

## Handwriting Deficits in Children with Minimal Brain Dysfunction: Effects of Methylphenidate (Ritalin) and Placebo

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*Fifty hyperactive and learning disabled children were selected for study because of severe handwriting difficulties. Ten handwriting deficits were recognized with great frequency in this sample of students. The children received methylphenidate (Ritalin) or placebo under double-blind conditions. Twenty-six students (52%) showed improvement in overall handwriting following the administration of methylphenidate for four weeks. Many of their handwriting deficits, including letter reversals, improved or disappeared. Placebo had little appreciable effect on the children's handwriting. Direct observation of the students while writing suggested that advances in handwriting skills were related to improved visual-perceptual-motor functioning. We believe that methylphenidate has a direct positive effect on visual-perceptual-motor deficits often found in children with hyperactivity and learning disabilities. A number of practical applications of our findings are suggested.*

**M**any children with hyperactivity and learning disabilities experience severe difficulties with handwriting. These difficulties

have been attributed to attentional or behavioral disturbances or to deficiencies in visual, perceptual, or motor functioning (Boder 1973, Boder 1976, Lerer, Lerer, & Artner 1977). Regardless of cause, poor handwriting contributes to diminished academic achievement in children with hyperactivity and learning disabilities.

The effectiveness of central nervous system stimulant drugs, especially methylphenidate (Ritalin), in improving the attention span, concentrating abilities, and overall behavioral functioning of many such children has been demonstrated (Knights & Hinton 1969, Connors 1972, Eisenberg 1972, Sleator & von Neumann 1974). Previous studies have also shown that following the administration of stimulant drugs, some children with hyperactivity and learning disabilities exhibit significant improvement in a number of psychological measures and cognitive tasks requiring visual, perceptual, and motor control (Campbell, Douglas, & Morgenstern 1971, Schain & Reynard 1975, Lerer & Lerer 1976).

We have recently demonstrated that the administration of methylphenidate resulted in

rapid, significant, and dramatic improvement in overall handwriting clarity in a majority of hyperactive and learning disabled children who had serious deficits in handwriting (Lerer et al. 1977). This report details the effects of methylphenidate on specific handwriting deficits exhibited by the 50 children previously investigated.

## METHODS AND SUBJECTS

The methodology used, the subject selection, and the characteristics of the population of children have been published elsewhere (Lerer et al. 1977). The information is summarized below.

The 50 children involved in this investigation were selected on the basis of serious difficulties with handwriting in addition to signs and symptoms of hyperactivity and learning disabilities. Their ages ranged from 8.5 years to 12.8 years. There were 41 boys and nine girls. All patients were white and of middle socioeconomic classes. The subjects had full-scale IQ scores from the Stanford Binet or Wechsler Intelligence Scale for Children between 86 and 124, with a mean score of 98 and a standard deviation of 12. The students were at least in the second grade, and all were receiving some form of academic remediation at the onset of the present study. However, no changes in the children's academic settings occurred during the investigation.

Following extensive initial multidisciplinary evaluations, the children were randomly assigned to two groups consisting of 25 children each. Comparison of the two groups failed to reveal any significant differences with respect to age, sex, or mean IQ scores. Patients in Group 1 received methylphenidate, 0.6 to 0.7 mg/kg/day in two equally divided doses with breakfast and lunch. Children in Group 2 received a placebo with breakfast and lunch. After four weeks, patients in Group 2 were switched to methylphenidate, and children in Group 1 were switched to placebo for four weeks. All students

completed the study. Compliance was excellent, and no significant side effects were noted.

Prior to the study and at two-week intervals thereafter, teachers submitted to the authors handwriting samples representing what they judged to be the individual child's best efforts. By design, teachers, parents, and evaluators of handwriting samples remained unaware of the treatment status of the subjects until the end of the study.

The handwriting assessments were carried out by three persons experienced with children's handwriting. Each sample submitted by teachers was compared to pretreatment samples and to any preceding samples submitted during the treatment period and was rated improved, unchanged, or worse. In the majority of cases, changes in students' handwriting were obvious. There were four instances in which agreement by the handwriting evaluators was not unanimous, and in those cases, the opinion of the majority was used.

Handwriting samples were analyzed for changes by noting improvement or lack of improvement or worsening in each of the deficit areas listed in Table 1. An individual child's handwriting was judged to be improved overall only if improvement was noted in four or more of these deficit areas. Similarly, overall worsening in handwriting was recorded only when deterioration occurred in four or more of the criteria. Otherwise the handwriting was arbitrarily judged to be unchanged.

In an effort to characterize changes in functioning that might be directly responsible for observed changes in handwriting, direct longitudinal observations of the students in the act of writing were made blindly by one or more of the evaluators.

## RESULTS

Because of the design of our study, all 50 subjects had serious problems with handwriting. Ten specific deficit areas that were identified with high frequency in our population are listed in

**TABLE 1. Number of children exhibiting specific handwriting deficits before and after treatment with methylphenidate (Ritalin) and placebo.**

Handwriting deficit	Group 1 (N=25)			Group 2 (N=25)		
	Pre-treatment	Ritalin 4 weeks	Placebo* 4 weeks	Pre-treatment	Placebo 4 weeks	Ritalin 4 weeks
Poor organization of material within space	25	9	21	25	25	10
Poor overall legibility of material	25	10	22	25	24	12
Inconsistent letter size and shape	25	12	24	25	24	11
Poor spacing within and between words	25	12	20	25	23	13
Poor placement of letters on line or between lines	25	11	20	25	24	14
Frequent erasures or reworking	25	14	22	25	25	13
Frequent omissions of letters or words	25	12	24	25	25	15
Poor rhythm and flow of writing	20	9	17	23	23	10
Slow speed	18	8	13	15	13	5
Letter reversals or inversions	14	5	13	12	12	4

\*In Group 1, samples of handwriting submitted during treatment with placebo were compared to pretreatment samples.

Table 1, which also records the frequency of improvement of each of the handwriting deficits following treatment with methylphenidate and placebo.

It is evident that methylphenidate positively affected handwriting deficits in many of the children, whereas placebo had little effect on them. These differences were particularly

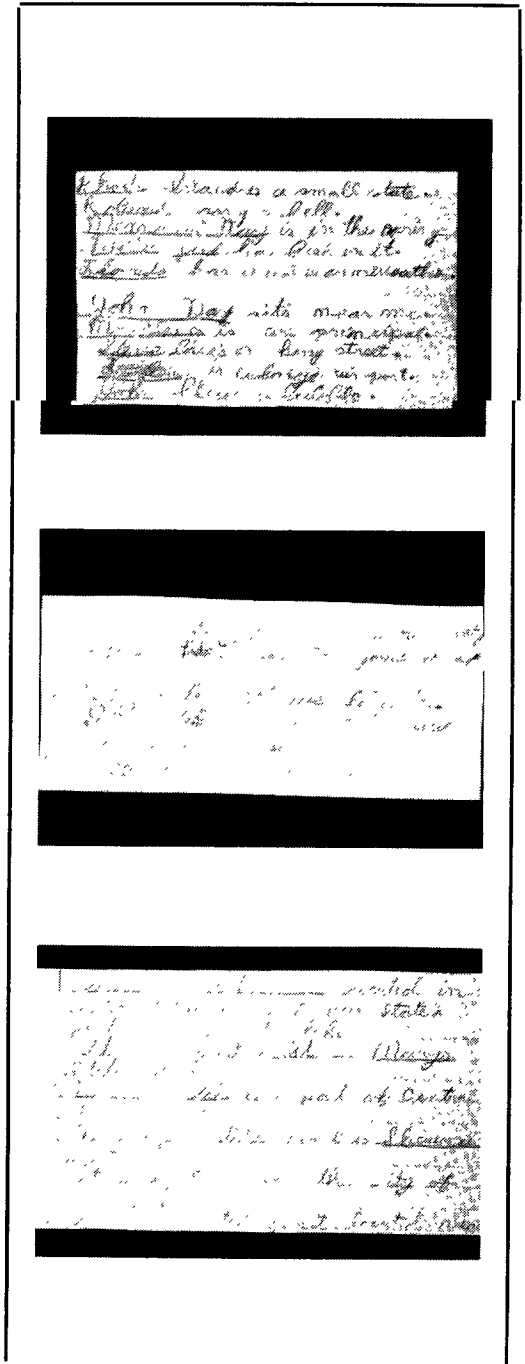
striking when one compared the handwriting samples of the 25 children in Group 1 receiving methylphenidate to those of the 25 children in Group 2 receiving placebo. When the subjects in Group 2 were switched from placebo to methylphenidate, numerous instances of impressive gains in deficit areas were recorded. It is interesting to note that when the children in

Group 1 were switched from methylphenidate to placebo, a few maintained the improvements in handwriting made while they were receiving methylphenidate.

Overall handwriting improvement (defined as improvement in four or more deficit areas) was recorded in 14 of 25 methylphenidate-treated children in Group 1 after four weeks. In contrast, only one placebo-treated child in Group 2 had improved his handwriting at the end of four weeks. Twelve children in Group 2 showed overall handwriting improvement four weeks after the switch from placebo to methylphenidate. The child who showed improvement with placebo had further improvement in handwriting following methylphenidate. After the 25 children in Group 1 were switched from methylphenidate to placebo, all 14 patients who had improved showed varying degrees of worsening, and the others showed no gains. In nine of the 14 children whose writing skills worsened, handwriting deteriorated to pretreatment levels. Although the other five continued to show improvement in handwriting when samples obtained after four weeks of placebo administration were compared to pretreatment samples, all demonstrated actual worsening of their handwriting when samples obtained during placebo treatment were compared to samples submitted during methylphenidate therapy.

As we had reported previously (Lerer et al. 1977), 26 of the 50 children (52%) showed improvement in overall handwriting following treatment with methylphenidate for four weeks. The differences between the number of methylphenidate-treated children and the number of placebo-treated children exhibiting improved handwriting were statistically significant ( $p < .001$ ).

Figure 1 illustrates a randomly selected collection of handwriting samples from a child who showed improvement following the administration of methylphenidate. The degree of improvement in handwriting shown in the figure is representative of that shown by the rest



**FIGURE 1.** Serial handwriting samples from an 11-year-old boy before treatment (top), after four weeks of placebo administration (middle), and after two weeks of methylphenidate therapy (bottom). Marked improvement in handwriting is evident.

of the students who improved. (For further examples see Lerer et al. 1977).

As a group, those children showing improvement in handwriting following treatment with methylphenidate exhibited rather uniform gains in the deficit areas listed in Table 1. Some children showed improvement in all 10 parameters; other children showed improvements in some deficit areas but not in others.

Letter reversals and inversions, a problem initially identified in 26 students, showed a tendency to improve or completely resolve within the first few days of methylphenidate therapy in those children who showed specific improvement in this deficit area. Many teachers specifically commented about this change and were surprised by the rapidity of improvement, particularly since several of these students had undergone educational remediation efforts for this problem without success.

The evaluators making longitudinal observations of the students in the act of writing noted that the children who improved seemed to have developed smoother and better coordinated fine motor movements after treatment with methylphenidate. Handwriting appeared to require less effort, and hand pressure on pencil or pen seemed steadier and less variable. With improvement in the rhythm and flow of writing, children who improved gained speed and accuracy.

We gained the clinical impression that those students who initially had greater difficulties with visual-perceptual-motor functioning were more likely to exhibit significant improvement in handwriting skills following methylphenidate treatment. Analysis of Koppitz scores in the Bender Visual Motor Gestalt Test showed a trend in this direction but no actual statistical significance. We did find that some of the children with the most bizarre handwriting patterns showed the most striking degrees of improvement following treatment with methylphenidate.

During the study there were 39 reported instances of delays of one hour or more in giving

the methylphenidate dose at lunchtime to 19 children exhibiting improved handwriting. Even this brief delay resulted in temporary worsening of handwriting in nine of the 19 students. Several parents reported worsening of handwriting during evening hours, after the pharmacological effects of methylphenidate wore off.

The 26 children who experienced improvement in handwriting while receiving methylphenidate have been maintained on the drug for follow-up periods ranging from 19 to 48 months. The gains in handwriting, as well as other concomitant improvements in functioning noted in our study, have been maintained during this period of time. Periodic reevaluations of neurologic, behavioral, and academic status and of handwriting have been performed nonblindly during this period. Nine of these students have stopped receiving methylphenidate after 17 to 29 months of drug treatment. Eighteen to 23 months later they continue to have average handwriting skills without specific medical intervention. The other 17 students continue to show varying degrees of worsening in handwriting skills following temporary trials of discontinuation of drug therapy.

When deterioration in handwriting skills was noted following the trials of cessation of methylphenidate therapy, the resultant regression in writing generally occurred slowly but steadily over a period of several weeks. However, in some instances, worsening occurred more rapidly and dramatically.

## DISCUSSION

Since the use of stimulant drugs such as methylphenidate in hyperactive and learning disabled children is widespread, it is imperative that physicians treating these children and parents and professionals observing their responses to drug therapy be aware of the specific benefits and limitations of these drugs. Clinically demonstrable direct effects of stimulant drugs on hyperactive, learning disabled children include favorable changes in

attention and behavior, improvement in a number of psychoeducational tests, and resolution of neurological abnormalities (Conners, Eisenberg, & Sharpe 1964, Epstein, Lasagna, Conners, & Rodriguez 1968, Knights & Hinton 1969, Lerer & Lerer 1976).

Although perhaps only a minority of hyperactive and learning disabled children exhibit serious problems with handwriting, we have shown that in 52% of these students, therapy with methylphenidate was effective in producing improvement in handwriting skills. When improvement in handwriting deficits occurred, it was rapid and easily recognized and, from our direct observations, appeared to be attributable to a direct positive effect of methylphenidate on visual-perceptual-motor functioning. We (Lerer & Lerer 1976, Lerer et al. 1977) and others (Sprague & Sleator 1973) have previously suggested that positive effects of stimulant drugs on visual-perceptual-motor performance in hyperactive children appeared to be independent of beneficial attentional and behavioral effects.

The information presented in this study should be of interest and of immediate practicality and usefulness to the educator, parent, and physician seeking to help the hyperactive and learning disabled child. We suggest evaluation of handwriting as a new, objective, simple measure worthy of assessment before and during stimulant drug therapy trials and at times of discontinuation of treatment. We also believe that analysis for changes in handwriting might be a useful parameter to incorporate in future studies evaluating or comparing the efficacy of medical and nonmedical treatment modalities for hyperactive children with handwriting disabilities.

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