



# The effect of computer-assisted therapeutic practice for children with handwriting deficit: A comparison with the effect of the traditional sensorimotor approach



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## ABSTRACT

The objective of this study was to compare the effect of computer-assisted practice with the sensorimotor approach on the remediation of handwriting problems in children with dysgraphia. In a randomized controlled trial, experiments were conducted to verify the intervention effect. Forty two children with handwriting deficit were assigned to computer-assisted instruction, sensorimotor training, or a control group. Handwriting performance was measured using the elementary reading/writing test and computerized handwriting evaluation before and after 6 weeks of intervention. Repeated-measures ANOVA of changed scores were conducted to show whether statistically significant differences across the three groups were present. Significant differences in the elementary reading/writing test were found among the three groups. The computer group showed more significant improvements than the other two groups did. In the kinematic and kinetic analyses, the computer group showed promising results in the remediation of handwriting speed and fluency. This study provided clinical evidence for applying a computer-assisted handwriting program for children with dysgraphia. Clinicians and school teachers are provided with a systematic intervention for the improvement of handwriting difficulties.

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## 1. Introduction

Handwriting is an essential fine motor skill in school-aged children, important for expressing, communicating and recording ideas, as well as for educational development, achievement in school and self-esteem (Phelps, Stemple, & Speck, 1985; Weil & Amundson, 1994). From surveys on occupational therapy service in elementary schools, the most common referrals were handwriting problems (Tseng & Cermak, 1993).

Although children with normal development can learn how to write through traditional training when aged six to seven, handwriting is actually a very complicated skill. Neat and smooth handwriting requires the maturity and integration of cognition, visual perception and fine motor skills (Tseng & Murray, 1994; Weil & Amundson, 1994; Volman, Van Schendel, & Jongmans, 2006).

Starting from the 1980s, numerous studies of methods to teach or improve children's handwriting were produced. The kinesthetic training approach was first proposed and found to have positive results in handwriting remediation (Laszlo &

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Bairstow, 1984); however, research by Sudsawad, Trombly, Henderson, and Tickle-Degnen (2002) examining the effect of kinesthetic training on handwriting performance in first graders did not successfully link kinesthesia and handwriting.

In the past decade, most handwriting remediation studies focused on comparing sensorimotor components training and task-oriented strategies. Based on an occupational therapy framework, Peterson and Nelson (2003) examined improvements in the printing skills of children who were at risk academically and socially. Occupational therapy was found to be effective in improving the academic outcome of printing by economically disadvantaged children. The largest gains for the intervention group were in the areas of space, line and size. However the writing speed did not significantly differ between the groups.

Jongmans, Linthorst-Bakker, Westenberg, and Smits-Engelsman (2003) conducted studies to investigate the effect of a task-specific self-instruction intervention; they concluded that the improvement especially involved the handwriting quality, but not the speed of children initially identified as having poor handwriting quality. Denton, Cope, and Moser (2006) studied the effects of sensorimotor-based intervention versus therapeutic practice on improving handwriting performance. They revealed that children receiving therapeutic practice moderately improved handwriting, whereas for children receiving sensorimotor intervention, there was a decline in handwriting performance. Even though some selected sensorimotor component functions improved with intervention, children who received sensory-based training without handwriting practice interventions did more poorly than children did in the control group.

Weintraub, Yinon, Hirsch, and Parush (2009) studied the effectiveness of sensorimotor and task-oriented handwriting intervention among elementary school-age students with handwriting difficulties; the results revealed that both groups had better overall legibility than the control group did; however speed did not show a significant increase in the sensorimotor group.

A recent study (Howe, Roston, Sheu, & Hinojosa, 2013) addressed the comparison between therapeutic practice and visual-perceptual-motor activity. The results showed that students in the intensive handwriting practice group demonstrated significant improvements in handwriting legibility compared with students in the visual-perceptual-motor activity group. No significant difference in effects on handwriting speed and visual-motor skills were found between the two groups.

From the above reviews, the results were not so consistent in the studies of handwriting remediation. Although most studies support task-oriented, self-instruction and intensive therapeutic practice, there was no significant evidence in the improvement of handwriting speed or fluency.

In addition to conventional programs, the advances in computer technology also provided an interesting and motivational program for the remediation of handwriting problems. Earlier studies tended to focus on sensory feedback; they provided more consistent results. Søvik (1980, 1981) revealed that children can be trained efficiently with regard to sensorimotor feedback control in tracing, tracking and copying tasks. Lally (1982) reported that computer-assisted handwriting exercises offer significant advantages over more conventional teaching techniques. Søvik and Teulings (1983) found that a training program employing computer-generated feedback could improve the smoothness of handwriting movements. It improved writing speed without diminishing writing accuracy or writing size. Similar results were found in the work of Søvik, Arntzen, and Thygesen (1986): training with sensory feedback could significantly improve both the accuracy and smoothness of the writing without any sacrifice in writing speed.

A study by Portier and van Galen (1992) compared postponed visual feedback and immediate feedback. The results provided evidence that practicing a handwriting task with immediate feedback most explicitly induces an on-line programming strategy, which can be identified from the differential effects on movement time and writing dysfluency.

Søvik and Arntzen (1992) compared the effects of social tracking (in cooperation with another person) and computer-assisted instruction on normal and dysgraphic children in copying and handwriting performance. The effect of tracking training was obvious, but no significant differences were revealed in measures of copying and writing between the two experimental groups. Moreover, in comparing the effectiveness of computer-based tracking and tracing exercises with traditional instruction in the remediation of handwriting difficulties, Roberts and Samuels (1993) revealed that the traditional group using pen and paper demonstrated more significant improvements than the computer groups on two major measures (computer exercise and teacher rating). From the above reviews, recent studies in computer-assisted program did not seem to provide consistent results in the remediation of handwriting difficulties.

From the above literature, explicit task-oriented practice showed a promising effect on improvement of handwriting quality, whereas computer-assisted training mainly enhanced writing fluency. We aimed to develop a motor learning based computer-assisted program for the remediation of handwriting problems. With immediate visual and auditory feedback, the incentive program provides task-oriented practices for enhancing handwriting skills. The objective of this study was to test whether the computer-assisted feedback training provides a more effective intervention than the traditional sensorimotor program does for children with handwriting deficits. The important features of the computer-assisted program include therapeutic practice, immediate sensory feedback and task-oriented intervention.

## 2. Materials and methods

### 2.1. Participants

The participant recruitment consisted of a two-step process. The first step was to screen children with dysgraphic characteristics by the referral of teachers in two public elementary schools in the Kaohsiung area, using the Chinese

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