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# The Log Handwriting Program Improved Children's Writing Legibility: A Pretest–Posttest Study

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## KEY WORDS

- evidence-based practice
- handwriting
- occupational therapy
- program evaluation
- task performance and analysis

**OBJECTIVE.** We determined the feasibility and outcomes of the Log Handwriting Program (Raynal, 1990), an 8-week training program based on task-specific practice of handwriting.

**METHOD.** We used a pretest–posttest design involving 16 first- and second-grade Australian students. Handwriting training sessions occurred in schools for 45 min per week over 8 weeks, in groups of 2 or 3. Weekly homework was provided. The primary outcome measure was the Minnesota Handwriting Assessment (range = 0 to 34; Reisman, 1999). Legibility, form, alignment, size, spacing, and speed were measured.

**RESULTS.** All six assessment subscales showed statistically significant differences. Legibility improved by a mean of 4.1 points (95% confidence interval = 2.5 to 5.7); form, 5.3 points; alignment, 7.8 points; size, 7.9 points; and space, 5.3 points. Speed decreased by 3.9 points.

**CONCLUSION.** Preliminary evidence indicates that an 8-week Log Handwriting Program is feasible and improved handwriting in primary school children.

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Handwriting is an important occupational skill requiring motor, sensory, perceptual, and cognitive abilities (Chu, 1997). As much as 60% of a school day can be spent on fine motor tasks, including handwriting (McHale & Cermak, 1992). Handwriting difficulties in children include illegible handwriting and inefficient writing speed. Handwriting legibility is affected by letter formation, horizontal alignment, size, spacing, and slant (Amundson, 2005). Approximately 20% of primary school–age children have been identified as being at risk for developing handwriting problems (Berninger et al., 1997). As a consequence, occupational therapists frequently provide remediation for children with handwriting difficulties (Reisman, 1991).

Handwriting remediation programs are often delivered on site at school, either individually (Case-Smith, 2002) or in small groups (Berninger et al., 1997; Peterson & Nelson, 2003). Individual models of therapy allow intervention to be provided according to each child's need (Case-Smith, 2002). Group models of delivery allow more children to receive treatment and may help to reduce waiting lists.

Limited research has investigated the effect of handwriting remediation programs, either individual or group, on handwriting legibility. To determine what constituted an evidence-based handwriting remediation program and inform the current study, we reviewed individual randomized controlled trials and pretest–posttest single-group studies; no systematic reviews were located.

## Evidence-Based Handwriting Remediation

### *Group Based*

Remediation programs that appeared to be most effective included task-specific handwriting training and motor learning principles (Jongmans, Linthorst-Bakker, Westenberg, & Smits-Engelsman, 2003), feedback about performance (Denton, Cope, & Moser, 2006), and required dedicated handwriting practice.

One such group program taught children with and without handwriting difficulties how to form letter shapes, improve their letter size and writing speed, and then transfer and use these skills during real-life writing (Jongmans et al., 2003). Systematic reflection also occurred after each writing exercise to help children identify problematic areas of their writing and develop appropriate motor plans for future writing. After 6 months, children with handwriting difficulties improved more on a 65-point handwriting scale than did a control group (between-group difference of 5.1 points, 95% confidence interval [CI] = -1.4 to 11.5). However, improvements varied across the sample, and this difference was not statistically significant, possibly because the study was underpowered.

Another group program involving task-specific practice of copied and dictated text and writing from memory (therapeutic practice) improved handwriting performance more than that of a sensory-motor-based program and more than in a no-treatment control group (Denton et al., 2006). Therapeutic practice involved repetition of different letters, using different writing implements, classroom assignments, therapist feedback, and child self-evaluation. A small mean improvement of 5.4 points (95% CI = -4.6 to 15.4) was reported on a 100-point handwriting scale after 5 weeks of intervention. However, handwriting in the control group also improved by 2.0 points (95% CI = -9.6 to 13.6). The sensory-motor-based program resulted in worse handwriting, with a mean decline of 8.7 points (95% CI = -17.4 to 0.1) on the 100-point scale. Although none of these within-group differences were statistically significant, the findings suggest that programs involving writing practice, repetition, and feedback may improve handwriting slightly more than no treatment, but a sensory-motor-based program may not improve handwriting and could even result in worse handwriting.

Other sensory-motor-based programs have resulted in little or no effect on handwriting performance when compared with traditional handwriting instruction (Sudsawad, Trombly, Henderson, & Tickle-Degnen, 2002). Sudsawad et al. evaluated the effect of kinesthetic training, which

involved children differentiating the height of their arms with their vision occluded and moving their hand through a stencil pattern while holding a stylus, also with vision occluded. A control group completed handwriting practice, copying letters, words, and sentences of increasing complexity. Feedback was provided regarding letter size, horizontal alignment, and spacing; however, the article provides little detail on these processes. Both groups received only 3 hr of intervention, which possibly explains the lack of effect in both treatment groups.

Another well-known program, Handwriting Without Tears (Olsen, 2003), uses multisensory materials such as wooden pieces, letter cards, and Play-Doh to teach letter formation and writing. That program resulted in small statistically significant changes in letter size (mean improvement = 1.8 points; 95% CI = 0.2 to 3.3) and spacing (mean improvement = 2.8 points; 95% CI = 0.6 to 4.9) when compared to traditional classroom instruction, using a 34-point handwriting scale (Owens, 2004). However, groups showed no statistically significant differences for letter legibility, form, or alignment. The large sample ( $N = 81$ ), use of a blinded assessor, and narrow CIs increase the believability of study findings, but group differences were still small.

Berninger et al. (1997) evaluated a group-based instructional program to improve letter formation and writing fluency but not letter size, spacing, or horizontal alignment using a randomized controlled trial design. They compared five instructional methods over 12 weeks (modeling, visual cue, memory retrieval processes, visual cue and memory retrieval processes, and copying techniques). Children practiced writing letters of the alphabet, arranged in a random order, with instruction given according to group allocation. Children then composed sentences on predetermined topics. (The article provides a detailed description of the program.) Multiple measures indicated that a combined visual cue and memory retrieval approach involving directional arrows was most effective for improving letter transcription (an improvement of between 18% and 43% was noted when comparing the results with those of a contact control group who received training unrelated to handwriting). These differences were statistically significant, and improvements translated into improved writing fluency; however, the effect on letter size, spacing, and horizontal alignment is unknown because these domains were not measured.

The last group-based handwriting remediation program we reviewed provided intervention to economically disadvantaged children and used a randomized controlled trial design (Peterson & Nelson, 2003). The experimental program encouraged motor planning, motor memory, and self-monitoring and aimed to improve letter legibility using

multisensory modalities (e.g., writing in shaving cream). Strategies were used to improve letter size, line use, and spacing, but the article does not describe these strategies well. Intervention was individualized but followed a general plan and involved only 5 min of actual handwriting practice per session. Despite the limited amount of writing practice, legibility improved by a small amount more in the experimental group—which showed a mean between-group difference of 2.9 points (95% CI = 0.7 to 5.2) on a 34-point handwriting scale—than in the control group.

### *Individual*

The evidence for individual handwriting remediation programs is currently only slightly better than that for group programs. Individual school-based training resulted in improved children's legibility in one study that included a nonrandomized control group for comparison (Case-Smith, 2002). The article provides a limited description of program content, partly because intervention was determined individually for each participant and provided by 12 therapists. Legibility improved by 14.2% (95% CI = 8.9 to 19.5) in the treatment group using the Evaluation Test of Children's Handwriting (Amundson, 2004), compared with a 5.8% improvement (95% CI = -2.2 to 13.8) in the no-treatment control group. The mean effect between groups was only 8%; however, measures were obtained from only 69% of those participants ( $n = 9$ ) originally allocated to the control group, potentially introducing bias.

### *Summary*

Few studies have evaluated the effect of handwriting remediation on handwriting performance, and few have provided sufficient detail to allow replication. The limited evidence suggests that specific practice of handwriting skills may improve writing performance more than sensory-motor-based intervention. However, effect sizes have generally been small and the differences have been statistically insignificant, partly because of small sample sizes and underpowered studies. Moreover, the quantity, or dose, of intervention provided in studies has varied from 3 hr over 6 school days (Sudsawad et al., 2002) to 24 hr over 6 months (Jongmans et al., 2003). Thus, the content of handwriting remediation programs and the amount of intervention needed to bring about clinically important changes remains uncertain.

In response to this gap in the pediatric literature, we planned and performed the current study, in which one handwriting remediation program—the Log Handwriting Program (LHP; Raynal, 1990)—was delivered and evaluated.

## Log Handwriting Program

The LHP was developed by an Australian occupational therapist (Raynal, 1990) and sequentially teaches the components of legible handwriting. First, letter formation is taught and practiced by grouping together letters of similar characteristics using child-friendly imagery. Next, the child's writing line is colored brown to represent a wooden log, and letters of the alphabet are introduced as animals living inside the log. Then memorable characters are used to prompt the development of correct letter alignment, size, and spacing. The LHP uses principles of task-specific training; however, no studies have yet examined the program's effect on handwriting legibility.

## Study Aims

The aims of this exploratory study were to (1) determine the feasibility of the LHP when delivered to small groups of primary school children, on site, during school hours and (2) determine whether the LHP improved handwriting performance, particularly legibility. We hypothesized that the LHP would bring about improvements in writing legibility (the primary outcome), letter form, horizontal alignment, size, and spacing (secondary outcomes) after 8 weeks.

## Method

We used a pretest-posttest single-group design. Ethical approval was gained from the relevant university and state government education department ethics committees.

### *Recruitment*

Six school principals in metropolitan Sydney, New South Wales, Australia, were approached to assist with recruitment. None of these schools offered handwriting remediation programs on site. Of those approached, five school principals agreed to participate. One principal declined because the training program was being provided by an honors research student rather than a graduate occupational therapist. Another school was subsequently excluded because it was not covered by the ethical clearance gained from the state education department. Inclusion criteria were children attending Year 1 or 2 classes (ages 6–8; in New South Wales schools, children have already completed 1 year of formal school education before commencing Year 1), children with writing that teachers identified as difficult to read or illegible and those with a score of  $\leq 30$  of 34 when tested on the Minnesota Handwriting Assessment (MHA; Reisman, 1999), children with no known comorbid physical or intellectual disability, and children

not receiving any concurrent handwriting intervention or services.

Information packs were sent to parents of potential participants via consenting schools and class teachers. Informed consent was sought from parents or guardians, which included their consent to assist their child with homework. Thirty-six information packs, including consent forms, were distributed. Of these, 32 signed consent forms were returned by the due date. Two parents did not consent to their child's involvement. One child was excluded because he was receiving external handwriting services. One signed consent form was returned too late for the child to participate.

Nadine Mackay then screened and pretested the 32 children of consenting parents using the MHA. Only those children with a score of  $\leq 30$  of 34 on the MHA legibility subtest (the primary outcome measure) were included to allow for some change on the MHA to be observed and avoid a ceiling effect at baseline. Our aim was to eliminate the problem highlighted in the study by Peterson and Nelson (2003), in which mean baseline legibility scores were high, allowing little room for improvement. Subsequently, 16 children in our study were excluded because they scored above our nominated cutoff. A letter was sent to parents of these 16 children detailing the reason for their noninvolvement. The remaining 16 children participated in handwriting training.

### *Handwriting Training Using the Log Handwriting Program*

Participants received 8 weekly handwriting training sessions of 45 min duration (6 hr total), conducted in groups of two or three. We chose this group size because resources were not sufficient for individual remediation. The group size also allowed adequate supervision, monitoring, and feedback to be provided to participants. Each child received three pages of homework (three exercises) per week to complete with the help of his or her parents. Children also received a workbook in which instructions for homework were printed and written work recorded.

Intervention commenced in the third term of the 2007 school year (June to September). Session times were coordinated with school teachers to ensure that children did not miss important classroom activities. Sessions were delivered by Nadine Mackay, a final-year occupational therapy honors student, who received training and supervision in the LHP from K. Raynal. If a child missed a session, a written letter was sent to the parents describing skills taught during that session, and extra homework was provided (three extra exercises).

*Session structure.* A similar structure was used for each weekly session. First, warm-up activities were conducted for approximately 5 to 8 min. Warm-up activities included

“animal walking” or wall push-ups, fine motor exercises (“Finger Olympics” and activities with Play-Doh), and 3 min of Callirobics (Laufer, 2006). Callirobics involved repetitive straight and curved writing patterns set to music, focusing on eye–hand coordination and fluency when writing.

Second, handwriting training and practice occurred for 25 to 30 min. Handwriting training commenced with a review of homework and skills taught in the previous session. Children were prompted to self-monitor their homework and identify areas for improvement. Next, handwriting instruction occurred, in which the therapist introduced techniques to assist skill development (detailed in the following sections). Practice worksheets were stapled into the children's workbooks. All materials were produced in keeping with font and script style used within local state schools (i.e., Foundation font). Sessions concluded with a fine motor game for 3 to 5 min to reward and motivate students.

*Session content.* Sessions 1 through 3 focused on letter formation. Letters were separated into groups consisting of similar shapes and characteristics. For example, letters starting with a *c* shape (*a, c, d, g, o, q*) were taught together. Letter shapes and forms were practiced in a dish of rice and then on paper. Each letter was practiced approximately 15 times on paper during the session or at home. In Session 4, the concept of log writing was introduced. The child's writing line was colored brown to represent a wooden log, and the letters of the alphabet were introduced as animals living inside the log. Children practiced writing single and capital letters inside the log. In Session 5, children practiced writing single words inside the log, and techniques were used to correct the horizontal alignment of letters. In Sessions 6 and 7, children practiced writing whole sentences inside the log and a finger puppet was used to improve word spacing. In Session 7, the log was replaced with “magic dots,” and exercises were given to assist children with developing punctuation. In Session 8, writing duration was increased (from one line to several lines), and children were given a set of “Rocket Rules” that summarized skills taught during previous sessions.

*Additional teaching strategies.* Regular verbal feedback was provided to enhance motor learning and skill development. For example, when practicing letter size, the verbal instruction given was “touch the top of the log and the bottom of the log.” Positive explicit verbal reinforcement was given for correct skill performance (e.g., “Great work! You started a *c*, went a long way up, and then came straight back down with your pencil to complete the letter *d*”). If a child demonstrated difficulty (e.g., formation of a particular letter or letter size), he or she performed extra practice of that skill in the workbook. A “most to least” prompt hierarchy was used. For example, for incorrect letter sizing, physical guidance with verbal prompting was given, followed by modeling

with verbal prompting, and finally verbal prompting alone. Stickers were placed at the front of each child's workbook during sessions to reward effort, quality work, completion of homework, and good behavior.

### Outcome Measures

The MHA (Reisman, 1999) was the primary outcome measure. The MHA is made up of six subcategories (legibility, form, alignment, size, space, and speed), with scores ranging from 0 to 34 for each subcategory. The primary outcome of interest was the MHA letter legibility subscore. Secondary outcomes of interest were the MHA subscores for letter form, size, alignment, spacing, and speed. The MHA is norm referenced, has excellent interrater reliability ( $r = .99$  with experienced raters,  $r = .98$  with inexperienced raters), and high intrarater reliability over 7 days ( $r = .98$  with experienced raters,  $r = .96$  with inexperienced raters; Reisman, 1993). The MHA's test-retest reliability is moderate ( $r = .72$ ).

The MHA requires students to near-point copy a pre-printed sample of eight words ("the quick brown fox jumped over lazy dogs"). The words are jumbled to eliminate speed advantages for students with good memory. Children are instructed to copy the words, writing "as they usually would when they are attempting to use good writing" (Reisman, 1993, p. 6), and to stop after 2.5 min of writing and circle their final letter. Completion of the remaining words is then permitted, providing a complete writing sample for scoring. Each letter is individually scored (1 or 0) for letter legibility, form, alignment, size, and space. A score of 1 means that a letter is acceptable; a problematic letter receives a score of 0. If a letter scores 0 for legibility, no points are subsequently allocated for form, alignment, size, or space (Reisman, 1993). Speed is scored by timing the number of letters written in 2.5 min.

Administration of the MHA was conducted by Nadine Mackay at the child's school before the intervention and repeated in the week after the final intervention session. An independent assessor, blind to study purposes, scored all pre- and posttest MHA forms after reading the MHA instruction manual. The 32 completed MHA forms (16 pretest and 16 posttest) were mixed together before being provided to the assessor for blind rating.

### Data Analysis

We calculated mean within-group differences for each of the six MHA subscales using paired  $t$  tests and 95% CIs. An  $\alpha$  level of .008 was applied after making a Bonferroni adjustment for the subscales.

Using an 80% power level and an  $\alpha$  of .05, a sample of 22 participants (per group) was calculated as adequate to show a 3.4-point change (10%) in handwriting legibility on

the MHA if such a change existed. For the power calculation, we used the standard deviation (4.0) from a previous study (Peterson & Nelson, 2003) that used the MHA. We determined a clinically significant improvement in handwriting legibility before the intervention as 10% or more on the MHA (a 3.4-point within-group change).

## Results

Data were collected for all 16 participants enrolled in the study at baseline and follow-up. No participants withdrew from the study. Table 1 provides a summary of participant characteristics.

Five children missed one of the eight sessions. A mean of 18.1 min was spent practicing writing on paper during Session 1 through 3 (standard deviation = 3.8 min), and a mean of 28.3 min was spent practicing during Sessions 4 through 8 (standard deviation = 1.8 min). Mean total practice time over the 8 sessions was 195.7 min. We did not include time spent practicing letter shapes in rice (Sessions 1–3) in these calculations. Of the 21 homework sheets provided to each child over 8 weeks (2 to 3 sheets per week), the mean number of sheets completed was 16.3 (standard deviation = 5.2).

Pre- and posttest scores are presented in Table 2. Statistically significant improvements and percentage change in handwriting performance were observed for all subscales except speed. A mean improvement of 4.1 points (95% CI = 2.5 to 5.7) was recorded for writing legibility, the primary outcome measure ( $p = .000$ ). Mean improvements between 5.3 points (95% CI = 2.5 to 8.0) for form and 7.9 points (95% CI = 3.3 to 12.4) for size were recorded for the other five secondary outcome measures. Writing speed decreased by a mean of 3.9 points (95% CI = 0.2 to 7.7).

**Table 1. Participant Characteristics at Baseline ( $N = 16$ )**

Characteristic	$n$ (%)
Gender	
Male	13 (81.3)
Female	3 (18.7)
Hand dominance	
Right	13 (81.3)
Left	3 (18.7)
Previously received services <sup>a</sup>	
Yes	5 (31.3)
No	11 (68.7)
English as primary language	
Yes	14 (87.5)
No	2 (12.5)

<sup>a</sup>Services include occupational therapy or physiotherapy.

**Table 2. Pretest, Posttest, and Within-Group Differences After 8 Weeks for Minnesota Handwriting Assessment Subscales**

Subscale	Pretest		Posttest		95% CI	% Change	<i>p</i> <sup>a</sup>
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)			
Legibility	27.6 (3.1)	31.7 (1.9)	4.1 (3.0)	2.5 to 5.7	15	.000	
Form	23.1 (5.2)	28.3 (5.8)	5.3 (5.1)	2.5 to 8.0	23	.001	
Alignment	20.1 (7.4)	27.8 (5.9)	7.8 (8.2)	3.4 to 12.1	39	.002	
Size	15.6 (6.8)	23.4 (7.3)	7.9 (8.5)	3.3 to 12.4	51	.002	
Space	24.4 (5.8)	29.8 (4.1)	5.3 (5.6)	2.4 to 8.4	22	.002	
Speed	28.9 (6.0)	25.0 (7.6)	-3.9 (7.1)	-7.7 to -0.2	14	.043	

Note. SD = standard deviation; CI = confidence interval. All subscales have a range of 0–34 points.

<sup>a</sup>All *ps* statistically significant at *p* < .05.

## Discussion

The primary findings of this study were that the 8-week LHP, which involved a task-specific approach to handwriting remediation, was feasible to deliver in schools and improved writing legibility, form, alignment, size, and spacing. An improvement of 15% was recorded for legibility, which we considered clinically worthwhile. Changes in secondary outcomes (letter form, alignment, size, and space) were also >10% and were considered to be clinically worthwhile after an 8-week intervention program.

The population recruited was reflective of the general pediatric population receiving handwriting remediation in Sydney, New South Wales, Australia, and reported in the handwriting remediation literature. For example, Berninger et al. (1997) reported that 72% of children in their sample were male, and 87% were right handed. In another study, 74% of children were male, and 66% were right handed (Case-Smith, 2002). Three local occupational therapy private practitioners who provided handwriting training to children in metropolitan Sydney reviewed their records for 2006. They reported that >75% of their clients during that time were boys and 75% were right handed, consistent with our sample. Thus, generalization of our results to a wider population is tentatively supported.

Our study's findings support a growing body of pediatric and adult motor learning literature that indicates that skill performance improves as people practice skills (or subskills) related to activity performance and receive feedback and reinforcement (Peterson & Nelson, 2003; Pohl, McDowd, Filion, Richards, & Stiers, 2006). A task-specific approach to handwriting and other fine motor skills is supported. Advancing current knowledge, this pilot study tested the feasibility of a structured program (the LHP) that can be, and is being, used in clinical practice. The program improved outcomes and may contribute to a more efficient use of resources where waiting lists are long.

The improvement in writing legibility during handwriting training resulted in slower written output in our study. Previous authors have observed that as task complexity and written output increases, writing speed decreases (Weintraub & Graham, 1998). Therapists providing writing training may need to be aware that written output is likely to decrease during training. Improved writing legibility may, however, result in reduced writing speed, leading to a child's not completing assignments or work tasks in the classroom on time (Graham, Berninger, Weintraub, & Schafer, 1998). Thus, a balance between speed and legibility is necessary. Researchers have suggested that legibility should precede attempts to improve writing speed (Peterson & Nelson, 2003), and thus legibility was our study's primary focus. Therapists may need to incorporate several sessions to improve writing speed after children have developed legible writing.

A major limitation of our study is the absence of a control group with which to compare outcomes. Improvements may have occurred as the result of participants' natural maturation or through the additional contact received. Second, follow-up was limited to one occasion, immediately after the handwriting sessions concluded. We do not know whether improvements were maintained after intervention. Strengths of the study include the LHP's clinical feasibility; the use of a standardized outcome measure with high interrater reliability and good test-retest reliability; and the use of a blinded, independent assessor to score handwriting test samples.

Although we calculated that a sample size of 22 was necessary to show a clinically important change in handwriting legibility, only 16 students were recruited. Despite the smaller sample, the handwriting program demonstrated a statistically and clinically significant change in handwriting legibility on the MHA. Findings are likely to be further strengthened using a larger sample, randomized to receive remediation or no remediation.

Further research is needed to confirm our study's results. Such studies should involve a larger sample, a nonintervention control group (or control group receiving a sham intervention), and random allocation to reduce selection bias. Also, the effect of treatment when administered individually versus within a group is not known and could provide valuable information to guide service delivery models. In addition, the quantity of intervention needed to improve handwriting performance remains unknown—that is, how many, how often, and for how long training sessions should be provided before clinically important changes occur.

## Conclusion

This study investigated the feasibility and outcomes of a handwriting training program—the LHP—on the writing legibility of children in Years 1 and 2. The 8-week LHP is feasible to deliver across schools and produced clinically worthwhile changes in writing legibility, form, alignment, size, and space. Preliminary evidence supports the use of the LHP in occupational therapy practice. ▲

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