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Original Articles

Methylphenidate Effects in Learning Disabilities

Psychometric Changes

Rachel Gittelman-Klein, PhD, Donald P. Klein, MD

The stimulants have the longest history of all major psychopharmacologic agents in child psychiatry. They were originally used by Bradley, in the 1940s, in the hope of improving the school performance of children in a residential treatment center, since stimulants improved adults' performance on intelligence and other psychological tests. Serendipitously, Bradley noted that some of the children in this mixed psychopathology group became calmer. Relatively well-designed studies established the fact that over a short period of time, stimulants reduced distractibility and hyperactivity. In addition, performance on various psychological tests was improved by stimulants among mixed groups of "emotionally disturbed" and hyperactive children, with and without learning difficulties. Studies are somewhat inconsistent in the specific tests that show improved results with treatment; the most prominent are the Wechsler Intelligence Scale for Children (WISC) performance, intelligence quotient (IQ), Porteus maze, and reaction time. Since published reports are too numerous to list, reference is made to a literature review.

All studies so far have reported that the performance of children selected for behavior disorders, conduct problems, or hyperactivity, sometimes combined with children with learning disabilities. In poor learners with notable psychopathologic findings, it is difficult to determine whether learning difficulties are secondary to adjustment problems, or whether these problems coexist independently. If the learning lags were secondary to the interpersonal maladjustment, improved behavior might lead to improved academic performance. Since no study of stimulant activity among children without psychopathologic findings has been conducted, it is not known whether the reported improvement in test performance represents a primary stimulant drug effect on cognitive processes, or a secondary improvement due to a primary, drug-induced, behavioral improvement.

This consideration has both practical and theoretical importance due to the spreading belief that minimal brain dysfunction (MBD) occurs in a variety of childhood disorders.

Within the MBD category, both hyperkinetic children and children with specific learning lags have been included. Further, MBD has been considered by some to be a syndrome for which a specific treatment is indicated, namely, stimulants (e.g., dextroamphetamine sulfate, methylphenidate hydrochloride, and, more recently, magnesium...
The primary indication for methylphenidate therapy is a diagnosis of D. Add., and possibly even in the case of tardive dyskinesia in children. It is then asked that hyperkinetic behavior or a child's diagnosis be based upon clinical judgment and not primarily on the use of stimulants. However, the most common indication that a child with atypical or other behavior is a consequence of methylphenidate therapy is a diagnosis of a child's diagnosis. However, the most common indication that a child with atypical or other behavior is a consequence of methylphenidate therapy is a diagnosis of a child's diagnosis. However, the most common indication that a child with atypical or other behavior is a consequence of methylphenidate therapy is a diagnosis of a child's diagnosis. However, the most common indication that a child with atypical or other behavior is a consequence of methylphenidate therapy is a diagnosis of a child's diagnosis. However, the most common indication that a child with atypical or other behavior is a consequence of methylphenidate therapy is a diagnosis of a child's diagnosis. However, the most common indication that a child with atypical or other behavior is a consequence of methylphenidate therapy is a diagnosis of a child's diagnosis.
The Paired Associate Test is a test of rote visual association. The child was shown a series of ten matching written designs, each paired with a familiar object. The presentation was on a teaching machine display, lasting five seconds for each trial. The meanings of the design was displayed again and the subject was asked to recall the familiar object. The score obtained represents the number of trials necessary to learn a series of ten pairings. Therefore, the lower the score, the more rapidly the learning occurred. On the Paired Associate Test, the children required an average of 91 trials before they learned ten consecutive associations. No norms are available for this test for rote memory.

On the Continuous Performance Test, the child was told to press a button when a red circle appeared in the display window of a teaching machine. The red circle is embedded in random order among other geometric figures that may be red or blue. Each exposure lasts five seconds; the total test lasts ten minutes. The red circle, in contrast, appeared 20 times. The child could make two errors per minute (1) he failed to press the button while the circle appeared (error of omission) or (2) he could fail to press the button while a circle appeared (error of commission). This test is designed to tap the ability to sustain attention.

On the Continuous Performance Test, the children pressed the button an average of 112 times when the criterion stimulus was not displayed, which is a very low level of errors of commission. Failure to press the button when the criterion stimulus was missed (errors of omission) occurred less than once on the average (18 times). These results indicate that the test was too easy for the children, and that the ceiling of their attention-sustaining ability was unattained.

Intercorrelation of Baseline Variables

<table>
<thead>
<tr>
<th>Test</th>
<th>Placebo Subjects (N = 32)</th>
<th>Methadone Subjects (N = 33)</th>
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<tbody>
<tr>
<td></td>
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<td>Socioeconomic Status</td>
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<td></td>
<td></td>
<td>Status</td>
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<tr>
<td>Full-scale IQ</td>
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<td>0.50 ± 0.19</td>
</tr>
<tr>
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<td>0.21 ± 0.03</td>
</tr>
<tr>
<td>Race (1 white, 3 black)</td>
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<td>0.21 ± 0.03</td>
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<tr>
<td>Family Stability</td>
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Dosage and Treatment Effects

After four weeks of treatment, the average daily methadone dose was 55 mg (range, 15 to 60 mg). After 12 weeks, the average dose was 50 mg/day (range, 20 to 60 mg). The drug effects on the psychological tests are presented in Table 5 and 6. The four-week results are discussed first; 12-week results follow.

After Four Weeks—After four weeks, the only WISC subset with a mean effect significantly improved by methadone therapy was the information subset (Table 5). Scores on the reading tests (WRAT and Gray Oral Reading) did not differ between the two groups and the two subsets of the t-tests (Table 6), though a slight trend in favor of the methadone-treated children on the WRAT reading scores was found (F = 1.20, P = .15, one-tailed). The WRAT arithmetic scores were greatly improved by methadone therapy after four weeks (F < .001). The WRAT spelling scores were not affected by treatment.

Among the cognitive tests (Table 5), a number of significant drug-related changes were observed after four weeks of treatment in keeping with previous investigators' findings using samples from different populations, the Porteus maze test, IQ was extremely sensitive to methadone therapy (F = .001). The qualitative nature of the results was confirmed by dividing the Porteus qualitative score by the number of moves completed, reflected drug-related improvement as well, at four weeks. The Visual Sequential Memory Test, which, like the Porteus maze test, requires visual vigilance and tracking, showed significant stimulant effect (F < .001). Visual Memory Test also showed a notable drug effect (F < .001). The Draw-A-Person, Continuous Performance, and Paired Associate Tests were not differentially affected by the stimulant after four weeks.

After 12 Weeks—The drug effect on the WISC was greater after 12 weeks of treatment (Table 5). Among the verbal tests of the WISC, the similarities subset scores showed a significant drug effect. Information scale scores were no longer different between the two treatment groups. The performance IQ showed a six-point increase attributable to the correlation after 12 weeks of treatment (F = .005). The drug effect is reflected in a four-point gain on the full-scale IQ. The increment in performance IQ was due to significant gains in favor of the drug-treated children on picture completion, block design, and coding. These performance robusts dealt with relatively meaningless content. The two subsets that require synthesis of familiar and meaningful stimuli (picture arrangement and object assembly) were unaffected by the medication.

The previously observed trend in favor of methadone-treated children on the DART reading scores was still present after 12 weeks, but did not reach statistical significance (F = 1.04, P = .34, one-tailed test). Strikingly, the notable advantage of the drug group in WRAT arithmetic scores was no longer present. Whereas, after four weeks of treatment, the drug group had a six-month reprieve over the placebo group, after 12 weeks, the drug group scored, on the average, about two months above the placebo group (scores after drug administration were corrected for baseline value). The stimulant-treated children showed relatively few changes between weeks 4 to 12. On the other hand, the placebo-treated children, who had shown changes over the first four weeks, improved sufficiently between weeks 4 and 12 to reach a level of performance significantly lower than that of the drug group.
Table 2.—Relationships in Improvement in Intelligence Quotient (IQ), Cognitive, and Achievement Tests

<table>
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<tr>
<th>Predictor of Improvement</th>
<th>IQ</th>
<th>Cognitive</th>
<th>Achievement Tests</th>
</tr>
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<tbody>
<tr>
<td>WRAT-1</td>
<td>0.34</td>
<td>0.26</td>
<td>0.21</td>
</tr>
<tr>
<td>WRAT-2</td>
<td>0.33</td>
<td>0.25</td>
<td>0.20</td>
</tr>
<tr>
<td>WRAT-3</td>
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</table>

The table shows the relationships between the WRAT-1, WRAT-2, and WRAT-3 scores and IQ, cognitive, and achievement tests. The highest correlation is between WRAT-1 and IQ, with a correlation coefficient of 0.34. The correlations between WRAT-2 and WRAT-3 with IQ are also high, at 0.33 and 0.34, respectively. The correlations with cognitive and achievement tests are lower, ranging from 0.20 to 0.26.

Predictors of Improvement

Seven demographic environmental and psychological characteristics were used to predict whether children received special education or not (Pearsone r). On the basis of significant associations were found a total of 0.06 (Table 9). Initial IQ, age, family stability, and later depression were associated with change in relationship to other placebo or methylphenidate.

Socioeconomic status (SES) was correlated with WRAT in both groups, but the difference was more marked in the trained placebo- treated children; the higher the social class, the greater improvement the teacher was likely to perceive (r = 0.47, p < 0.05). The reverse was true for verbal intelligence; the lower the class, the greater improvement was noted. In the placebo group, black children were significantly less improved on the WRAT arithmetic test (r = 0.4, p < 0.05). Children with relatively greater family instability tended to be perceived as more improved if treated with placebo. Children with relatively higher levels of school stability tended to improve more on the WRAT arithmetic test on methylphenidate treatment (r = 0.35, p < 0.05).

The results indicate that children of low SES and unstable family backgrounds were more likely to be seen as improved while receiving placebo than higher SES children. Conversely, teachers perceived the response to methylphenidate as more notable in higher SES children.

Consistency of Improvement

The ultimate goal of treatment of learning disability is to improve academic performance. To determine whether children who improved on one measure of achievement did so in other measures, the 3-week corrected change scores of the achievement tests for children who received methylphenidate were correlated. In order to determine to what extent the teacher's impression of improvement was related to the child's performance, the teachers' evaluations of children who were performed were compared to determine what extent improvement on cognitive tests and on achievement tests was associated, and whether consistency of improvement from one type of test to another was consistent.

Achievement Tests—The results are presented in Table 10. Among the methylphenidate subjects, the teachers' ratings of improvement were correlated with each other on the WRAT only. The WRAT was used as a measure of the teacher's consistency of improvement on the WRAT reading and arithmetic.

No relationship between WRAT reading and arithmetic improvement was found in the drug group.

On placebo subjects, WRAT arithmetic and reading improvement scores were positively associated (r = 0.50, p < 0.001). This finding probably reflects increased motivation, positive effect, and other nonspecific factors. The two tests were used as a placebo group between the WRAT and reading test, which was found in the methylphenidate group, may be due to lack of variance in outcome ratings.

Intelligence Quotient and Cognitive Tests.—The adjusted postadministration scores of the cognitive tests, as well as the IQ scores, were correlated with the methylphenidate treatment groups and the placebo and methylphenidate groups (Tables 11 and 12).

Methylphenidate Group—Eleven significant associations were found at P < 0.05; but only 0.10 of change between change in psychological test scores and change in academic performance (Table 11). The number is small, it exceeds chance expectation, especially since all but one of the relationships are to the predicted direction. The salient findings are that improvement in mental ability is associated with improvement in reading comprehension and with gains on the Gray Oral Reading Test. The ability to visualize stimuli organized in a set order, the ability to discriminate the capacity to read.

The second seemingly important part is that in the methylphenidate group, the arithmetic computation (WRAT) is associated with improvement in performance tasks. In the placebo group, only two of the associations between the psychological tests and academic performance were significant. There was no pattern of change relationships observed in this group.

COMMENT

The operational definition of learning disability used in this study was a two-year lag in reading achievement in elementary school children, in spite of normal IQ. Others have used the child's mental age, rather than IQ, to evaluate his expected attainment in reading, so that learning disabilities are defined by a discrepancy between expected and reading test scores. Since the latter definition was not used in this study, results obtained cannot be simply generalized to children who meet these different criteria for learning disability. However, 222 of the children in this study were at least two years behind the achievement level congruent with their mental age. The mean difference between the Gray Oral Reading Test was 2.35 years (SD, 1.47) below the mean mental age.

The results, using a group of children selected exclusively for learning disabilities and excluding children with hyperactivity or behavior disorders, confirm the findings that stimulants are instrumental in improving performance. No evidence was found that methylphenidate did not differ from those previously reported in mixed diagnostic groups. Thus, our design allows us to affirm that stimulation therapy is not secondary to drug effect. Since a general improvement factor was anticipated, our results do not appear to be due to other physiological changes.

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negative attitude and did not apply themselves to their work. We are currently testing this hypothesis.

The significant negative relationship between change in WISC comprehension and WRAI spelling scores should probably be attributed to chance factors. This is the only finding opposite from the predicted direction.

The fact that a notable short-term, but no long-term effect was found in arithmetic against the practice of generalizing from results obtained in studies of a few weeks' duration.

The data established that stimulants enhance certain cognitive processes in children. This finding is compatible with the theory that stimulants do not have a paradoxical effect on children, at least with regard to cognitive processes. Nonetheless, it is conceivable that stimulants do not have a uniform effect across all psychophysiological regulatory mechanisms. This issue will be discussed in another article dealing with the lack of behavioral activation by methylphenidate in this sample.

In a recent report dealing with normal adults, tests of conceptual thinking were improved by dextroamphetamine therapy. However, our findings tend to show that such improvements did not occur in children with learning disabilities. It may be that children, in general, are different from adults. More specifically, learning-disabled children may have a specific deficit in left hemispheric-mediated conceptual-verbal functions. When treated with stimulants, their residual normal brain functions show an increase, but their damaged functional capacities do not, leading to the apparent specificity of drug effect on noncognitive visual processing skills. To resolve this question would require the study of stimulant effects in normal, as well as learning-disabled children. If the normal children had conceptual verbal improvement similar to those reported in normal adults, the evidence for qualitatively different neurophysiological functioning in learning disabilities would be conclusive. However, ethical considerations raise questions about such investigations. Nontherapeutic studies require a compelling social interest combined with minimum risk.

As is true for "normal," the subjects in this study had no significant behavior disorders, and in this sense, were not "disturbed," but they had a manifest dysfunction. The investigation of methylphenidate effects was justified by the growing use of the medication in such patients, a practice that required study since it had no scientific basis. Hopefully, this study provides objective data for more informed clinical decisions.

This investigation was supported in part by National Institute of Mental Health grant MH 36070.

The methylphenidate used in this investigation was supplied as Ritalin by CERF Pharmaceutical Corp., Paramus, N.J. The matching placebo capsules were supplied by Smith, Kline & French Laboratories, East Hanover, N.J.

The forms reflecting the degree of stability and curricular in the home and the level of motor activity in the clinic are available on request to the authors.

Nonproprietary Name
and Trademark of Drug

Methylphenidate—Ritalin.

References