RESEARCH

Stimulant Medication and Reading Performance: Follow-up on Sustained Dose in ADHD Boys with and Without Conduct Disorders

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The study examined the sustained effects of methylphenidate on reading performance in a sample of 42 boys, ages 8 to 11, with attention deficit-hyperactivity disorder (ADHD). Two subgroups were formed based on the presence or absence of co-occurring conduct disorders. Subjects were selected on the basis of their positive response to methylphenidate as determined in a series of original medication trials (Forness, Cantwell, Swanson, Hanna, & Youpa, 1991). For the purpose of this study, subjects were placed on their optimal dose of medication for a 6-week period and then tested on measures of oral reading and reading comprehension equivalent to those used in the original trials, retested after a week without medication (placebo), then tested again the following week after return to medication. Only the subgroup with conduct disorders responded, and this response was limited to reading comprehension improvement in only those subjects who also demonstrated improvement in oral reading on original trials. No response differences were found between subjects with or without learning disabilities.

Any study of effects of stimulant medication on academic performance in children with attention deficit-hyperactivity disorder (ADHD) may be complicated by a number of factors, two of which are among the most prominent. The first involves difficulty in diagnosis, particularly the issue of overlap among symptoms of ADHD and conduct or oppositional disorders (Carlson & Rapport, 1989; Henker & Whalen, 1989; Hinshaw, 1987; Lambert, 1988; Loney & Milich, 1982; McGee, Williams, & Silva, 1984; Prior & Sanson, 1986; Shapiro & Garfinkel, 1986; Shaywitz & Shaywitz, 1988; Werry, Reeves, & Elkind, 1987), as well as possible differential response to stimulant medication between these two groups (Greenhill, 1989; Rapoport & Zametkin, 1988; Swanson & Taylor, 1988; Taylor, 1988). The second involves the wide variability of cognitive or academic functioning found in samples of children with ADHD (Atkins & Pelham, 1991; August & Garfinkel, 1990; Cotugno, 1987; Douglas, 1988; Felton & Wood, 1989; Forness, Youpa, Hanna, Cantwell, & Swanson, in press; Goldstein, 1987a, 1987b; Hamlett, Pellegrini, & Conners, 1987; Holborow & Berry, 1986; Nussbaum, Grant, Roman, Poole, & Bigler, 1990; Szatmari, Offord, & Boyle, 1989; Tarnowski & Nay, 1989; Vander Meere, Van Baal, & Sergeant, 1989; Voelker, Carter, Sprague, Gdowski, & Lachar, 1989).

Although reading is the academic area of most interest to teachers in the elementary grades, very few of the above studies have focused on improvement in reading skill, because of difficulties in measuring drug effects in this area (Dykman & Ackerman, 1991; Forness & Kavale, 1988; Gadow, 1991; Swanson, Cantwell, Lerner, McBurnett, & Hanna, 1991). Although effects of stimulant medication on reading have certainly been noted, dependent measures in this area have generally shown the most variability across studies, especially when compared to other measures of academic performance (Barkley, McMurray, Edelbrock, & Robbins, 1989; Douglas, Barr, O'Neill, & Britton, 1986; Douglas, Barr, Amin, O'Neill, & Britton, 1988; Dykman & Ackerman, 1991; Kupietz, Winsberg, Richardson, Maitinski, & Mendell, 1988; Richardson, Kupietz, Winsberg, Maitinsky, & Mendell, 1988). Very few of these studies have examined the effects of *sustained* treatment as opposed to short-term response in medication

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trials; none have done so while also controlling for the presence or absence of conduct or oppositional disorders and learning disabilities and while focusing on measures of functional reading performance.

The present study attempts to address these issues by assessing effects of methylphenidate during functional reading performance after 6 weeks of sustained treatment in a carefully selected sample of subjects with ADHD, screened for the presence or absence of conduct or oppositional disorders and learning disabilities. Subjects were selected from those determined to be drug responders in a series of initial medication trials (Forness et al., 1991).

Method

Subjects

Subjects were selected during a 4-year period from referrals to the UCI Child Developmental Center, which served primarily children with attention deficit disorder, and the UCLA Child Psychiatry Outpatient Department, which served children with a range of psychiatric disorders. Two different sites were used, to alleviate the possibility of subjects being selected differently as a result of referral bias. Only boys between the ages of 8 and 11 years were considered for subject selection.

The selection process for this study involved three stages. Screening with standard questionnaires was first performed to obtain scores (ratings) on dimensions of behavior. This was followed by a structured interview, to obtain categorical diagnoses based on DSM-III-R (American Psychiatric Association, 1987) criteria. Finally, subjects selected in this way underwent double-blind, placebo and medication trials in the Forness et al. (1991) study; those determined to respond to stimulant medication, as described below, were selected for the current study.

Parents and teachers of subjects first completed screening questionnaires for ADHD and conduct or oppositional disorders; this stage is described in more detail in Forness et al. (1991). A score of 15 or more on the Conners Ten-item Index Questionnaire (Conners, 1969) was used as the initial criterion for ADHD. Initial subgrouping was then accomplished with the Iowa Conners Questionnaire (Loney & Milich, 1982), using clinical cutoff scores of 7 or more on the Inattention/Overactivity scale and 5 or more on the Aggressive/Defiant scale, to form pure and mixed subgroups of subjects, respectively. The next stage, which also took place in the initial study (Forness et al., 1991), involved the Diagnostic Interview for Children and Adolescents, with specific revision (Swanson & Taylor, 1988) for diagnoses of ADHD, Oppositional Defiant Disorder, or Conduct Disorder in DSM-III-R. This interview was also used to screen for exclusion conditions (e.g., auditory hallucinations, etc.). Subjects were then assigned to one of two subgroups: "pure ADHD" or "mixed ADHD," the latter being ADHD plus Conduct or Oppositional Defiant Disorder.

In the final stage, subjects were selected on the basis of their response to the stimulant methylphenidate (Ritalin) in double-blind, placebo trials described in more detail in Forness et al. (1991). These trials essentially involved three dosage levels (0.3 mg/kg, 0.6 mg/kg, and 1.0 mg/kg), randomly ordered and interspersed with a placebo. A baseline session using equivalent dependent measures of drug response (see below) preceded the trials. Each subject was kept on the placebo condition or one of the three dosage conditions for essentially a full week each, over 4 consecutive weeks. Both subjects and research staff were blind as to the order of conditions, which was randomized. Subjects were selected for the present study who demonstrated significant improvement over placebo on any one of the three dosage levels as described below.

Subjects thus selected for the present study were 20 of 27 subjects from the original mixed, and 22 of 28 subjects from the original pure, subgroups in the Forness et al. (1991) study. This represented a response rate of approximately three of every four subjects in each group improving their performance with medication, and no subject dropped out for reasons of drug tolerance or related complications. Mean ages of boys in the pure and mixed subgroups in the current study were 9.7 ($SD = 1.6$) and 9.5 ($SD = 1.5$) years, respectively. Percentage of subjects from ethnic minority background was 10% and 13.6%, respectively, for each subgroup. These data did not differ significantly from those of subjects in the original study.

Psychoeducational Testing

Each subject in the original study was administered the following battery of tests prior to selection: Wechsler Intelligence Scale for Children-Revised (Wechsler, 1974); Peabody Individual Achievement Test (PIAT) (Dunn & Markwardt, 1970); Woodcock Reading Mastery Tests (WRMT) (Woodcock, 1973); and Key Math Diagnostic Test (KMDT) (Connolly, Nachtman, & Pritchett, 1976). Two additional academic analyses were also made in the original study. One was an analysis of differences among groups on the reclustered subtests of the WISC-R. In that analysis, subscale means were computed for each subject on the "memory-concentration" cluster (Arithmetic, Coding, Digit Span), the "visual-perceptual" cluster (Picture Completion, Object Assembly, Block Design), and the "linguistic" cluster (Vocabulary, Similarities, Comprehension). Differences on these clusters have been shown to be related to the diagnosis of a learning disability, though only unequivocally for the first cluster and only relative to its position with other clusters in children with learning disabilities (Kavale & Forness, 1984). The other analysis was number of subjects with LD in each group as diagnosed by a discrepancy of 1 standard deviation between ability and

achievement according to a standard regression formula in use with children with LD in California at the time of the study (California State Department of Education, 1983). Table 1 presents these testing results for subjects selected for the present study. These data did not differ significantly from those of subjects in the original trials, except for the between-group difference in reading comprehension.

Medication Procedures

After the initial trials for baseline, placebo, and three dosage levels were completed in Forness et al. (1991), each subject's "best" dose from among the three levels of methylphenidate was determined by his response in these original trials to a paired-associates task developed by the second author (Swanson & Taylor, 1988). Briefly, this method involved systematic presentation of pictures of six animals, each matched with unrelated alphabetical letters. After a 1-minute exposure (study time), the child was asked to identify letters when only the animals were presented (testing time) and then provided a subsequent display of the correct answers (feedback time). The entire series of study, test, and feedback was then repeated on subsequent trials until the child got the entire series correct on two consecutive occasions. The subject's number of errors and trials to criterion were determined for each level of medication. Performance on this paired-associates task has been found to correlate well with other concurrent measures of drug response, including continuous performance tests and teacher rating scales, and to distinguish those children who respond to stimulants from nonresponders in a highly reliable fashion (Swanson, 1990; Swanson et al., in press). The best average response from among the three levels of methylphenidate was selected on this basis rather than on the basis of each subject's response to reading measures (described below), because no consistent responses were demonstrated over the initial trials except for one subgroup (mixed) on one measure (reading comprehension), with no significant dose effect (Forness et al., 1991). However, because accuracy in oral reading is a commonly used indicator of academic performance in classroom settings, subjects were also identified as responders by a *secondary* measure of improved performance on oral reading, which is described below. Subjects were considered to be responders on the paired-associates task or the oral reading task if their performance improved at a level of 25% or greater over placebo in the original trials, as described in detail in Swanson et al. (in press).

Each subject was then placed on his optimal dose for purposes of the present study and maintained on it for a period of 6 more consecutive weeks, according to the original daily schedule but without a weekend washout period used to separate conditions in the original trials. At the end of this 6-week period, each subject was administered the dependent measures of reading, as described below. Each subject was then taken off medication for 1 week (i.e., placed on placebo) and again retested on the alternate forms of these measures. Each subject was then returned to his optimal dose for 1 remaining week for a final retesting. Although clinical practice suggests that testing in the *sixth* week should indicate the child's best response to treatment over time, each child presumably also received reading instruction in the regular grades during this period, and thus medication effects could not be reliably separated, at this point, from instructional effects. Return to placebo in the seventh week and reintroduction of the optimal dose in Week 8 was therefore necessary to demonstrate medication effects, per se. Note that all of the subjects received instruction in regular classrooms, and no attempt was made to control or modify the standard instruction in reading that each subject received during the study. Teachers were, however, blind as to specific drug conditions, and thus there was presumed to be no particular change in standard instruction over the 13-week protocol. Because each subject was selected and administered the study protocol at each site in serial order of referral, subjects were of necessity tested and treated with medication at different points in the school year. No subject was initiated in the study if his protocol over the 13 consecutive weeks (i.e., baseline, placebo,

TABLE 1
Means and Standard Deviations for Both ADHD Subgroups

Variable	Pure ($n=20$)		Mixed ($n=22$)	
	Mean	*SD*	Mean	*SD*
Age	9.7	(1.6)	9.5	(1.5)
WISC-R: Full Scale IQ	108.8	(14.4)	103.7	(13.6)
Verbal IQ	109.2	(14.7)	102.6	(14.2)
Performance IQ	106.7	(14.3)	105.6	(15.0)
Attention Cluster	9.5	(2.8)	8.9	(2.5)
Verbal Cluster	11.2	(3.0)	10.8	(2.3)
Perceptual Cluster	11.5	(2.7)	11.5	(3.0)
PIAT: Reading Recognition[a]	5.6	(2.7)	4.5	(2.0)
Reading Comprehension[a,b]	6.0	(3.0)	4.4	(3.0)
Woodcock: Total Reading[a]	5.2	(3.2)	4.0	(1.8)
Key Math: Math Grade Level[a]	5.3	(2.4)	4.3	(1.7)
Average IQ–achievement discrepancy in reading	−2.9	(1.8)	−3.2	(2.2)
Number meeting 1 *SD* discrepancy formula for LD	3		4	

Note. WISC-R = Wechsler Intelligence Scale for Children–Revised; PIAT = Peabody Individual Achievement Test.
[a]Grade-level equivalents presented here, though note (in text) that standard scores were used in analyses. [b]Denotes statistically significant between-group differences for this variable ($p<.05$).

original three dosage trials, and 8-week follow-up) could not be completed prior to school vacations.

Oral Reading and Comprehension

The dependent measures in the Forness et al. (1991) study involved accuracy and time to complete equivalent oral reading passages and measures of time and accuracy on equivalent reading comprehension exercises, and these were also used in the same fashion as described below (except when noted otherwise). The first two measures were number of errors in oral reading performance and total seconds required to finish an oral reading passage, as determined in the following fashion. Data were obtained in each of the baseline, placebo, and three medication conditions in the original trials using performance from four oral reading selections. One selection was used in the baseline and three were used in each of the first 3 weeks of randomized conditions (i.e., medication or placebo). The first selection was then reused in the last week of the randomized conditions, and the next selections were reused in the present follow-up study. Selections were used in the same order for all three groups throughout. Selections were short paragraphs (51 to 66 words), at the first- through fifth-grade levels of difficulty, taken from the Gray Oral Reading Test (GORT) (Gray, 1963; Robinson, 1984). This test has only four alternate forms (A, B, C, and D) at each level of difficulty; therefore, only four equivalent passages were available. At least 5 or 6 weeks would have elapsed, however, before any possibility existed of repeated testing on any one passage, and thus practice effects were deemed rather negligible. In order to control for difficulty level, the four reading selections were matched throughout to each subject's reading level on the PIAT Reading Recognition subtest (within at least a 6-month level of the subject's score). Thus, the experimental tasks were kept at a difficulty level *within the subject's reading ability* for each of the original sessions and the follow-up sessions. This procedure was employed to avoid the possible floor or ceiling effects sometimes found in studies in which subjects at the extremes, in either age *or* performance, may have functioned at a threshold too low to establish even a minimal baseline performance on the dependent measure or too near to perfection on the task at baseline, thus negating the possibility of any noticeable improvement with treatment. This approach was deemed preferable to controlling, after the fact, with analysis of covariance, with reading level as covariate, because some subjects may have had floor or ceiling effects that such an analyses could not have addressed.

Subjects were scored on the basis of their performance in their oral reading of the first 50 words in each paragraph. In each of the sessions, the examiner scored each of the children's individual oral reading performances. The first dependent measure was the number of errors (i.e., a raw score error count) that the child made on the first 50 words read in each of the sessions. Criteria for errors were the same as designated in the GORT manual. The second dependent measure was the number of seconds to complete reading of the first 50 words, as measured by a stopwatch.

The second two measures, for each of the baseline, placebo, experimental, and follow-up sessions, were performance on reading comprehension and time needed to complete a paper-and-pencil reading comprehension exercise. Materials were 8 of the 25 passages selected from Lessons 5 to 19 of each level of "Getting the Facts" booklets of the Specific Skill Series (Boning, 1978). This allowed a different but equivalent form to be used for each week of the original and follow-up trials. Instructions for silently reading the passages and answering the comprehension questions remained identical to those provided in the manual, with the following exceptions. The individual story passages and the comprehension questions were each photocopied on a separate, single sheet of paper. The subject was told that, after he finished reading or studying the story, the story page would be removed and he would be given a separate page of questions to answer about the story by circling the correct choice (three to four possibilities per answer) in pencil.

In order to control for different levels of reading comprehension, each subject's passages were selected from the grade-level booklet most closely corresponding (within a 6-month level) to each subject's PIAT Reading Comprehension score, thus also keeping the task at an acceptable level of difficulty throughout all trials, as noted above in regard to the oral reading measures. The two dependent measures for reading comprehension were the total number of questions correctly answered in each session, out of a possible 10 questions, and the total number of seconds required to read the passage and answer the questions. However, because of the lack of any statistically significant difference or identifiable trend in either group on this measure in terms of time to completion in the original study, a measure of reading comprehension time was not analyzed at follow-up. Three measures were thus gathered in each of the follow-up sessions in Weeks 6 to 8: (1) time in seconds needed to complete an oral reading passage of 50 words, (2) number of errors in oral reading of 50 words, and (3) number of correct responses (out of 10) on a paper-and-pencil reading comprehension exercise. Total time for these procedures (given in the order described) was approximately 10 minutes for each session.

Data Analysis

Because reading instruction in the classroom was ongoing during the original medication trials, the 6-week follow-up, and the reversal and reinstatement in Weeks 7 and 8, respec-

tively, direct comparison of on- and off-medication conditions at comparable points in and across time was necessary, to attempt to separate effects of medication from effects of instruction. No control group was included in this design, as medication effects in both the original study and the current study were assessed using a design in which each subject served as his own control; that is, he was assessed at baseline and assessed both on and off medication, during double-blind placebo and medication conditions. As indicated above, oral reading and reading comprehension levels were controlled by yoking level of oral reading passages and reading comprehension exercises to each subject's PIAT Reading Recognition and Reading Comprehension scores, respectively, and keeping these constant with equivalent forms throughout. Because a wide range of IQ levels remained in reference to each subject's reading levels, however, IQ was used as a covariate.

Therefore, comparisons were made between all off-medication conditions, that is, baseline, placebo in original trials, and placebo (reversal) in Week 7, and all on-medication conditions, that is, optimal dose in original trials, optimal dose after 6 weeks of treatment, and optimal dose (reinstatement of medication) in Week 8. Separate comparisons were made for each dependent variable (oral reading and comprehension). Multiple analyses of covariance by group (pure or mixed) and by condition (three off-medication and three on-medication conditions) were therefore used. This allowed specific comparison between groups and across conditions for which a specific pattern of response should be expected. In such a pattern, baseline and placebo measures should reflect similar levels of performance during original trials, with an improvement in response on optimal dose in original trials. This should be followed by further improvement after 6 weeks of sustained treatment, with a slight drop in performance when medication is withdrawn (placebo) in Week 7, followed by return to at least the same level of improvement or better in Week 8 (reinstatement).

An even more rigorous design would have involved a separate control group receiving either no medication or a placebo over the 8-week follow up, but this was not possible in the present study. To the extent that methylphenidate is generally understood to merely assist children to focus attention during tasks such as reading, and to not necessarily improve reading itself, a positive response to methylphenidate in the present study was expected to be associated with a pattern of improvement over 6 weeks that would be "interrupted" in Week 7 and resumed in Week 8.

Results

Table 2 presents results for the 20 subjects in the pure and 22 subjects in the mixed subgroups. Note that data from baseline, placebo, and optimal dose were determined in original trials (Forness et al., 1991). The data on sustained 6-week treatment with this optimal dose, the return to placebo condition in Week 7, and the reinstatement of optimal dose in Week 8 were obtained in this study. Of 20 subjects in the pure subgroup, 7 responded optimally to the 0.3 mg/kg dose, 7 to the 0.6 mg/kg dose, and 6 to the 1.0 mg/kg dose. Of 22 subjects in the mixed subgroup, 9 responded to the 0.3 mg/kg dose, 8 to 0.6 mg/kg, and 5 to 1.0 mg/kg. As can be seen in Table 2, subjects in the pure subgroup appear to have improved their oral reading speed over the 6-week treatment, gaining approximately 7 to 9 seconds over original trials, dropping off by about 4 seconds the following week when placed on placebo, and continuing their progress when reinstated on the optimal dose. Subjects in the mixed subgroup, on the other hand, seem in general to have improved incrementally from each condition to the next. None of these differences, however, were statistically significant, principally because of the wide variability in response among subjects in the pure subgroup, as indicated by the relatively large standard deviations across

TABLE 2
Means and Standard Deviations Across Conditions and Measures by Subgroup

	Oral Reading					
	Time in seconds		Errors		Comprehension	
Condition	Pure	Mixed	Pure	Mixed	Pure	Mixed
Baseline	41.4 (20.9)	39.5 (9.8)	4.5 (2.5)	4.0 (2.2)	7.8 (1.7)	8.1 (1.7)
Placebo	42.4 (29.0)	34.4 (7.2)	4.9 (3.3)	3.5 (1.8)	8.3 (1.7)	7.9 (1.6)
Optimal dose in original trials	40.7 (18.8)	34.6 (12.9)	4.0 (2.5)	3.2 (2.6)	8.6 (1.2)	8.3 (1.2)
Optimal sustained dose (6 weeks)	33.1 (16.9)	31.2 (8.0)	2.8 (2.0)	3.0 (2.5)	8.3 (1.9)	9.0 (1.0)
Placebo in Week 7	37.6 (12.1)	29.2 (9.6)	3.0 (1.5)	2.7 (1.2)	8.9 (1.4)	8.4 (1.4)
Reinstatement in Week 8	32.5 (9.8)	28.7 (7.6)	2.7 (2.1)	2.5 (1.8)	9.0 (1.1)	9.1 (0.9)

most of the conditions for this subgroup.

In number of errors made during oral reading, there was also no statistically significant effect. Note for the pure subgroup in Table 2 that, although there was a slight increase in oral reading errors under original placebo conditions, errors for this subgroup decreased slightly on the original optimal dose, decreased substantially over the 6-week treatment, rose slightly in the placebo in Week 7, and decreased again with reinstatement of optimal dose in Week 8. The mixed subgroup, on the other hand, decreased incrementally from each condition to the next.

However, somewhat the reverse of this pattern occurred for correct responses on the comprehension exercise, for which there was an effect for drug that approached statistical significance, $F(2,80)=2.57$, $p<.08$. Note, however, that the pure subgroup increased incrementally from one condition to the next, with the exception of a slight decrement over the 6-week treatment on optimal dose, while the mixed subgroup increased their number of correct answers to the comprehension questions with medication over both original baseline and placebo conditions, then increased on optimal dose over 6 weeks, dropped slightly on placebo in Week 7, and resumed progress in Week 8 with reinstatement. Note, too, that IQ was used as covariate in each of the above comparisons.

In order to explore the tendency of subjects to respond on reading comprehension, both groups of subjects were further divided into those who responded in original trials on both the primary measure of response, the paired-associates task, and the secondary measure of response, the oral reading task (i.e., a decrease in errors), as described in the methods section. There were 15 of 22 pure subjects and 14 of 20 mixed subjects who were optimal responders on both these tasks. In this analysis of subjects responding on one versus both measures, there was a statistically significant effect, $F(2,70)=3.01$, $p<.05$, suggesting that only when initial response to drug is determined to occur on two different measures does the pattern for the mixed groups demonstrate a significant response over time on reading comprehension. Similar analyses by responder status did not affect results on either of the oral reading measures. There also appeared to be no apparent trend to respond differentially by level of dose or by LD status on any of the above analyses.

Discussion

Only subjects in the mixed ADHD subgroup in the original trials improved their reading performance, and they did so only in correct answers to comprehension questions (Forness et al., 1991). These mixed ADHD subjects were the only ones with even a tendency toward improved performance on *sustained* treatment with methylphenidate in the present study. Over the 8-week follow-up, they demonstrated a predicted pattern of improvement on reading comprehension, but this was not statistically significant. Only when subjects in this group were selected as responders on *both* a paired-associates task and an oral reading task did this improvement reach statistical significance. Because the mixed subgroup scored significantly lower in initial reading comprehension on the PIAT than the pure ADHD subgroup, one might indeed have expected more room for improvement, though yoking reading comprehension tasks to these initial scores likely tended to remove this difference as a potential artifact. Any intellectual differences that might have existed between subgroups were likewise partialed out in the analyses, and LD diagnostic status appeared not to affect results. Indeed, the present study represents a rather strict test of drug effects, as attempts were made to control for so many previous research artifacts (e.g., careful specification of ADHD, division by subgroups of ADHD, more realistic measures of academic performance, control for floor and ceiling effects by yoking to entering reading scores, use of different dosage levels, and careful measurement of responder status). Thus, even those effects that approached significance are worth noting.

The means of both ADHD subgroups on baseline measures also appeared relatively equal across all three dependent measures, though placebo phenomena or subject variability seemed generally responsible for the lack of significant medication effects, especially in the pure subgroup. Note that the placebo condition in original trials was interspersed with three different dosage conditions in a random, double-blind design in which each subject served as his own control and thus should have been unrecognizable to both child and examiner. However, in the present study, the placebo condition was not randomly interspersed, though it is not clear if this affected results. Several of the studies cited earlier nonetheless employed only placebo conditions *without* a baseline, and such a design might have produced misleading findings in both original trials and in the present follow-up.

The very slight tendency toward a pattern of improved response by subjects in the mixed subgroup on reading comprehension gives only very tentative support to Taylor's (1988) hypothesis that the combination of ADHD and conduct or oppositional disorders perhaps sets the stage for a response to stimulant medication that is different from that accorded to pure ADHD. Taylor suggested that subjects with a mixed diagnostic picture may be considerably more common in clinical populations and may be much more likely than pure subjects to evidence cognitive or academic problems. Mixed ADHD subjects were indeed the only ones who demonstrated an immediate medication response in original trials (Forness et al., 1991). Sustained treatment on optimal dose, however, is more persuasive evidence, in that it is

more similar to realistic treatment conditions in pediatric or psychiatric practice. The mixed ADHD subgroup appeared to continue to show a response on follow-up; but this pattern only reached significance when a second, nontraditional measure of drug response (i.e., a decrease in oral reading errors) was added to determine their responder status.

Recent theories of reading comprehension (e.g., Cornoldi, 1990; Hall, 1989) suggest that complex memory processing deficits are more likely to be responsible for poor performance than deficits in more peripheral areas such as attention or perception. Oral reading or decoding involves primarily associative memory, while reading comprehension requires this same associative memory to operate at a much more automatic and fluent level and also requires the ability to invoke much more complex associative and serial processes in combination with retrieval of prior linguistic and experiential knowledge. As noted, Taylor (1988) suggested that pure ADHD may be less cognitively debilitating, overall, compared to the mixture of both ADHD and conduct disorders. The combination of attentional difficulties and the adverse environmental consequences of conduct disorders may act additively to diminish concentration on a more complex task, such as reading comprehension. This hypothesis is only speculative and rests on relatively limited evidence of additional neuropsychological and related cognitive disabilities in children or adolescents with conduct or oppositional disorders (see Kazdin, 1987, or Hinshaw, in press, for a review). The mixed ADHD subgroup seemed to be considerably more deficient (although generally not reaching statistical significance) in most areas of intellectual and academic performance on psychoeducational testing than the pure subgroup in the present study. That conduct or oppositional defiant disorders as a syndrome may bring *added* cognitive liabilities to the syndrome of ADHD may thus support some speculation about why only this group tended toward improvement on this task. It has been suggested that subjects' effort improves on complex tasks when they are administered stimulant medication (Douglas, 1988), and improved effort may have indeed tended to benefit the mixed ADHD subgroup on the more complex task of reading comprehension. The present study provides only very tentative support for such speculation.

At present, these findings cannot be extended to attention deficit disorders *without* hyperactivity, a third possible subgroup that continues to be recognized within the attention deficit disorders spectrum (American Psychiatric Association, 1987) and one that may indeed be different in terms of stimulant response from either of the two groups studied herein (Lahey & Carlson, 1991). The present results also seemed to be relatively independent of IQ and of a learning disability diagnosis, though analyses between subjects with and without LD were compromised by the lack of a significant number of subjects for the former group. What is somewhat surprising is that the *level* of the optimal dose also did not appear to affect results, especially as it is generally held that low doses of stimulants are more likely to be helpful in cognitive tasks than higher doses (Gadow, in press). The pure ADHD subjects were almost equally distributed among the low (0.3 mg/kg), medium (0.6 mg/kg), and high (1.0 mg/kg) levels as their optimal dose, whereas mixed ADHD subjects were only slightly more likely to be at either the low (41%) or middle (36%) doses. That subjects' optimal dose was initially determined on another, albeit highly reliable, cognitive measure besides reading may have resulted in lack of positive findings by level of dose on these reading tasks. Between 70% and 80% of subjects in each subgroup responded to stimulant medication in this sample, which is consistent with response rates in previous studies on children with ADHD (Barkley, 1990).

To conclude, it should be stressed that both the nature of the reading task and the presence or absence of an associated diagnosis of conduct disorder seem to be important considerations for further research on methylphenidate treatment of children with hyperactivity. Diagnostic subgrouping within ADHD has not been considered of major importance in classroom referrals or in referrals for related services, although it has recently tended to be viewed as a critical variable within psychopharmacotherapy for such children (Campbell & Spencer, 1988). As more psychopharmacologic research tends to focus on differential response of pure versus mixed ADHD groups, these considerations may begin to take on more practical importance in regard to classroom learning in specific academic areas.

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AUTHORS' NOTE

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