Use of the Dynamic Interactional Model for Handwriting Intervention in Children: Explanatory Case Study

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Abstract

Objective: The present study investigates the effectiveness of a dynamic interactional (DI) approach combined with the traditional perceptual-motor (PM) approach, versus the PM approach alone, for intervention in children's handwriting difficulties.

Methods: An explanatory case study design with a sample of four children was used. Effectiveness was assessed by examining handwriting, fine-motor abilities and self-awareness.

Results: Both interventions were efficient in improving fine-motor and handwriting abilities. The combined intervention showed a greater improvement, while the order of the interventions did not influence improvement.

Conclusions: The present study results reflect the relevance of interweaving a DI intervention, with an emphasis on the awareness component, with the more traditional PM intervention approaches for treating children with handwriting problems.

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Handwriting is a very complicated human activity that represents a neurological process involving the activity of the brain in terms of visual, motor, perceptual, cognitive and emotional functions. The performance of handwriting calls for the integration of many skills, such as linguistics, cognition (attention, memory, perception, and motor learning), fine-motor skills, and visual-motor integration (Reisman, 1993; Tseng & Cermak, 1993).

It has been suggested that writing difficulties may be of a lower or a higher order (Berninger et al., 1997). Higher-order difficulties refer to problems in planning and content generation. Lower-order difficulties refer to the mechanical requirements for producing text, that is, the formation of the letters on the writing surface, which may manifest in terms of the legibility of the written product or in writing speed (Graham, 1990; Graham & Weintraub, 1996). These difficulties may have serious consequences for students' academic progress, emotional well-being, and social functioning (Amundson, 2005; Cornhill & Case-Smith, 2002; Kaminsky & Powers, 1981). It has been documented that between 10%-20% of school-aged children encounter handwriting difficulties (Yinon & Weintraub, 2000), which might become a major factor in learning disabilities. Graham and Weintraub (1996) claim that although children with dyslexia are characterized by both reading and writing difficulties, problematic writing is the more prominent of the two.

Handwriting difficulties have become a major area of intervention in occupational therapy (OT) over the last 15 years. More and more children with handwriting problems have been referred to occupational therapy evaluation and intervention in order to reduce their difficulties and to help them develop new skills or strategies and compensations for coping with class activities and demands (Amundson & Weil, 2001; Benbow, Hanft, & Marsh, 1992; Chu, 1997; Tseng & Cermak, 1993).

In the last decade, an abundant literature on children's handwriting within OT has focused on three main issues: (a) understanding the basis of handwriting difficulties (Copley, 1990; Summers, 2001; Volman, van Schendel, & Jongmans, 2006; Weintraub, 1997; Weintraub & Graham, 2000), including the influence of ergonomic factors on handwriting performance (Parush, Levanon-Erez, & Weintraub, 1999; Rosenblum, Goldstand, & Parush, 2006; Tseng & Cermak, 1993); (b) evaluation and assessment from both theoretical as well as clinical and research points of view (Bonney, 1992; Chu, 1997; Feder, Majnemar, & Synnes, 2000; Rosenblum, Parush, & Weiss, 2003a; 2003b; 2003c); and (c) intervention programs for improving handwriting performance, though only a few were examined for their effectiveness

(Berninger et al., 1997; Chu, 1997; Harris & Livesey, 1992; Subsawad, Trombly, Henderson, & Tickle-Degnen, 2002; Yinon & Weintraub, 2000; Ziviani & Watson-Will, 1998).

The importance of building intervention protocols and studies to show the effectiveness of OT is widely discussed in our profession. Among the studies that evaluated interventions, some showed improvement in handwriting and some did not. Case-Smith (2002) investigated the effects of school-based OT services on students' handwriting and concluded that interventions focused on visual-motor skills and handwriting practice improved the quality of handwriting. Other interventions that improved handwriting performance were the perceptual-motor (PM) approach (Addy, 1996), the motor-focused intervention (Smith-Engelsman, Niemeijer, & Van Galen, 2001), and a combined approach using visual cues and the memorization of letters (Berninger et al., 1997).

Razon and colleagues (2009) conducted a vast project including 147 children from a low socioeconomic background. The study showed the efficiency of a visual-motor treatment for first grade students in mainstream schools. First grade students with fine-motor problems and handwriting difficulties improved their fine-motor and graphomotor skills after a short-term visoumotor intervention (Razon, Efraim, & Bart, 2007).

Peterson and Nelson (2003) evaluated whether OT interventions, including biomechanical, sensorimotor, and teaching-learning strategies, improved academic outcomes. Results support the effectiveness of OT intervention in improving the academic outcome of printing (D'Nealian printing) in children who are economically disadvantaged. Although this is an important study, it must be noted that despite their academic and social disadvantages, the children in the sample did not have actual handwriting difficulties.

Sudsawad, Trombly, Henderson, and Tickle-Degnen (2002) studied the effect of kinesthetic training on handwriting performance in first grade students. Results showed improvement in kinesthetic skills, but no significant effect on handwriting speed and legibility. Denton, Cope, and Moser (2006) studied the effects of sensorimotor and therapeutic interventions on handwriting and sensorimotor components in elementary school children, and found that children who received only sensorimotor intervention showed only a partial improvement in sensorimotor components and experienced a decline in handwriting performance.

An intriguing attempt was made in the field of physiotherapy to use a cognitive self-guidance method for children with poor handwriting and speed

(Jongmans, Linthorst-Bakker, Westenberg, Bouwien, & Smits- Engelsman, 2003). This method was based on the Cognitive Orientation to Occupational Performance (CO-OP) approach (Martini & Polatajko, 1998) and on neuromotor task training (Jongmans, 2003). The findings of this research showed that the effectiveness of the intervention varies according to children's characteristics (i.e. children in special education vs. children in regular education, and the degree of handwriting difficulties experienced by children), and to the outcome measures (i.e. handwriting quality and speed).

Various approaches to assessment and intervention for handwriting difficulties have been developed. The perceptual-motor (PM) is one of the most common approaches in use among occupational therapists for the purpose of enhancing both fine-motor and handwriting skills (Addy, 1996; Case-Smith, 2002). However, research results show that there is a gap between intact fine-motor skills and the ability to write appropriately (Sudsawad et al., 2002).

Hence, focusing on PM skills in therapy does not always result in enhanced handwriting, which is the purpose of the intervention (Subsawad et al., 2002). Other approaches that show their benefits when used to treat handwriting difficulties include the cognitive approach, which was showed to be more effective than a multisensory approach for improving handwriting legibility (Zwicker & Hadwin, 2009).

Toglia (1992, 1998, 2005) developed the dynamic interactional (DI) approach to cognitive rehabilitation, emphasizing metacognition and self-awareness, and the use of strategies in relation to performance for adults with brain injury. The DI approach addresses the learning potential of the person and his/her ability to transfer learning to daily activities. It provides a framework for addressing cognitive impairments by changing the person, strategies or awareness, the activity or the environment. The ability to transfer skills learned in one situation to another situation is constantly observed and worked on, within a specific level of task difficulty. Based on this assumption, it is expected that the client will apply the targeted strategy within a variety of situations. Toglia encourages further exploration of the DI approach with other populations than those with a brain injury, such as children with learning disabilities.

Cognitive approaches have been introduced as part of rehabilitation for children in OT (Cermak, 2005; Josman, 2005; Josman & Jarus, 2003; Missiuna, Malloy-Miller, & Mandich, 1998; Polatajko & Mandich, 2005). The DI approach was found to be effective in improving graphomotor abilities, self-care, and mobility in the rehabilitation of adolescents with traumatic brain

injury (Zlotnik, Sachs, Rosenblum, Shpasser, & Josman, 2009). However, not much is mentioned on the influence of self-awareness on the handwriting performance of children in the occupational therapy (OT) literature. The issue of awareness is of central importance in the treatment of children, as the awareness of their strengths and weaknesses influences learning and its generalization (Belmont, Butterfield, & Ferretti, 1982). Indeed, the education literature extensively describes the metacognitive interventions undertaken with children in the school system (Bender, 2002).

Based on the literature and cognitive models, we suggest that children with handwriting difficulties can benefit from an intervention that includes the DI approach (Toglia, 2005) applied together with PM approaches in rehabilitating handwriting. Regarding the DI intervention, the main focus in this study was on enhancing the child's awareness of his strengths and limitations. The purpose of the present study was to investigate the effectiveness of a DI approach combined with the traditional PM approach for intervention in the handwriting difficulties of children. The study's novelty includes the use of an explanatory case study research design within an intervention, which compares between the PM approach alone and a combined PM and DI approach.

Method

The explanatory case study (Yin, 1999), using a ACABA and ABACA design (Dietz, 2006) was selected to examine the effectiveness of DI approach combined with a PM approach in the intervention of handwriting difficulties in four children. Phase A represents the baseline and the assessment phase; Phase B represents the traditional PM intervention; Phase C represents the combined PM and DI intervention. This design allowed for a systematic measurement of individual changes in each participant's handwriting, in each of the interventions. In addition, it enabled a comparison of the two interventions and an examination of the order effect of the interventions.

This methodology is not only a means of describing a phenomenon, but is also a method for providing insight into the uniqueness of cases. Yin (2003) defines it as a method that provides answers to the "how and "why" questions, that provides insight into the uniqueness of cases. This type of comprehensive understanding can be achieved through a process known as thick description, which involves an in-depth description of the entity being evaluated.

Yin presented eight desired characteristics for creating rigorous explanatory case study, four of which were applied throughout this study, as follows:

1. Case replications - all participants were recruited according to the inclusion criteria.
2. Provision of a consistent protocol for accurate comparison of results. The intervention was based on guidelines from a treatment protocol that is detailed in an appendix.
3. Operationalization of the case study, which enables the identification of the research's questions. The data collection was directed to answer the original hypothesis.
4. Triangulation- validating data from various sources. Evidences were collected from a handwriting evaluation, a neuro-motor test, assessments of self-awareness, and the informal writing of participants' names and addresses throughout the intervention.

Participants

Four boys were included in the study: 2 from the second grade and 2 from the third grade. By this stage, typical children have fully acquired handwriting performance. The inclusion criteria were: (a) a diagnosis by a psychologist or special learning assessor of learning disabled with handwriting difficulties,(b) handwriting difficulties due to fine motor difficulties, (c) mainstreamed in a public school, (d) a score of at least one standard deviation below the average score in two of the six subtests of the Hebrew Handwriting Evaluation (HHE) (Erez & Parush, 1999), and (e) a score of at least two standard deviations below the average score in two of the three subtests of the Purdue Test. The exclusion criteria were (a) previous participation in an OT intervention, and (b) a diagnosis of attention deficit disorder (ADD) or attention deficit hyperactivity disorder (ADHD).

All participants were children referred for handwriting intervention to an occupational therapist in an after-school learning center in northern Israel, and who matched inclusion criteria. The initial sample included 6 children, although 2 children were excluded: One boy completed his intervention in a shorter time and was therefore excluded from the study, while another failed to comply and was also excluded. Thus, the final sample consisted of 4 boys: Two from the second grade and 2 from the third grade. All participants were born in Israel, with Hebrew as their first language and also the language spoken at home. All parents were high-school educated and above.

Participant 1 was an 8-year, 3-month-old boy in second grade. Towards the end of first grade, his teacher identified handwriting difficulties, especially

slowness in writing, poor organization on the paper and poor legibility. Following psychological testing, he was referred to OT as well as speech therapy and remedial teaching. His level of achievement is equal to the average of his classmates, and his language abilities are a little lower than average for his age.

Participant 2 was a 9-year-old boy in third grade. In the second grade, his teacher identified difficulties with completing his handwriting tasks on time, particularly when copying from the board or when taking dictation or an exam. He was referred to OT by the psychologist and to art therapy due to emotional difficulties. His level of achievement is higher than the average of his classmates, and his language abilities are accurate.

Participant 3 was a 9-year, 3-month-old boy in second grade. In the second grade, his teacher identified handwriting difficulties, especially poor organization on the paper and poor legibility. He was referred to OT by the psychologist. His level of achievement is equal to the average of his classmates, and his language abilities are a little lower than average for his age.

Participant 4 was an 8-year, 3-month-old boy in third grade. Towards the end of first grade, his teacher identified handwriting difficulties, especially poor organization on the paper, poor pencil grasp, and slowness in writing. He was referred to OT by the psychologist. His language abilities are appropriate to his age, and his level of achievement is on par with that of his classmates.

Instruments

The Hebrew Handwriting Evaluation (HHE) (Erez & Parush, 1999) was used for examining the product of a handwriting paragraph, specifically for assessing legibility via both global and analytic measures. The handwriting paragraph was identical for all the children. Inter-rater reliability for the HHE is $r = .75\text{-}.79$; $p < .001$. Construct validity of the HHE has been established by demonstrating statistically significant differences ($t = -2.34$; $p = .027$) between the performance of children with proficient and poor handwriting (Dvash, Levi, & Traub, 1995). The outcome measure for the HHE written product includes a "global legibility" assessment, reflecting the overall clarity of handwriting (scored on a 4-point Likert scale, ranging from 1= the most legible to 4= the least legible). In addition, the "analytic" outcome measure is comprised of the following three variables: letters erased and/or overwritten (letter line protrusion), spacing between words and letters (extension or overlap), and letter size. The minimum score for spatial arrangement is 9, the maximum is 24. For all four outcome measures of the HHE, a low score indicates good performance, whereas a high score indicates poor performance.

The *Purdue Pegboard Test* (PPT) (Tiffin, 1987; Tiffin & Asher, 1948) measures finger and hand dexterity (Spreen & Strauss, 1991). Essentially, it constitutes a test of timed motor speed and motor coordination sensitive to subtle neuro-motor dysfunction (Flyckt et al., 1999). An additional score is generated by adding scores obtained on the first three subtests (Desrosiers, Hebert, Bravo, & Dutil, 1995).

An *awareness questionnaire* was designed expressly for the present study, based upon the awareness questions included in the Contextual Memory Test (CMT; Toglia, 1993), which was adapted for children (Josman, Berney, & Jarus, 2000a). The purpose of the questionnaire was to investigate the children's awareness of their handwriting abilities.

The questionnaire was administered both before and after testing handwriting. To assess general awareness, children were asked seven questions, such as: "Do you prefer reading or writing?" For assessing self-predictions of handwriting ability, children were asked nine questions, such as, "If I ask you to copy a paragraph with five lines, how long do you think it will take you?" Answers are scored on a 4-point Likert scale, ranging from 1= a very short time to 4= a very long time. Questions in this part represent dimensions of legibility, time, spelling errors, skipping letters and spacing. To assess personal estimations, children were asked 10 questions upon completion of the test, such as, "Was it difficult for you to copy the story?" Answers were scored on a 4-point Likert scale, ranging from 1= not at all to 4= very difficult.

A general awareness composite score was computed by summing the answers to five of the seven questions, based on the CMT (Toglia, 1993). The additional two general questions were scored separately. The prediction and estimation answers were compared to actual handwriting performance on the HHE test. Four questions from both the prediction and estimation parts were selected for this analysis. The scores obtained were compared to expected norms (HHE) of second- and third-grade children in order to compare the participants' self-awareness with actual performance, as shown in Table 1.

The original CMT questionnaire has an internal reliability of 0.73-.081 and a test-retest reliability of 0.85-0.95. Discriminant validity was established in the adaptation for children (Josman et al., 2000a) (see Appendix 1).

Table 1
Four Prediction Awareness Questions in Comparison to the HHE Test

Scale	Question 1: How long will it take you to copy the paragraph?	Actual writing time (in minutes) 2nd grade	3rd grade
1	Very short	Less than 4 minutes	Less than 3 minutes
2	Short	4 minutes	3 minutes
3	Long	4-5 minutes	3-4 minutes
4	Very long	More than 5 minutes	More than 4 minutes
Scale	Question 2: Do you think all the letters and words you wrote will be legible?	Actual number of unidentified letters 2nd grade	3rd grade
1	All of them	3 and less (above average)	3 and less (above average)
2	Most of them	4 (average)	4 (average)
3	A small part of them	5-8 (borderline)	5-8 (borderline)
4	None of them	9 and up (deficient)	9 and up (deficient)
Scale	Question 3: How many corrections and deletions you think you have in the paragraph?	Actual no. of deletions and corrections 2nd grade	3rd grade
1	A lot less than 3	0 or 1 (above average)	0 or 1 (above average)
2	Less than 3	2 (average)	2 (average)
3	More than 3	3 (borderline)	3 (borderline)
4	A lot more than 3	4 and up (deficient)	4 and up (deficient)
Scale	Question 4: Will you keep spaces among words and letters?	Final spatial organization grade 2nd grade	3rd grade
1	Always	7 and less (above average)	7 and less (above average)
2	Often	8 (average)	8 (average)
3	Rarely	9-10 (borderline)	9 (borderline)
4	Never	11 and up (deficient)	10 and up (deficient)

The children completed a signing task four times in each phase of the study (about every second session). The signing task required the participants to sign their first and second names and to write their home addresses. This handwriting task was analyzed according to two criteria in the HHE: the number of unidentifiable letters and the spatial arrangement of letters. These were calculated by a caliper and included the examination of vertical alignment, spacing and letter size.

A demographic questionnaire was constructed to collect demographic data on the children and their families. Sample items included child's age, number of siblings, birth order, child's difficulties, other treatments and reasons for referral. This was administered only at the beginning of the study.

Procedure

At the outset of the study, letters of consent were sent to all parents of the participating children, and all four parents signed the consent. Official approval to conduct the study was obtained from the Chief Supervisor of the Educational Ministry in Haifa, as well as from the authorities at the after-school learning center where the study was conducted.

During the 6 months, each child received an individual intervention, and all participants started and completed the intervention on the same day. Between 18 or 19 sessions were conducted, with each session lasting for 45 minutes. There were, however, fewer sessions within a specific phase due to holidays or vacation days. All participants received the same interventions but in a different sequence. Participants 1 and 2 started with the combined intervention, whereas Participants 3 and 4 started with the PM intervention.

Thus, the procedure for participants 1 and 2 was: 1. Phase A - baseline evaluation, using the initial assessment tools (HHE, PPT and awareness); 2. Phase C - combined intervention (CI); 3. Phase A - baseline revaluation; 4. Phase B - PM intervention; 5. Phase A - baseline final evaluation. Procedure for participants 3 and 4 was ABACA as mentioned above. Participant 1 and 2 received 8 sessions in Phase B (PM), participant 1 received 10 sessions in Phase C (combined intervention), while participant 2 received 11 sessions in Phase C (CI). Participant 3 received 10 sessions in Phase B (PM), while participant 4 received 11 sessions in Phase B (PM). Both participants received 8 sessions in Phase C (CI). All assessments were performed in one session.

The intervention protocol for this study is included in Appendix 2.

Data Analysis

Data analysis included a visual examination of the slope, height, and direction of the trend line for each variable between phases. To analyze name and address writing, performance on every second session was examined, yielding eight single measures. The data were analyzed by visually examining the slope, height, and direction of the trend line for each variable among the eight single measures.

Results

Study results are presented for all three assessment tools used (Hebrew Handwriting Evaluation [HHE], Purdue Pegboard Test, and the awareness questionnaire). Performance on each instrument and participant's writing of his name and address is presented in Tables 2 and 3.

Participant 1 received a combined intervention (CI) first and a perceptual-motor intervention (PM) second. In Table 2, we see that the number of letters copied in one minute (writing time) did not increase following each type of intervention. There was an increase in the number of erasures and corrections following the CI and a decrease following the PM. There was a decrease in the number of unidentifiable letters following the CI and a slight increase following the PM. The score for spatial organization was higher following the CI, while no change for this measure occurred following the PM. Note that a lower score on the HHE indicates better performance than a higher score.

Table 2 shows an increase in the Purdue test score, both for the non-dominant hand and for both hands together, following each of the phases. There was a decrease in the score for the dominant hand following the CI and a rise following the PM. Table 3 illustrates the participant's improvement in writing his name and address on two measures, unidentifiable letters and spatial organization. Following the CI, scores on both of these variables increased. At the end of the PM intervention a peak was observed.

Table 4 presents the level of self-prediction and self-estimation (i.e., awareness level), for all participants, as well as their handwriting performance. In order to decrease the number of variables presented, we combined the four questions into one score that ranges from 4 (good handwriting ability) to 16 (impaired handwriting). Accordingly three categories were established: score 4-8 (minimal handwriting impairment), score 9-12 (moderate handwriting impairment) and score 13-16 (severe handwriting impairment).

As table 4 shows, Participant 1 had the lowest awareness level throughout the three phases of intervention. He always rated himself as having a slight

handwriting problem, while it was found that he actually had a moderate to severe problem. As such, his degree of improvement was the smallest in that he remained in the category with a moderate handwriting problem.

Participant 2 first received a CI and then a PM. As we see in Table 2, the number of letters copied in one minute (writing time) increased after each type of intervention, though there was a greater change following the CI. The number of his erasures and corrections rose slightly following the CI and decreased again to his starting point. The number of unidentifiable letters decreased following the CI and rose again after the PM. The final score for spatial organization improved following the CI and regressed following the PM (however, it was better than his starting point). Note that a lower score on the HHE indicates better performance than a higher score.

As Table 2 shows, there was an increase in the score of the Purdue test for each hand alone and with both hands together following each of the two phases. None of the measures revealed a difference in improvement between the two types of interventions (CI and PM). In other words, the degree of improvement was identical after each.

Table 2 depicts the change over the course of the eight times that the participant wrote his name and address. There was an improvement in the two variables of unidentifiable letters and spatial organization. Following the CI there was a consistent decrease in the number of unidentifiable letters (from a score of 3 to 1), and following the PM there was an additional steadier, yet less stable decrease (from 1 to 0). Following the CI there was a consistent improvement in spatial organization (from a score of 12 to 8), while following the PM there was an additional, but less significant and stable improvement (from 8 to 7).

This participant displayed the highest level of awareness in comparison to the other participants, throughout the course of the intervention (see Table 4). Following both of the first two phases, he rated himself as having a slight handwriting problem, which was in actuality true. This being the case, his rate of improvement was the greatest, with a turnaround from a severe to a slight problem.

Table 2
Performance of Participants 1+2 on all Tests

Phase		A1 CI			A2 PM				A3
Participant 1									
The Hebrew Handwriting Evaluation (HHE)	writing time (minutes)	4.3			4.1				4.02
	no. of corrections	2			9				5
	unidentified letters	25			11				15
	total organization score	10			8				8
Purdue	dominant hand (right)	10			8				13
	non-dominant hand (left)	8			10				11
	two hands together	6			7				7
	Type of Intervention	-----CI-----			------PM------				
Name and Address	Assessment Number	1	2	3	4	5	6	7	8
	no. of unidentified letters	6	4	2	3	4	4	5	2
	organization	10	9	9	8	8	8	9	8
Participant 2									
The Hebrew Handwriting Evaluation (HHE)	writing time (minutes)	4.45			3.3				2.5
	no. of corrections	2			4				2
	unidentified letters	6			4				7
	total organization score	9			6				7
Purdue	dominant hand (right)	8			9				10
	non-dominant hand (left)	9			10				11
	two hands together	6			7				8
	Type of Intervention	-----CI-----			------PM------				
Name and Address	Assessment Number	1	2	3	4	5	6	7	8
	no. of unidentified letters	3	2	2	1	2	0	1	0
	organization	12	10	9	8	8	7	8	7

Participant 3 received a PM first and then a CI. He improved the number of letters copied in one minute (writing time) after each of the two phases, with more improvement following the CI. However, as we see in Table 3, the change in overall time was insignificant. There was a slight improvement in the number of erasures and corrections following the CI intervention only. A decrease in the number of unidentifiable letters can be seen especially following the CI intervention. An improvement in spatial organization was noted following both interventions. Note again that a lower score on the HHE indicates better performance than a higher score.

Table 3 illustrates the changes in this participant's Purdue test scores following each of the two phases. We see that he improved on each hand alone and with two hands together following each phase. There was a greater improvement in his dominant and non-dominant hands following the CI. His performance with both hands together did not improve between the two types of interventions.

As for the change in the two variables over the course of writing his name and address eight times, Table 3 shows that this participant improved on both. Following each type of intervention, there was a slight decrease in the number of unidentifiable letters, with no significant difference between the two types of interventions. There was a slight improvement in spatial organization following the PM (from a score of 10 to 9) and an additional, steady improvement following the CI (from 9 to 8).

This participant displayed a moderate level of awareness, rating himself appropriately following the first and last phases. His category moved from a moderate handwriting problem to a slight one (see Table 4).

Participant 4 received a PM first and a CI second. On the HHE, he improved in the number of letters copied in one minute (writing time) following each of the two phases, with more improvement following the CI. However, as we see in Table 3, the change in overall time was smaller. There was a rise in the number of corrections and erasures following the PM, but there was a decrease in their number following the CI, dropping to less than the starting point. There was a slight improvement in the number of unidentifiable letters following the CI intervention and an improvement in the general organization score, with more improvement following the CI. Once again, note that a lower score on the HHE indicates better performance than a higher score.

Table 3
Performance of Participants 3+4 on all Tests

Phase		A1 PM			A2 CI				A3
Participant 3									
The Hebrew Handwriting Evaluation (HHE)	writing time (minutes)	2.5			2.2				1.35
	no. of corrections	3			4				2
	unidentified letters	17			14				10
	total organization score	10			8				6
Purdue	dominant hand (right)	12			14				14
	non-dominant hand (left)	9			11				14
	two hands together	8			10				12
	Type of Intervention	-----PM-----			----------CI------				
Name and Address	Assessment Number	1	2	3	4	5	6	7	8
	no. of unidentified letters	5	3	4	3	2	3	2	2
	organization	10	9	10	9	8	9	8	8
Participant 2									
The Hebrew Handwriting Evaluation (HHE)	writing time (minutes)	6.05			5.4				5.05
	no. of corrections	4			6				3
	unidentified letters	3			3				2
	total organization score	10			9				7
Purdue	dominant hand (right)	10			11				13
	non-dominant hand (left)	7			9				13
	two hands together	8			9				10
	Type of Intervention	-----PM-----			----------CI------				
Name and Address	Assessment Number	1	2	3	4	5	6	7	8
	no. of unidentified letters	2	1	2	1	1	1	0	0
	organization	8	8	9	7	7	7	6	6

Table 3 outlines the changes in this participant's Purdue test scores following each of the two phases. We see that there was an improvement for each hand alone and with both hands together following each phase. There was a greater improvement for each hand alone following the CI. Performance with both hands together was identical following each type of intervention.

Table 3 shows that this participant improved in writing his name and address after each phase of intervention. A slight and unsteady decrease in the number of unidentifiable letters was noted, with a more stable improvement following the CI. There was an unsteady improvement in spatial organization (from a score of 8 to 7) following the PM, and a more consistent and stable improvement following the CI (from 7 to 6).

This participant saw himself as having a slight handwriting problem throughout the course of the intervention, which was true only at the end of the intervention. Despite his low level of awareness, he improved nicely over the course of the intervention, moving from a severe to a slight handwriting problem (Table 4).

Table 4
Self-prediction, Self-estimation, and Therapist Assessment of Handwriting Performance According to Three Categories in the 4 Participants

Participant 1	Overall prediction	Overall estimation	Handwriting
Baseline 1	Moderate difficulty	Minimal difficulty	Minimal difficulty
Baseline 2	Minimal difficulty	Moderate difficulty	Severe difficulty
Baseline 3	Moderate difficulty	Minimal difficulty	Minimal difficulty
Participant 2	Overall performance	Overall estimation	Overall prediction
Baseline 1	Moderate difficulty	Moderate difficulty	Severe difficulty
Baseline 2	Moderate difficulty	Moderate difficulty	Moderate difficulty
Baseline 3	Minimal difficulty	Minimal difficulty	Minimal difficulty
Participant 3	Overall performance	Overall estimation	Overall prediction
Baseline 1	Moderate difficulty	Moderate difficulty	Moderate difficulty
Baseline 2	Moderate difficulty	Minimal difficulty	Minimal difficulty
Baseline 3	Minimal difficulty	Minimal difficulty	Minimal difficulty
Participant 4	Overall performance	Overall estimation	Overall prediction
Baseline 1	Minimal difficulty	Minimal difficulty	Severe difficulty
Baseline 2	Moderate difficulty	Minimal difficulty	Minimal difficulty
Baseline 3	Minimal difficulty	Minimal difficulty	Minimal difficulty

Discussion

The objective of this study was to examine the efficacy of DI and PM treatment interventions and their influence on the motor abilities and handwriting skills of children with handwriting problems. An explanatory case study using an ACABA and ABACA design was used to collect data before and during the interventions, which were administered over the course of half a year during allocated periods of time.

The OT interventions were found to be efficient in improving participants' fine motor skills and handwriting abilities, with the greater improvement usually occurring following the combined intervention (i.e., PM and DI). The order of the interventions over the course of the study was not found to influence improvement. There was some improvement in the level of both general and self-awareness among the participants towards the end of the interventions, as reflected by their predictions and estimations. However, there was no correlation between the improvement and the type of intervention given. Interestingly, among three of the children, improvement in the level of awareness was related to their improvement in handwriting and motor skills.

The improvement found in fine-motor abilities, handwriting skills and level of awareness (both general and specific) provides support for much of the research in the literature on various intervention approaches that treat motor skills as being at the core of handwriting problems. Interventions based on OT approaches, such as sensory integration and perceptual-motor training, have been found to improve fine motor abilities and, in turn, handwriting skills (Addy, 1996; Donald & Allen, 1995). However, there is at times a discrepancy between an improvement in fine-motor skills and an improvement in handwriting, in favor of fine-motor skills (Case-Smith, 2002; Subsawad et al., 2002). An improvement in the efficiency of handwriting seems to be related, then, to the development of additional skills, including language skills and cognitive skills (Yinon & Weintraub, 2000). Therefore, improving handwriting skills necessitates work on such additional skills above and beyond motor skills, for instance, cognitive and metacognitive skills.

The present study used the explanatory case study in order to examine the efficacy of two different types of interventions. Both the perceptual-motor approach (the more accepted of the two) and the combined intervention (i.e., PM and DI) were used to improve handwriting abilities among four children. This technique was found to be efficient in other studies for examining different intervention methods and for documenting clinical changes following

their use (Zlotnik et al., 2009). It allows the immediate examination of intervention effectiveness and the implementation of appropriate changes. Therefore, the explanatory case study is very applicable and recommended as a method of research in the OT clinic.

In recent years, we have witnessed a significant development in regard to cognitive rehabilitation in the field of OT (Katz, 2005; Zlotnik et al., 2009). It has been employed primarily with a population of senior citizens with neurological deficits (CVA), head injuries, dementia and Alzheimer's disease, as well as adolescents with traumatic brain injury. Nevertheless, no specific mention is made related to handwriting skills. The contribution of the present study is in revealing the importance of including meta-cognitive components in each handwriting intervention for children.

It is important to note that the explanatory case study is characterized by a small number of subjects. This study included 4 boys; 2 in second grade and 2 in third grade. Due to the elimination of 2 of the 6 initial participants, the ability to generalize from the results of this study may be limited even further. However, in reviewing studies that were conducted in the past decade using this or similar methods such as single case study design, it was found that most of them included only 3 or 4 subjects. Another limitation of this study is the number of testing for baseline. Since the tests that we used in this study have a learning effect and one can not use them frequently, our baseline was conducted only once each time before intervention B, before intervention C and after intervention B or C.

The second author functioned both as researcher and therapist, noting changes that occurred in the participants during the different types of interventions. Because this role may have influenced the researcher's objectivity to a certain degree, two outside experts were used to interpret the HHE results of the participants and to analyze their handwriting samples (i.e., names and addresses) according to the HHE over the course of the intervention in order to prevent bias in the results.

The awareness questionnaire on the topic of handwriting was composed on the basis of the principles set forth in Toglia's questionnaire (1992). The present study used a questionnaire for which content validity was carried out by three experts, who examined it and made changes accordingly. As a researcher and a clinician, the second author found the questionnaire to be too long for the participants, and some of the questions were hard for them to understand and required additional explanation for clarification (especially those including more than four response options).

The results of the study lead to the conclusion that there is a place for DI intervention in addition to PM intervention approaches for treating children with handwriting problems. Since the results cannot be generalized to a wider population, which in any case would have to be done in reference to an exact replication of the population, the results of the present study need to be replicated using this method on additional groups of children. In addition, other accepted methods should be used on a larger sample of children.

We also recommend further research on the influence of a DI intervention on other intervention areas within OT. In addition, the efficiency of this type of intervention among older children (third through sixth grade) should be explored. It is recommended that a researcher with more time available expand the scope of the interventions in each phase, especially in relation to the DI, which apparently requires more time for internalization and integration among young children. Finally, the awareness questionnaire used in the present study should continue to be developed in order to more efficiently examine awareness among young children, and its validity and reliability should be examined more in depth.

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