982) found that the mechanics of handwriting influenced the quantity of text generated but not the quality of the text. They asked students in Grades 4 and 6 to compose text under three conditions. First, students were asked to dictate at normal speed to a writer who transcribed the text. In another condition, students wrote their own text. Finally, Scardamalia et al. used a slow dictation condition where the writer transcribed the spoken text at a rate consistent with the students' hand-written text. Students produced most text in the normal dictation condition followed by slow dictation. The shortest text was produced when students wrote their own compositions. However, the quality of compositions was not influenced by method of text generation. This led Scardamalia et al. to suggest that mechanics has a small impact on the composition process in the intermediate grades.

In a replication study, Graham (1990) found that mechanics of handwriting related to orthographic–motor integration influenced both the quality and quantity of the written product. While the quality of compositions was similar in the slow and normal dictation conditions, the quality of written product was poorer when students wrote their own compositions than when they dictated to a scribe. Graham attributed this to the cognitive demands of handwriting when children were required to write their own text. The length of composition was influenced by the rate of dictation. Children produced longer compositions in the slow dictation condition.

Berninger and Swanson (1994) argued that data from 300 primary, intermediate, and junior grade children indicate that orthographic–motor integration skills are

critical in the development of all components of writing. They also found that transcription (writing their ideas on the page) accounted for a decreasing proportion of variance in composition fluency (quantity) as students develop from primary to junior high. Similarly, there was a decline in the amount of variance in composition quality accounted for by transcription as students grew older. Although its influence declined as children grew older, transcription continued to contribute to both composition fluency and quality through to junior high grades.

Christensen and Jones (2000) found that orthographic–motor integration accounted for 67% of the variance in written language scores of students in their second year of schooling. However, unlike Berninger and Swanson (1994) they reported that correlations remained fairly consistent across grade levels. In Grade 3 r =.74, Grade *5* r =.70, and Grade 8 r =.65.

There is some evidence to suggest that handwriting difficulties may be particularly important for more capable children experiencing problems in written language. Yates, Berninger, and Abbott (1994) found that transcription skill was the best variable to differentiate good and poor writers among intellectually talented students in elementary grades.

In addition to correlations demonstrating a relationship between orthographic–motor integration and competence in written language, Jones and Christensen (1999) found that practice in handwriting can significantly improve young children's ability to produce high quality written text. They tested the impact of an intervention designed to facilitate efficient handwriting with children in Grade 2 who demonstrated low levels of written language achievement due to problems with orthographic–motor integration. Prior to the intervention these children had written language scores significantly below their peers. After one semester of practice in handwriting, children's orthographic–motor integration as well as their written language matched a normally-achieving control group of peers.

Thus, there is a strong relationship between orthographic–motor integration and the length and quality of children's writing. Additionally, intervention in handwriting alleviates very young children's orthographic–motor integration problems and enhances their ability to generate creative and well-structured written text. However, it is not clear that simply enhancing the handwriting skills of older students will address their problems in written language. Unlike young children, adolescents have experienced many years of failure and frustration in writing. In addition to the impact that a history of failure has on motivation, students who have experienced chronic difficulties in writing have missed out on years of skills development acquired though the process of writing. Therefore, it may be that older students do not gain the same magnitude of benefit from facilitation of handwriting skills that has been observed in younger students. Alternatively, it may be that managing the cognitive load required to write, through development of automaticity in handwriting, may allow these students to focus attention appropriately and employ their accumulated language skills to produce text. That is, attention to handwriting may enhance adolescents' written language in the same way that it does for younger students.

Thus, this study examined the impact of enhancing adolescents' orthographic–motor integration related to handwriting on their ability to produce creative and well-structured written text.

Method

Participants

Participants were 50 students in Years 8 and 9 at a secondary school in Brisbane, Australia. All students had low levels of orthographic–motor integration related to handwriting. The average age was 13 years, 6.5 months. There were 22 girls and 28 boys.

Materials

Writing speed and accuracy. Orthographic–motor integration related to handwriting was assessed by a measure based on a task developed by Berninger, Mizokawa, and Bragg (1991). Students were asked to write as many letters in correct alphabetical order as possible in one minute. They were told to complete all the lower case letters first, and if time permitted write upper case letters. If they completed both lower and upper case, they began the sequence again.

Scoring followed the same format as the timed accuracy measure used by Berninger, Mizokawa, and Bragg (1991). The number of letters which students correctly formed and wrote in the correct sequence was counted. Omissions, reversals, transpositions, and substitutions did not contribute to the score. Inter-rater reliability using Pearson's product moment correlation was $r = .99$.

Quality of written language. Written language was assessed from a piece of independently generated text. Quality of written text was scored on: creativity and originality of ideas (five marks), logical organization and structuring of ideas (five marks), technical accuracy of spelling and grammar (five marks), comprehensiveness and elaboration of ideas in relation to the topic (five marks), and pragmatic awareness and sensitivity to audience (five marks). The inter-rater reliability for quality scores using Pearson's product moment correlation was $r = .89$. Length (fluency) was assessed by counting the number of words students wrote on the topic.

Procedure

Selection of participants. Initially, all Year 8 and 9 students in the school were assessed for orthographic–motor integration. Students with scores more than two standard deviations below the mean were invited to participate in the study. In all, 56 students agreed to participate. Students were matched on gender and orthographic–motor integration and randomly assigned to either control or experimental groups. Three students failed to complete all data collection activities due to

prolonged absence as a result of illness or transfer to another school. Both the absent students and the students they were matched to in their matched pairs were deleted from the study, so that 25 matched pairs of students completed the intervention and all assessments.

Pre-testing. Participants completed a hand-written piece of text. The topic was "My greatest challenge." Students were given three minutes to think about what they would like to write on the topic. They were then given 20 minutes to complete the task. They worked independently without assistance. They were asked to "have a try" at spelling any word they didn't know rather than seeking help.

Intervention. All students met in groups of five or six with a tutor. Sessions lasted 20 minutes per day for eight weeks. Sessions were scheduled during normal lesson times. However, times varied from day to day so that students did not miss excessive amounts of work in any particular content area.

The control group completed a written journal. Students were encouraged to write whatever was significant for them each day. Journals were read by the tutor after each session. Comments of encouragement and interest were provided to student (e.g., "It sounds like you had an interesting time, could you tell me a little more?"; "That must have been very difficult for you"). However, they were not given feedback on technical aspects of their writing.

The experimental group completed a handwriting program. The program was specifically developed for the project. It provided sequenced practice in writing letters, words, and sentences. Letters were sequenced according to shape. The program began with letters based on a circle (e.g., a, d, c), and continued with other formations until all letters were covered. Initially single letters were practiced in isolation. This was followed by two- and three-letter exercises, so that various entries and exits were practiced. Finally words, phrases, and short sentences were introduced.

Progression through the sequence was criterion based. When students felt they had mastered the letter that they were working on, they could undertake a mastery test. When students reached a criterion of 60 letters per minute they were advanced to the next level in the sequence. The criterion of 60 letters per minute was selected because it was the approximate mean for students of this age in a previous study.

Post-testing. This followed the same format as pre-testing. Students completed orthographic–motor integration and written language assessments. The topic for written language was "A great adventure."

Results

Means and standard deviations for each measure at pre- and post-test are given in Table 1.

Table 1. Means and standard deviations for each measure at pre- and post-test

Measure		Pre-test		Post-test	
		Journal	Handwriting	Journal	Handwriting
Orthographic–motor integration	Mean	26.67	26.28	28.42	48.54
	SD	(4.52)	(4.70)	(10.78)	(22.26)
Written text quality	Mean	10.04	9.86	10.85	15.88
	SD	(4.07)	(4.98)	(3.88)	(4.16)
Written text length	Mean	116.29	108.48	87.88	197.77
	SD	(60.2)	(64.56)	(47.8)	(47.54)

The independent variables were type of instruction (journal vs. handwriting). The dependent measures were orthographic–motor integration, quality, and length of written text. A multivariate analysis of variance was used to test for significant differences between means on each dependent measure. It was anticipated that practice in handwriting would enhance students' orthographic–motor integration, as well as quality and length of written text.

There was a significant main effect for time ($F[3,42] = 9.7$, $p < .001$, $\eta^2 = .56$) and a main effect for group ($F[3,42] = 16.2$, $p < .001$, $\eta^2 = .31$). In addition there was a significant group by time interaction effect ($F[3,42] = 17.5$, $p < .001$, $\eta^2 = .54$).

Follow-up univariate tests were conducted for each measure. These indicated that there was a main effect for time on all measures: orthographic–motor integration ($F[1,44] = 26.1$, $p < .001$, $\eta^2 = .37$), quality of written text ($F[1,44] = 25.9$, $p < .001$, $\eta^2 = .37$), and length of written text ($F[1,44] = 6.8$, $p < .001$, $\eta^2 = .13$).

There was a main effect for group on all measures: orthographic–motor integration ($F[1,44] = 10.5$, $p = .002$, $\eta^2 = .19$), quality of written text ($F[1,44] = 5.0$, $p < .03$, $\eta^2 = .10$), and length of written text ($F[1,44] = 6.815.8$, $p < .001$, $\eta^2 = .27$).

There was also a significant time by group interaction effect for orthographic–motor integration ($F[1,44] = 16.3$, $p < .001$, $\eta^2 = .27$), for quality of written text ($F[1,44] = 16.6$, $p < .001$, $\eta^2 = .27$), and for length of written text ($F[1,44] = 27.3$, $p < .001$, $\eta^2 = .38$).

Post hoc analyses were undertaken using Tukey's to identify the precise locus of effect of the interaction effects. These demonstrated the same pattern of effects on all measures. The differences between groups at pre-test were not significant. However, the handwriting group performed better on all measures at post-test. There was a significant difference from pre- to post-test for the handwriting group. However, the difference from pre-test to post-test for the journal group was not significant. Figures 1–3 illustrate the interaction effects on each measure.

As the quality of written text measure was composed of five elements, a multivariate analysis of variance was carried out on the components of the quality score. The independent variables were time (pre-test vs. post-test) and group (handwriting vs. journal). The dependent measures were creativity and originality of ideas, logical organization

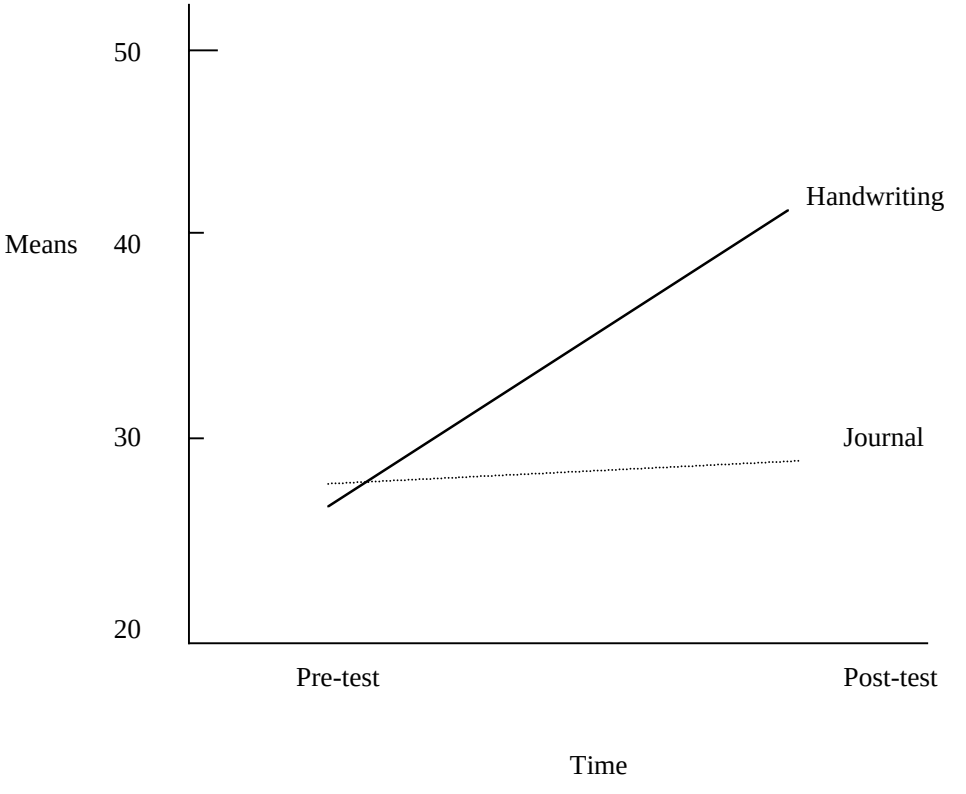

Figure 1. Means for both groups at pre- and post-test on measure of orthographic–motor integration

and structure, technical accuracy, comprehensiveness, and pragmatic awareness and sensitivity to audience. Means and standard deviations are given in Table 2.

There was a significant main effect for time ($F[1,41] = 3.9$, $p = .005$, $\eta^2 = .33$) and a significant time by group interaction ($F[1,41] = 3.7$, $p = .007$, $\eta^2 = .31$). Follow-up univariate analyses indicated significant main effects for time and interaction effects for time by group on all variables. Post hoc testing using Tukey's was conducted to determine the precise locus of time by group interaction effects. The same pattern of significance was found for all variables. The differences between groups at pre-test were not significant. However, the handwriting group performed better on all measures at post-test. The difference between pre-test and post-test was significant for the handwriting group but not for the journal group.

Discussion

Existing research has established a strong relationship between orthographic–motor integration related to handwriting and students' ability to produce creative and

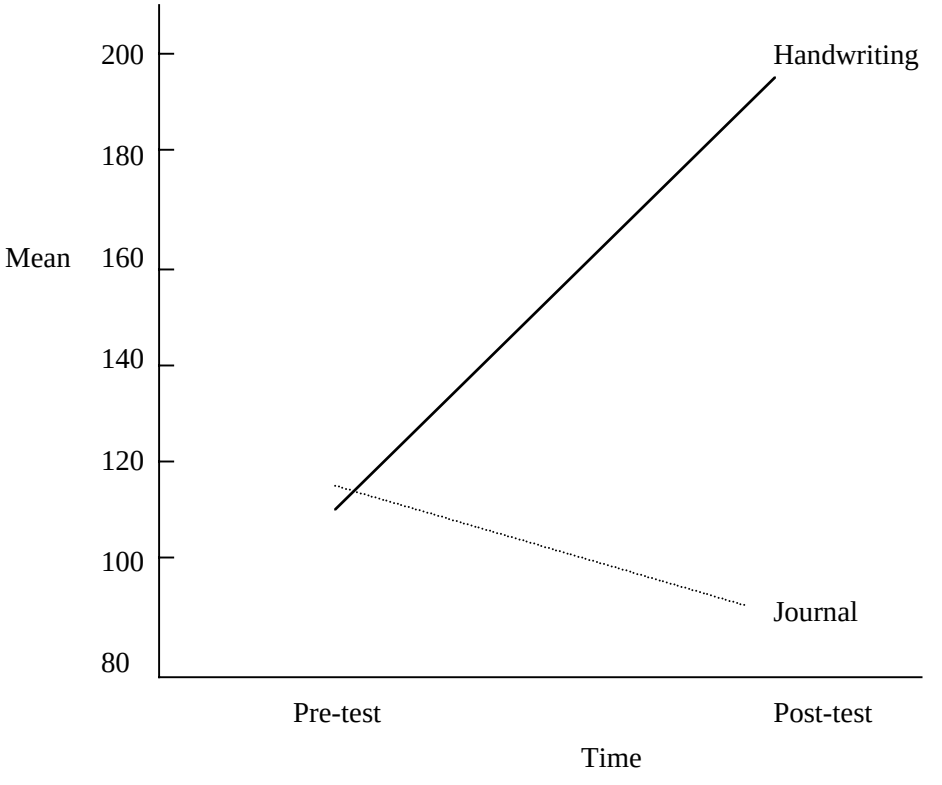

Figure 2. Means for both groups at pre- and post-test on length of written text

well-structured written language (Berninger & Swanson, 1994; De La Paz & Graham, 1995; Graham, 1990). Some correlational studies suggest that orthographic motor integration accounts for more then 50% of the variance in written language. Some studies have indicated that the influence of orthographic–motor integration declines with age (Berninger & Swanson, 1994). However, others indicate that it continues to exert an influence on writing into secondary grades (Christensen & Jones, 2000). Given the impact of handwriting skills on children's ability to generate sophisticated text, it appears critical that children develop smooth and efficient handwriting. Jones and Christensen (1999) demonstrated that providing young children with practice in writing letters and words significantly improves the quality of their written language skills.

The study reported here demonstrated that although students in secondary school with very low skills in orthographic–motor integration have experienced many years of failure in writing, they can also benefit from a structured handwriting program. Although both the journal and handwriting groups were equivalent at pre-test, the scores for the handwriting group after eight weeks of intervention were significantly better on all post-test measures. In other words, by facilitating students' ability to put

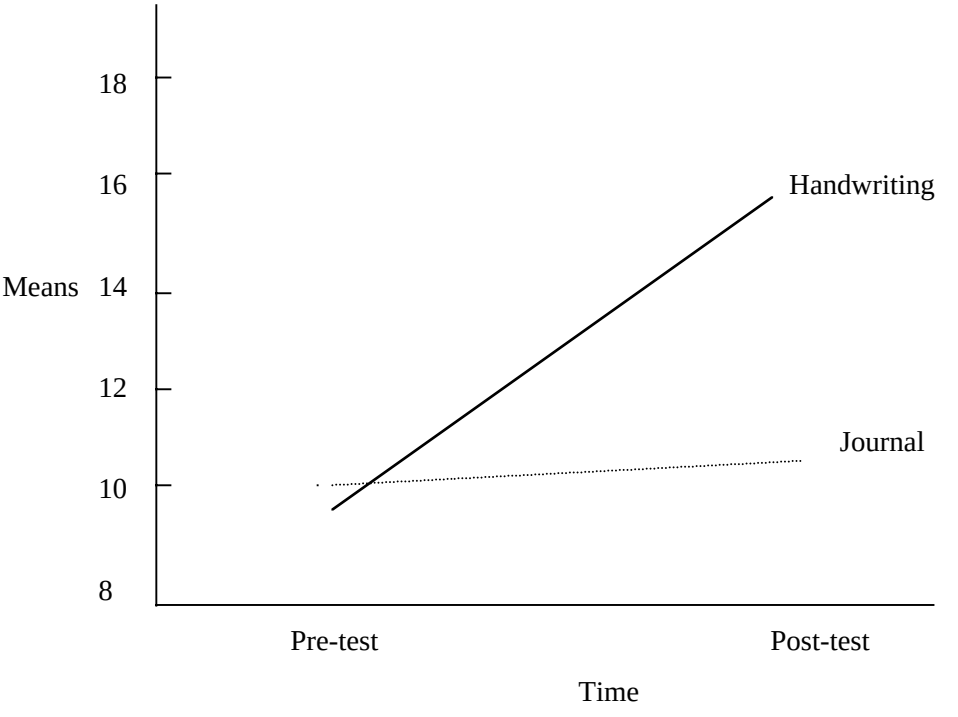

Figure 3. Means for both groups at pre- and post-test on quality of written text

letters and words on the page, their ability to produce text was also enhanced. This text was more creative, original, technically accurate, logically sequenced, and better organized, and showed greater pragmatic awareness and sensitivity to audience. These differences were not trivial. Effect sizes indicated that the time by group interaction

Table 2. Means and standard deviations for each component of quality of the written text measure at pre- and post-test

		Pre-test		Post-test	
Measure		Journal	Handwriting	Journal	Handwriting
Originality	Mean	2.0	1.9	2.1	3.1
	SD	(.20)	(.20)	(.17)	(.16)
Organization	Mean	2.0	2.0	2.2	3.1
	SD	(.20)	(.20)	(.20)	(.16)
Accuracy	Mean	2.0	2.0	2.2	3.1
	SD	(.19)	(.18)	(.18)	(.18)
Comprehensiveness	Mean	2.0	1.9	1.7	3.1
	SD	(.22)	(.22)	(.22)	(.19)
Clarity	Mean	1.9	1.8	2.1	3.1
	SD	(.21)	(.21)	(.20)	(.19)

accounted for 27% of scores on quality of written text and 38% of the length of text. At post-test, scores for the handwriting group were 70% higher in orthographic–motor integration and 46% higher in quality of written text than the journal group. Additionally, the handwriting group wrote approximately twice as much text.

Thus, it appears that by enhancing students' ability to produce letters efficiently, the cognitive load associated with orthographic–motor integration was substantially reduced. This allowed students to deploy their cognitive resources to the most complex and demanding aspects of the task involving ideation, syntactic and semantic monitoring, and pragmatic awareness.

It should be noted that the focus of the intervention was on developing automaticity in orthographic–motor integration as indicated by speed and fluency of handwriting. It did not emphasize quality of handwriting or the production of copy-book words and letters. Students were required to produce words and letters that were legible. The focus of the study was on improvement in students' ability to produce high-quality written text through reduction of the cognitive load required by handwriting.

It is not suggested that interventions to develop automaticity in orthographic–motor integration will be effective for all students with difficulties in production of written text. Rather, automaticity in orthographic–motor integration is a necessary but not sufficient prerequisite to sophisticated text production. Without automaticity in orthographic–motor integration, students do not have sufficient cognitive resources to focus attention on the more complex and demanding aspects of writing. Lack of automaticity means that sufficient attention is not available to even begin to focus on these demanding aspects of the task. However, once automaticity has been established, it is necessary for students to develop skills in higher-order aspects of the tasks. For these students further attention to orthographic–motor integration is likely to be unproductive.

The failure of the journal group to demonstrate improvement in written language commensurate with the handwriting group is interesting. Students in the journal group were encouraged to write text every day. However, it appears that as their difficulties in orthographic–motor integration were not addressed, their ability to produce text remained unaltered.

The journal writing intervention was not equivalent to regular on-going instruction. Students working on journals participated in small group instruction, working under the guidance of a tutor, where they received consistent praise and encouragement. The interventions were structured so that they were conducted in an interpersonal climate that was supportive and warm. Achievement and effort on tasks was acknowledged and respected. Thus, students in the journal group were given a number of experiences that could be expected to improve their written language skills. Nevertheless, their writing skills appear to have shown little improvement as a result of their experiences.

It should be noted that students in the handwriting group did not receive any instruction in written language. Nevertheless, their written language showed dramatic improvement. Thus, it appears that older students who are failing in written language because of problems in orthographic–motor integration can be assisted to overcome their difficulties both in handwriting and in production of written text

though a structured handwriting program. In contrast, students who were given enhanced experiences in producing written text, but did not address their problems with orthographic–motor integration, remained virtually static in terms of both the amount of text they produced and the quality of that text.

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