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The Single and Combined Effects of Multiple Intensities of Behavior Modification and Methylphenidate for Children With Attention Deficit Hyperactivity Disorder in a Classroom Setting

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Abstract. Currently behavior modification, stimulant medication, and combined treatments are supported as evidence-based interventions for attention deficit hyperactivity disorder in classroom settings. However, there has been little study of the relative effects of these two modalities and their combination in classrooms. Using a within-subject design, the present study investigated the single effects of behavior modification (no, low, and high intensity), methylphenidate (placebo, 0.15, 0.30, and 0.60 mg/kg), and the combination of these treatments in an analogue classroom setting with 48 children (ages 6–12) diagnosed with attention deficit hyperactivity disorder. Results indicated substantial effects of both unimodal treatments and their combination on measures of classroom behavior, productivity, and teacher ratings of functioning. The results are discussed in light of the current literature on single and combined treatments for attention deficit hyperactivity disorder.

Prevalence rates place at least one child with attention deficit hyperactivity disorder (ADHD) on average in every classroom in the United States (e.g., American Psychiatric As-

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sociation [APA], 1994; Rowland et al., 2002). The effective treatment of ADHD in school settings is thus critical (Walker, Ramsey, & Gresham, 2003–2004). Current interventions for ADHD include three evidence-based treatments: behavior modification procedures, stimulant medication, and the combination of behavior modification and stimulant medication (American Academy of Pediatrics, 2001).

These three treatment approaches are well-established interventions for treating ADHD in the classroom, but the studies establishing these interventions generally contrast one of the treatments against a no-treatment or placebo control, rather than head-to-head comparisons of each other and their combination. This is problematic because the questions of practical importance to schools go beyond mere demonstrations of acute treatment efficacy. Critical questions concern how behavior modification and stimulant medication treatments compare to one another and how they might be best combined to promote positive classroom outcomes—two questions that currently have received relatively little attention in the literature.

Behavioral approaches in the classroom typically involve working with teachers to modify antecedents (e.g., commands, establish rules and behavioral expectations) and consequences (e.g., rewards for meeting behavioral expectations, punishments following proscribed behaviors) of targeted behaviors (DuPaul & Stoner, 2003). Behavior modification has long been the cornerstone of effective classroom management (Alberto & Troutman, 2003; Horner, Sugai, Todd, & Lewis-Palmer, 2000; Schloss & Smith, 2003; Stage & Quiroz, 1997; Walker et al., 2003–2004). Classroom management approaches vary from relatively nonintensive techniques (e.g., ignoring minor inappropriate behaviors) to more potent programs (e.g., response cost). Pelham and Murphy (1986) defined *clinical behavior therapy* (e.g., training teachers to administer clear commands, to use contingent praise, to establish a school-based daily report card with home rewards), which is typically implemented in general education classrooms via teacher consultation, as a less intensive approach (i.e., lower dose); in contrast, *contingency management* strategies (e.g., token economies) were defined as high-intensity approaches more frequently used in special educational settings. Both clinical behavior therapy and contingency management approaches appear to be acutely effective interventions for children with ADHD in the classroom setting (DuPaul & Eckert, 1997; Pelham & Fabiano, 2007; Pelham, Wheeler, & Chronis, 1998).

Only a few single-case design studies have compared the relative effects of clinical behavior therapy versus contingency management in classroom settings. Small-*N*, single-subject studies conducted 40 years ago demonstrated that increasing intensities (e.g., doses) of behavior modification resulted in improved effects for general classroom management (e.g., Madsen, Becker, & Thomas, 1968; O'Leary, Becker, Evans, & Saudargas, 1969). More recently, a few single-case studies (e.g., Abramowitz, Eckstrand, O'Leary, & Dulcan, 1992; Atkins, Pelham, & White, 1989; Hoza et al., 1992; Northup et al., 1999) demonstrated similar effects with children diagnosed with ADHD. Such studies are important because contingency management approaches are more complex and staff or time intensive, requiring higher costs. If a lower intensity, clinical approach is effective, then a more costly one and one arguably less likely to be implemented in school settings can be avoided. Studies directly comparing lower and higher "doses" of behavior therapy with ADHD children in school settings are needed.

In addition to behavioral approaches, pharmacological interventions with stimulant medication are also widely employed in schools to treat ADHD (e.g., Rowland et al., 2002; Wolraich, Hannah, Baumgaertel, & Feurer, 1998). Over the past several decades, many studies have reported significant acute effects of stimulant medication in regular classroom and analogue settings (Conners, 2002; Greenhill & Ford, 2002). These studies have shown that medication acutely improves on-task behavior, disruptive behavior, and seatwork productivity. However, these studies also have limitations. First, despite the large number of studies, there are relatively few dose–response studies in classroom settings (e.g., Carlson, Pelham, Milich, & Dixon, 1992; Evans et al., 2001; Rapport et al., 1982), with individualized titration being more widely used, particularly in recent years (e.g., Pelham et al., 2001; Wolraich et al., 2001). Further, the range of doses typically varies between moderate and high doses (e.g., 0.30–0.75 mg/kg), only rarely focusing on lower doses that might have fewer risks of side effects (Pelham, Bender, Caddell, Booth, & Moorer, 1985; Werry & Sprague, 1974). Further, there is a lack of measurement consistency across different study designs, with between-group studies generally relying on behavior rating scales of symptoms, and crossover and single-subject design studies using more ecologically valid measures of functioning, such as observations of classroom behavior and percentage of seatwork assignments completed (Fabiano et al., 2007). This heterogeneity of measures is problematic because intervention effects often vary across measures (e.g., Multimodal Treatment Study of ADHD [MTA] Cooperative Group, 1999). A reliance on a single type of measure (e.g., symptom rating scales, classroom observations) may limit the conclusions that may be reached on a treatment's effectiveness; it may bias a study toward favoring a particular treatment (e.g., ADHD symptom rating scales are more likely to identify medication-related improvements).

A key question regarding treatment for ADHD is that of the relative effects of these two treatment modalities in classroom settings, and the literature examining this question to date is limited by several factors. First, the relative doses or intensities of the compared treatments influences the results of the studies. For example, single-subject studies (Gulley et al., 2003; Northup et al., 1999) that use contingency management approaches in analogue classroom settings reveal very large and comparable effects of the two modalities. For example, Northup illustrated how time-out was equal to or more effective than medication for four children with ADHD in an analogue classroom. In contrast, a recent, prominent, multisite, clinical trial employed a clinical behavioral approach in natural classroom settings, and has been interpreted as indicating that behavior therapy was not effective relative to medication (MTA Cooperative Group, 1999). However, these results are limited for several reasons, including the discontinuation of the behavioral treatment months before end-point assessments were collected (Pelham, 1999). Further, no studies beyond a few single-case studies compare multiple intensities or doses of behavioral and combined treatments—that is, the relative dose–response curves of the two modalities.

A handful of single-subject studies have attempted to address these limitations by comparing multiple intensities of stimulant medication and behavior modification, including school-based case studies (Atkins et al., 1989; Rapport, Murphy, & Bailey, 1982) and studies of treatment effects in analogue classroom settings using contingency management approaches (Abramowitz et al., 1992; Hoza et al., 1992; Northup et al., 1999). These studies indicated that high-dose behavior modification (e.g., token economy with response cost) approximates the effectiveness of moderate doses of medication alone. However, the definitions of low- and high-intensity behavior modification vary widely across studies (e.g., time-out vs. reprimands in one study, immediate reprimands vs. delayed reprimands in another), making generalization to other studies difficult. Further, prior studies have used different doses of medication, uniformly failing to use a wide range of medication dosages, again limiting generalizability.

Finally, a small number of studies have examined the single, comparative, and *combined* effects of behavioral and pharmacological treatments in analogue classroom settings. Four larger, within-subject design studies with sample sizes ranging from 16 to 31 have investigated the effects of a single dosage of behavioral treatment combined with multiple medication doses in an analogue classroom within the context of a summer treatment program (STP) setting (Carlson et al., 1992; Kolko, Bukstein, & Barron, 1999; Pelham et al., 1993; Pelham, Burrows-MacLean et al., 2005). These studies suggest four general conclusions: (a) the single effects of behavior modification and stimulant medication in the classroom are substantial; (b) combining a moderate dose of stimulant medication (e.g., 0.30 mg/kg) with behavior modification approximates the effect of a high dose of medication alone; (c) significant improvement in behavior occurs at moderate doses of medication, with relatively little clinically significant improvement obtained with increasing doses; and (d) the effects of single and combined treatments vary across settings, domains, and sources of measurement. Notably, none of these studies manipulated the intensity of the behavior modification procedures, and none used low doses of medication, limiting the conclusions that can be reached regarding the combined effects of the treatments.

In summary, behavior modification, stimulant medication, and their combination are established as efficacious treatments for ADHD in classroom settings. Currently, there is little information on the appropriate doses of each single treatment needed, in what combination, for improving behavior in important functional domains in the classroom. The present study addresses these limitations by investigating the single and combined effects of multiple intensities of behavior modification and stimulant medication treatment in an analogue classroom setting using multiple measures of classroom functioning.

Method

Design

The current investigation consisted of two within-subjects factors: behavior modification (no behavior modification, NBM; low-intensity behavior modification, LBM; and high-intensity behavior modification, HBM) and medication (placebo, 0.15, 0.30, and 0.60 mg/kg methylphenidate [MPH] three times per day [t.i.d.]). Behavioral treatment was varied in 3-week blocks with the order of the three conditions randomized by group of children. Medication was randomly assigned within each child and varied daily during a 9-week STP.

Participants

Forty-four boys and four girls between the ages of 5 and 12 years entered the investigation. All participants were enrolled in the 2002 STP for children with ADHD conducted at the State University of New York at Buffalo. Participants were recruited using multiple methods including referrals from schools, physicians, and mental health agencies, radio advertisements, and mailings. Participants were required to meet *Diagnostic Statistical Manual* (4th ed.) diagnostic criteria for ADHD (American Psychiatric Association, 1994), to have an estimated full-scale IQ of at least 80, and to have no documented adverse response or nonresponse to MPH. ADHD diagnostic procedures were consistent with an evidence-based approach, including parent and teacher ratings, parent semistructured interviews, and ratings of psychosocial impairment (Pelham, Fabiano, & Massetti, 2005). Parents and children provided informed consent and the State University of New York at Buffalo Health Sciences Institutional Review Board approved the protocol. The sample was 79% Caucasian and 21% African American, Hispanic, Native American, or mixed race. Table 1 presents descriptive and diagnostic information on the sample.

One child's parents elected to stop medication for their child after 2 days because of their concerns about possible side effects of the medication; this child is not included in the analyses. One child's 0.60 mg/kg late-afternoon dose was reduced because of side effects (this change does not affect the analyses). The remainder of the participants (n = 46) had complete data.

Setting

The investigation took place in the context of the STP (Pelham, Fabiano et al., 2005; Pelham, Greiner, & Gnagy, 1998; Pelham & Hoza, 1996). The STP lasted 9 hr Monday through Friday and was conducted for 9 weeks. Children spent 2 hr in academic settings and the remainder of the time in group recreational activities (skill drills, games, swimming, and art).

Table 1
Means and Standard Deviations for Participant Characteristics

Item	*M*	*SD*
Age, years	9.35	1.98
Estimated full-scale IQ[a]	106.33	14.61
Reading achievement[b]	98.88	13.39
Arithmetic achievement[b]	101.90	14.17
Spelling achievement[b]	97.27	13.26
DSM-IV items endorsed by parents or teachers		
Inattention	8.5	0.9
Hyperactivity/Impulsivity	7.5	2.0
Oppositional/Defiant	5.2	2.4
Conduct Disorder	1.6	1.6
IOWA Conners Parent Rating Scale Inattention/Overactivity[c]	10.33	2.96
IOWA Conners Parent Rating Scale Oppositional/Defiant[c]	7.52	4.74
IOWA Conners Teacher Rating Scale Inattention/Overactivity[c]	10.25	3.75
IOWA Conners Teacher Rating Scale Oppositional/Defiant[c]	5.35	4.39
Disruptive Behavior Disorders Parent Rating Scale[d]		
ADHD	2.05	0.59
Oppositional/Defiant	1.28	0.61
Conduct Disorder	0.28	0.24
Disruptive Behavior Disorders Teacher Rating Scale[d]		
ADHD	1.87	0.65
Oppositional/Defiant	0.96	0.69

Note. IQ and achievement scores included in this table are standard scores. Symptom means are presented as raw scores. DSM-IV = *Diagnostic Statistical Manual* (4th ed.); ADHD = attention deficit hyperactivity disorder.
[a] IQ scores were estimated from vocabulary and block design subtests of the Wechsler Intelligence Scale for Children—3rd ed. (1991).
[b] Weschler Individual Achievement Test (The Psychological Corporation, 1991).
[c] Loney & Milich (1982).
[d] Pelham, Gnagy, Greenslade, and Milich (1992).

Children were placed in groups of 12 according to age. They were supervised in recreational settings by five students who were either undergraduates or graduates, and a teacher and an aide in academic settings, all of whom were trained and supervised by permanent staff members. Each group participated in activities using the same schedule for the entire program duration. This article summarizes the results from the classroom setting (see Burrow-MacLean et al., 2003, and Pelham et al., 2003, for the results of the recreational and home settings). During the classroom period, children worked on individual seatwork assignments in the areas of reading, math, and language arts for 30 min; peer tutoring activities in reading (Fuchs, Mathes, & Fuchs, 1993) for 30 min; and individualized computer assignments for 30 min. This article contains information collected during the 30-min seatwork period of the classroom. The three behavioral conditions are outlined in the sections that follow. In all behavioral conditions, children could be suspended or sent home for severely aggressive or disruptive behavior that would endanger any child or staff member.

Each classroom was staffed with a teacher and an aide, and there were four teacher–aide pairs in all (two pairs worked with two different classes whereas the other two pairs worked with a single class). The teachers were all women: one was a certified special education teacher with 5 years of teacher experience, one was a graduate from a bachelor's program in elementary and special education, and the other two were graduates of a psychology program with bachelor's degrees. The aides were three women and a man, who were advanced bachelor's degree in psychology students or recent graduates.

HBM

In the HBM condition, all standard STP behavioral treatments were implemented, and their descriptions follow.

Classroom rules. There were standard classroom rules (e.g., "Be Respectful of Others," "Stay on Task") and structure for each activity (e.g., children were seated at individual desks in rows for seatwork). Classroom rules were reviewed each day at the beginning of the activity, and were integrated into the following point system.

Point system. A reward and response cost point system was implemented in the classroom. Children began each class with a "bank" of 100 points, and they lost 10 points for each rule violation. Children earned 25 points for each seatwork assignment they completed, and they earned an additional 25 points if the assignment was completed accurately. Children were awarded bonus points for having few rule violations and completing at least two of the three assignments accurately. Each time a classroom rule was violated, children received feedback from staff by labeling the behavior and informing the child of a point loss (e.g., "You lose 10 points because you are out of your assigned seat."). Children also received feedback in the form of labeled praise, and points were awarded for appropriate behavior (e.g., "Terrific job completing your math assignment accurately, you earn 25 points for completion and 25 points for accuracy.") Point losses and awards were recorded on a public point board. Points earned in the classroom contributed to the child's weekly total, which was required to participate in an end-of-the-week field trip (e.g., barbeque, video game party).

Time-out. Time-out procedures with escalation for inappropriate behavior, time reductions for appropriate behavior, and contingent release components (i.e., must be behaving appropriately before the time-out is ended) were used when children exhibited aggressive, destructive, or defiant behavior (Fabiano et al., 2004).

Social reinforcement and social honors. Praise and social reinforcement were provided liberally to children who behaved appropriately. Children earned daily social rewards (buttons and accompanying privileges) for high point totals and improvements. Stickers were awarded in the classroom to children who exhibited low levels of rule violations and completed their work. Children who exhibited exemplary behavior throughout the entire program day earned "honor roll" status, which conferred additional privileges (e.g., helping the teacher pass out materials, access to special school supplies).

Daily report cards. Children received daily report cards (DRCs) evaluating their performance on individualized target behaviors (O'Leary, Pelham, Rosenbaum, & Price, 1976), including targets in the classroom setting and recreational settings. Children gained access to a daily postlunch and end-of-the-day recess period by attaining 75% of possible goals on their DRC. DRCs were reviewed with parents at the end of the day, and parents were instructed in parent training classes how to provide daily and weekly home-based rewards contingent on positive DRC performance.

Classroom recess. After each segment of the classroom, children were allowed to participate in a 5-min in-class recess period contingent on their meeting DRC goals. Children who did not earn recess completed individualized seatwork assignments at their desks.

Individualized behavioral programs. After the first week of the HBM condition, if the standard procedures were not sufficient to produce the desired behavioral changes, consistent with procedures operationalized in the

STP manual (Pelham, Lang et al., 1998), individualized behavioral programs were developed in which behavioral consequences were modified or increased in intensity. Individualized programs were implemented for 21% of participants (n = 10). Programs typically targeted academic seatwork completion, rule-following behavior, or both. They were developed within the treatment team based on a functional behavioral assessment of the child's problematic behavior. For example, a student who exhibited high rates of negative behaviors in an apparent effort to avoid seatwork (i.e., to be placed in time-out during seatwork) had an individualized behavior program wherein time-out was suspended during the academic period, and the minutes of time-out obtained during the class were served during the swimming period, a preferred activity.

LBM

In the low-intensity condition, the basic structure and treatment components remained similar to the HBM condition. Modifications to treatment components follow.

Classroom rules. Classroom rules were reviewed each day at the beginning of the activity, but children did not lose points for breaking activity rules (they received feedback only).

Point system. The point system was not in place during the LBM weeks. The same behavioral rules applied, but children received feedback only, without earning or losing points (e.g., "You broke the rule of 'Be Respectful' by talking back to an adult."). Teachers recorded the frequency of rule violations on a clipboard, and did not publicly post rule violations in the classroom.

Time-out. Rather than the time-out procedure, fixed-length sit-outs (2.5, 5, or 10 min, based on age), without a contingent release component based on appropriate behavior, were used when children exhibited aggressive, destructive, or defiant behavior.

Social reinforcement and social honors. Praise and social reinforcement were provided liberally to children who behaved appropriately. A consequence of appropriate classroom behavior, such as completing work accurately, was labeled praise (e.g., "Excellent work on your math assignment today, you completed the whole paper accurately!"). Stickers were awarded at the end of class to children who exhibited low levels of rule violations and completed their work. Children earned daily social rewards (buttons, but without accompanying privileges) for appropriate behavior (i.e., three or fewer classroom rule violations) and improvements. There was no honor roll.

DRCs. Children received DRCs as in the HBM condition. However, parent-provided rewards were administered on a weekly basis rather than a daily one.

Classroom recess. Classroom-based recess was awarded noncontingently.

NBM

In the NBM condition, the behavior modification system was suspended to emulate a typical camp–classroom setting. The structure and content of the activities remained the same. The same behavioral rules applied, but children received feedback about their rule violation only, without earning or losing points. Children did not receive DRCs and time-out procedures were not used. Social reinforcement was given infrequently, and children earned classroom recess and other rewards noncontingently.

Random orders of behavioral treatments were created for the 3 years of the project. The children in the present study were grouped according to age (Group 1 included the youngest up to the oldest in Group 6) in six groups and the specific orders were 1: LBM, HBM, NBM; 2: NBM, HBM, LBM; 3: NBM, LBM, HBM; 4: HBM, NBM, LBM; 5: HBM, LBM, NBM; and 6: LBM, NBM, HBM.

Medication Assessment

The medication assessment procedure was a double-blind, within-subject evaluation of placebo and three doses of immediate-release MPH: 0.15, 0.30, and 0.60 mg/kg per dose (Pelham, 1993; Pelham, Burrows-MacLean et al., 2005). Average doses were 5.30 mg (range = 2.5–10), 10.8 mg (range = 5–20), and 21 mg (range = 12.5–30) for the three conditions, respectively. All doses were administered on a t.i.d. schedule, at 7:45 a.m., 11:45 a.m., and 3:45 p.m. Drug conditions varied on a daily basis, and were randomized so that each child received each drug condition at least once each week. Because there were 15 days within each behavioral treatment condition, the placebo, 0.15, and 0.30 conditions were repeated 4 times within each behavioral condition, and the 0.60 condition was repeated 3 times. The classroom seatwork period was scheduled to occur at least 30 min after the child ingested either the morning or afternoon dose. The children, their parents, and all clinical staff members were blind to medication condition. The medical director could unblind medication conditions in cases of severe side effect reports.

Dependent Measures

Classroom rule violations. Each instance of a classroom rule violation was counted across the study conditions (in the LBM and NBM conditions, all behaviors were recorded, although children did not earn and lose points). The STP rule categories have been used in numerous studies to measure treatment effects, and they evince reliability and validity (Pelham, Fabiano, & Massetti, 2005). For the purposes of the analyses, rule violations were combined to form a single measure of the frequency of classroom rule violations.

An independent observer (GAF) collected reliability data by watching three children in a group for the classroom period, independently classifying and recording rule violations for those children. Observations were sampled across groups and days, for 20% of the available observations. Reliability was determined by using the formula suggested by Kazdin (1982). Specifically, a frequency ratio was calculated by dividing the smaller frequency total collected by the larger frequency total and multiplying by 100%. Aggregating across rule violation categories, the frequency ratio ranged from 61% to 100% for each class (M = 84%; SD = 15). Although this particular method of calculating reliability has an inherent limitation because of an inability to determine whether the actual rule violations recorded were the same between the observer and teacher, the results of the reliability procedures support the reliable collection of rule violation data. As another estimate of reliability, mean observer–teacher differences ranged from 0 to 2.71 across rule violation categories.

Seatwork completion. The percentage of seatwork completed each day was calculated and used as a dependent measure. Seatwork completed was defined as the number of items completed divided by the total number of items assigned multiplied by 100%. Seatwork accuracy was not analyzed as an outcome because seatwork levels were established so that the child could complete approximately 80–100% of the problems accurately, and accuracy means ranged from 80% to 94% across conditions.

Symptom ratings. Each day, teachers completed a rating scale that included the items from the IOWA Conners Rating Scale (Loney & Milich, 1982). The 5-item Inattention/Overactivity factor and 5-item Oppositional/Defiant factor were used as dependent measures. These factors have been shown to relate to longer measures of ADHD and oppositional defiant disorder or aggressive symptoms, and are sensitive to treatment effects (Pelham, Fabiano, & Massetti, 2005). For all analyses, the sum score on each factor was used.

Effectiveness and stress ratings. Each day, teachers completed ratings of the stress of interacting with the children and the effectiveness of their interactions with the children. These ratings ranged from 0 (*not at all*) to 6 (*very much*). Similar questions have been shown to discriminate between parental interactions with normal and deviant children (Pelham, Lang et al., 1998) and to detect medication (Chronis et al., 2003) and behavior modification (Chronis et al., 2004) effects.

Impairment ratings. Each day, teachers completed items from the teacher Impairment Rating Scale (Fabiano et al., 2006). These items asked about how the child's problems affected his or her relationship with the teacher and the overall classroom functioning. Scores ranged from 0 to 6, with higher scores indicating greater impairment. For all analyses, raw scores were used. The Impairment Rating Scale has demonstrated appropriate levels of internal consistency and temporal consistency, and validational studies indicate concurrent, convergent, and discriminant validity (see Fabiano et al., 2006, and Evans, Allen, Moore, & Strauss, 2005, for more information).

Side effects. Teachers completed the Pittsburgh Side Effects Rating Scale daily (Pelham, 1993), and study staff monitored the ratings for clinically significant adverse events. The rating scale contains 12 items that represent the most common stimulant-related side effects. Raters are instructed to record whether each side effect was not present or occurred at mild, moderate, or severe levels. The average report of moderate or severe side effects across days in each medication condition (regardless of behavior modification condition) served as a dependent measure.

Treatment Integrity and Fidelity

All staff attended a week-long training that included didactic instruction, role-plays, large-group instruction, and practice with online feedback for specific treatment components (e.g., how to administer and monitor a time-out in LBM and HBM; how to administer the suspension procedure in NBM). Staff took weekly quizzes to monitor knowledge of procedures and point system classification.

Classroom behavioral procedures were monitored using treatment integrity and fidelity procedures as outlined in the STP manual (Pelham, Greiner, & Gnagy, 1998). Each class was observed once a week by the first author and a treatment integrity and fidelity form was completed, yielding observations on 20% of class days. Each treatment integrity form included a checklist of prescribed (e.g., children were costed points in the HBM condition for each rule violation and these were marked on a public point board) and proscribed (e.g., rules were not reviewed or posted during the NBM condition) intervention components (Waltz, Addis, Keorner, & Jacobson, 1993). In addition, three randomly selected students were observed in each class. The observer recorded the number of commands issued individually to the children, the number of negative behaviors the children exhibited, and the number of praise statements directed toward the children. The number of commands and praise statements directed toward the entire class were also recorded. The ratio of positive to negative behaviors in each condition was calculated by dividing the number of instances of social reinforcement by the total number of negative behaviors plus commands. Staff members were given immediate feedback on their performance and their adherence to each of the three behavioral treatment conditions.

The medication manipulation was also implemented as intended. To ensure accurate pill administration, two staff members independently verified that the correct pill was administered, and both verified that the child swallowed the pill. In the few instances in which a child arrived too late to receive a dose on time, data from that day were not included in the following analyses.

Results

Manipulation Check

Treatment integrity and fidelity checklists indicated that on average 98.6% of intervention procedures were implemented as intended (range = 84–100%). In the NBM condition the ratio of positive to negative behaviors was 0.43 (SD = 0.47). This ratio was 3.59 (SD = 2.58) in the LBM condition and 5.78 (SD = 4.33) in the HBM condition, supporting the integrity of the classroom interventions. The medication manipulation was also implemented as intended.

Treatment Outcome Analyses

For all analyses, a 4 (medication: placebo, 0.15, 0.30, 0.60 mg/kg) × 3 (behavior modification [BMOD]: NBM, LBM, HBM) repeated-measures multivariate analysis of variance was performed in the SPSS general linear model. Orthogonal contrasts were used to detect differences among increasing dosages of both BMOD and medication. Where significant Medication × BMOD interactions were found, simple effects tests were performed within each level of each treatment to test for effects of the other treatment, and pairwise tests were conducted within each level of treatment with alpha set at .05 (e.g., placebo–drug differences were examined within the three levels of BMOD).

Classroom Rule Violations and Academic Productivity

On the behavioral measures, there were significant main effects of BMOD [$F(4, 182) = 7.78$, $p < .001$]. The linear component tests were significant ($p < .001$) for both measures; quadratic components of the orthogonal contrasts were significant ($p < .002$) for classroom rule violations. There was also a significant main effect of medication [$F(6, 274) = 24.21$, $p < .001$]. Orthogonal tests showed both linear and quadratic effects ($p < .007$) for all measures.

The interaction between the two factors was statistically significant [$F(12, 550) = 3.66$, $p < .001$]. Results of this analysis are presented in Table 2, and the results for seatwork rule violations and percentage of seatwork completed in each condition are displayed in Figure 1.

Simple effects tests showed that BMOD had significant effects at all levels of drug and that drug had significant effects at all levels of BMOD ($p < .05$). To further examine the interaction, pairwise tests of all combinations were examined. These comparisons showed that, in general, as dose of medication increased there were no differences between the LBM and HBM conditions (both conditions remained significantly different from NBM, however, $p < .05$). In general, dose–response curves of medication flattened as the dose of behavior modification increased. For classroom rule violations, when NBM was implemented, all drug conditions were significantly different from placebo, and 0.60 mg/kg was significantly different from the lower two doses. When LBM was implemented, the difference between placebo and 0.15 mg/kg was no longer significant, and 0.60 mg/kg was significantly different from 0.30 mg/kg but not 0.15 mg/kg. At the level of HBM, all medication conditions were significantly different from each other with the exception of 0.15 and 0.30 mg/kg. A different pattern emerged for the seatwork completion measure, however. When LBM and HBM were implemented, medication conditions were significantly different from placebo ($p < .05$), but not each other, indicating no significant incremental effect of medication past 0.15 mg/kg when behavior modification was used.

Teacher Ratings

On the teacher ratings, there were significant main effects of BMOD [$F(12, 174) = 4.47$, $p < .001$]. The linear component tests were significant ($p < .002$) for all measures; quadratic components of the orthogonal contrasts were significant ($p < .05$) for all ratings except teacher ratings of stress ($p < .08$) and ratings on the IOWA Oppositional/Defiant scale ($p < .07$). There was also a significant main effect of medication [$F(18, 377) = 6.95$, $p < .001$]. Orthogonal tests showed both linear and quadratic effects ($p < .002$) for all measures.

The interaction between the two factors was significant [$F(36, 1193) = 1.95$, $p < .01$]. Results of this analysis are presented in Table 2.

Simple effects tests showed that BMOD had significant effects at all levels of drug and that drug had significant effects at all levels of BMOD. To further examine the interaction, pairwise tests of all combinations were examined. Similar to the classroom rule violation measure, these comparisons showed that, in general, as dose of medication increased there were generally no differences among the LBM and HBM conditions (both conditions remained significantly different from NBM,

Table 2
Means and Standard Deviations for Behavioral Measures and Teacher Ratings

	Placebo			0.15 mg/kg MPH			0.30 mg/kg MPH			0.60 mg/kg MPH		
	NBM	LBM	HBM	NBM	LBM	HBM	NBM	LBM	HBM	NBM	LBM	HBM
Measure	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Frequency of rule violations	45.11 (65.74)	11.90[a] (26.56)	6.35[a] (11.27)	22.02 (45.82)	4.88[a] (16.91)	1.90[a] (3.68)	14.14 (33.60)	2.00[a] (4.98)	0.94[a] (1.58)	8.12 (32.64)	0.55 (1.11)	0.43 (0.85)
Percentage of seatwork completed	0.45 (0.25)	0.53[a] (0.24)	0.57[a] (0.23)	0.61 (0.24)	0.69 (0.21)	0.71[a] (0.19)	0.53 (0.24)	0.72[a] (0.19)	0.75[a] (0.17)	0.65 (0.23)	0.73[a] (0.20)	0.74[a] (0.18)
Iowa I/O rating	5.86 (4.68)	3.68[a] (3.85)	3.10[a] (2.88)	3.17 (3.54)	1.59[a] (2.34)	1.32[a] (1.53)	1.98 (2.69)	1.17[a] (2.01)	0.82[a] (1.04)	1.40 (2.46)	0.50[a] (0.77)	0.47[a] (0.78)
Iowa O/D rating	1.68 (2.30)	0.85[a] (1.41)	0.59[a] (0.75)	0.87 (1.52)	0.23[a] (0.63)	0.25[a] (0.49)	0.50 (1.09)	0.24 (0.61)	0.11[a] (0.23)	0.40 (1.22)	0.10 (0.43)	0.04[a] (0.14)
Teacher stress rating	1.77 (1.59)	1.21[a] (1.36)	0.93[a] (0.91)	1.01 (1.18)	0.65[a] (0.84)	0.49[a] (0.50)	0.79 (0.93)	0.49[a] (0.67)	0.37[a] (0.39)	0.59 (0.81)	0.32[a] (0.39)	0.30[a] (0.29)
Teacher effectiveness rating	1.97 (1.47)	1.31[a] (1.14)	1.21[a] (0.93)	1.24 (1.09)	0.89[a] (0.89)	0.80[a] (0.62)	1.04 (0.98)	0.79[a] (0.76)	0.66[a] (0.55)	0.89 (0.93)	0.61[a] (0.57)	0.56[a] (0.46)
IRS teacher	2.10 (1.84)	1.15[a] (1.15)	1.08[a] (1.04)	1.26 (1.33)	0.58[a] (0.82)	0.47[a] (0.59)	0.87 (1.02)	0.52[a] (0.74)	0.35[a] (0.48)	0.69 (1.03)	0.26[a] (0.39)	0.22[a] (0.29)
IRS classroom	1.97 (1.93)	1.00[a] (1.18)	0.98[a] (1.05)	1.19 (1.39)	0.60[a] (0.88)	0.41[a] (0.57)	0.85 (1.12)	0.47[a] (0.74)	0.30[a] (0.41)	0.67 (1.04)	0.24[a] (0.39)	0.16[a] (0.23)

Notes. MPH = methylphenidate; NBM = no behavior modification; LBM = low behavior modification; HBM = high behavior modification; I/O = Inattentive/Overactive; O/D = Oppositional/Defiant; IRS = Impairment Rating Scale.
[a] Different from NBM at this drug level.
[b] Different from LBM at this drug level.

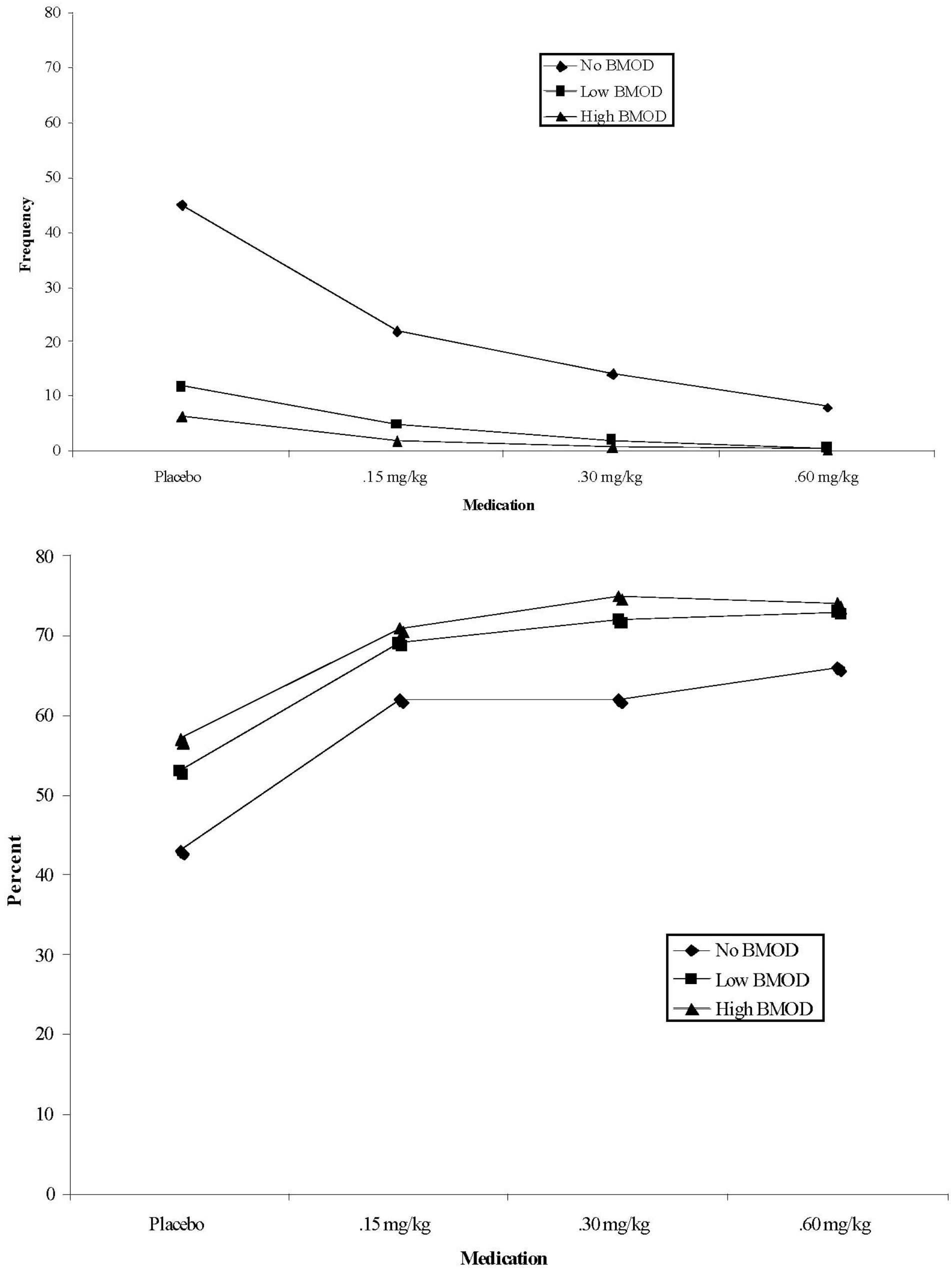

Figure 1. Graphs of classroom behavior measures. The top panel illustrates frequency of classroom rule violations at each level of behavior modification and medication and the bottom panel represents percentage of assigned seatwork completed at each level of behavior modification and medication. BMOD = behavior modification.

however). When the teacher ratings of each level of medication across BMOD conditions were considered, the pattern of tests indicated medication was significantly different from placebo and the individual doses were different from one another when NBM was implemented ($p < .05$). When LBM and HBM were implemented, medication conditions were all significantly different from placebo ($p < .05$), but the pattern of results indicated there were fewer significant differences between the active medication conditions. Interestingly, however, there were more significant differences than for the objective rule violation and seatwork completion measures reported above.

Effect Sizes

To examine the magnitude of treatment effects, effect sizes were computed for each child for the measures of classroom rule violations and seatwork completion. Effect sizes were computed between each of the 11 treatment combinations and the NBM placebo (no treatment) condition. Effect sizes were computed within child by taking the mean difference between the two conditions and dividing by the no-treatment standard deviation (Pelham et al., 1993).

Figure 2 illustrates the mean effect size averaged across children for each of the 11 active treatment conditions for the measure of classroom rule violations and seatwork completion. As the top panel of Figure 2 shows, all effect sizes for classroom rule violations were in the moderate to very large range, and effect sizes for the HBM condition are comparable to those we have previously reported in the STP classroom setting (Pelham et al., 1993). Results were comparable for the measure of seatwork completion, although the effect sizes were generally larger in magnitude. Differences between average effect sizes for each combination of treatment were analyzed using pairwise comparisons. Because of the large number of tests conducted, significance levels were corrected using Bonferroni-correction procedures (.05/55 tests = .0009). Results for the analyses for rule violation effect sizes indicated LBM alone was significantly less effective than 0.60 + LBM, 0.15 + HBM, 0.30 + HBM, and 0.60 + HBM. The dose of 0.15 mg/kg MPH was significantly less effective than 0.60 + LBM, 0.15 + HBM, 0.30 + HBM, and 0.60 + HBM. None of the other conditions differed from one another. For the effect sizes calculated from seatwork completion data, at Bonferroni-corrected alpha levels, none of the conditions differed from one another.

Side Effects

Ratings from the Pittsburgh Side Effects Rating Scale were averaged across days within drug condition (regardless of BMOD condition) for the 47 children. As previously noted, one participant's medication was discontinued because of parental concerns about side effects (mainly buccal-lingual movements) after 2 days of treatment, and one child's afternoon dose was reduced on the 0.60 mg/kg days because of parent-reported anxiety and mood symptoms. No other children had side effects rated by the teacher at an average level of moderate or severe.

Discussion

The results of this study have important implications for the classroom-based treatment of children with ADHD. Unlike other studies in which the dosages of behavior modification or stimulant medication were limited, not compared, or not combined, this study is one of the first to investigate in a classroom setting the effectiveness of varying intensities of *both* behavior modification and MPH alone, in comparison to one another, and in combination. Results supported the effectiveness of behavior modification, stimulant medication, and their combination in the classroom setting. The single and comparative effects of each treatment, the effectiveness of combined treatment, and the clinical implications, will be discussed in turn.

Behavior Modification

This study used a NBM, a LBM, and a HBM condition. The NBM condition was designed to approximate a classroom setting with minimal contingency management (ex-

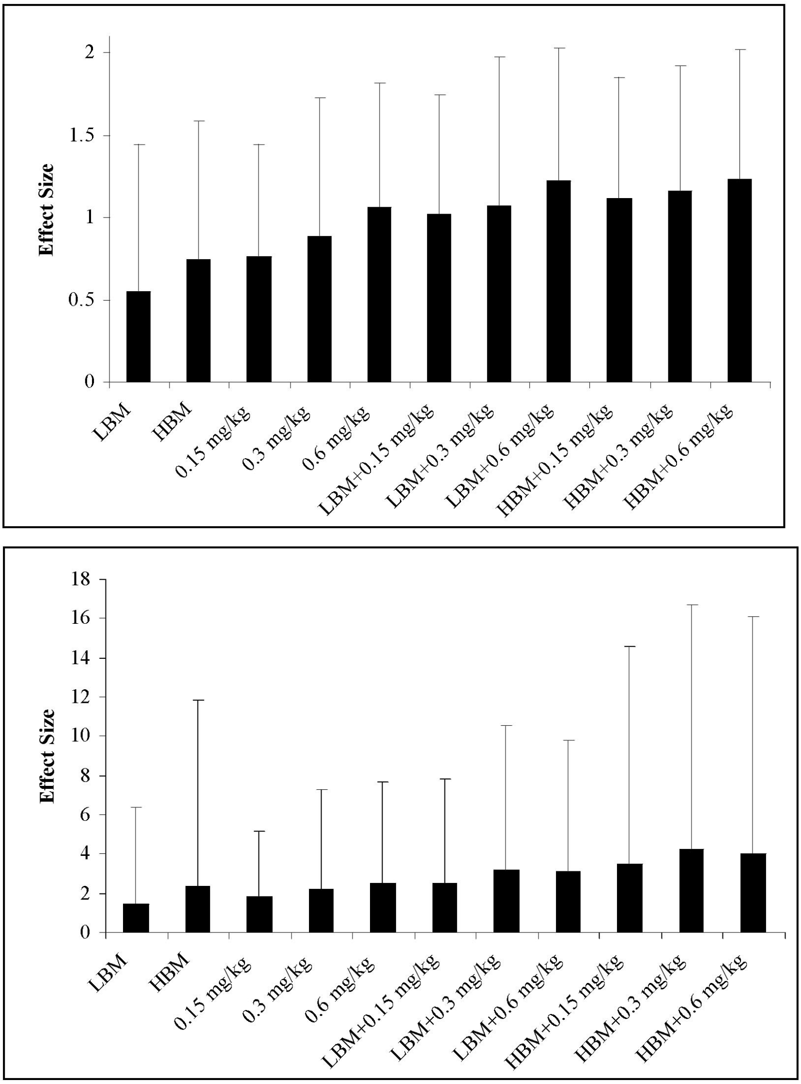

Figure 2. Graph of effect sizes. The top panel displays the effect sizes for the measure of classroom rule violations, and the bottom panel displays the effect sizes for seatwork completion. *Note:* Effect sizes were calculated by subtracting the mean number of rule violations in each condition from the mean number of rule violations in the no behavior modification + placebo condition and dividing by the standard deviation of the no behavior modification + placebo condition. LBM = low behavior modification; HBM = high behavior modification; 0.15 mg/kg = 0.15 mg/kg methylphenidate; 0.3 mg/kg = 0.30 mg/kg methylphenidate; 0.6 mg/kg = 0.60 mg/kg methylphenidate.

cept for serious, negative behaviors). The LBM condition used simple behavioral techniques (e.g., a DRC with weekly rewards, sit-outs), and HBM used the well-established STP procedures (Carlson et al., 1992; Chronis et al., 2004; Pelham, Burrows-MacLean et al., 2005; Pelham, Fabiano et al., 2005; Pelham et al., 1993). The main effect of behavior modification indicated the behavior modification procedures used in the study were superior to the NBM condition. LBM and HBM procedures resulted in substantial improvement in classroom rule violation frequency (effect size = .55 and .74, respectively). Likewise, LBM and HBM procedures resulted in significant improvement in academic productivity.

The results of the academic productivity measure indicated that adding a behavioral treatment component resulted in the completion of 15–21% more seatwork compared to baseline functioning without a reduction in accuracy. Because academic achievement is dependent on the amount of time spent completing academic tasks (e.g., Berliner & Rosenshine, 1977), these results suggest the addition of a behavioral intervention would result in substantial increases in academic output across a school year. These results are consistent with many other studies with children with ADHD that demonstrate improved seatwork completion with the addition of behavior modification procedures (e.g., Pelham, Burrows-MacLean et al., 2005; Pfiffner & O'Leary, 1987). Currently, there are no studies that demonstrate behavior modification effects on long-term academic achievement (e.g., MTA Cooperative Group, 1999), but these results suggest that behavior modification procedures sustained over years may show promise in this regard.

The effect sizes indicated that low-intensity behavior modification procedures were generally effective for classroom deportment and seatwork completion with some additional but nonsignificant benefit resulting from HBM (see Figure 1). This is not surprising, given that the LBM procedures approximate those of a regular classroom setting in which the teacher uses behavior modification as a classroom management strategy, a well-established intervention in school settings (Walker et al., 2003–2004). Interestingly, the effect sizes for the LBM and HBM treatment conditions did not significantly differ, indicating that *at a group level*, the less intensive intervention was as effective in improving classroom deportment as the HBM procedure. Additional analyses in this study will investigate potential predictors or moderators of the need for higher dosage behavioral interventions for some children with ADHD in classroom settings.

These results also place other studies of behavior modification in an appropriate context. In this study, the acute effects of behavior modification were substantial, when compared to a condition where all behavior modification procedures were removed. In other studies of behavior modification in natural environments (e.g., MTA Cooperative Group, 1999) study-implemented behavioral treatment may have had less of an effect than medication in the classroom, arguably because high rates of *background* behavior modification present in classrooms (Gottfredson & Gottfredson, 2001; Walker et al., 2003) *minimized* the contrast between manipulations of behavioral interventions or comparisons of behavior modification to a waiting list or community control group.

Medication

The main effect of medication obtained in this study replicated many studies of medication effects in classrooms that illustrate significant beneficial effects of medication (e.g., Connors, 2002; Pelham et al., 2001; Swanson, McBurnett, Christian, & Wigal, 1995). Used alone, medication effects in the classroom were approximately linear for improving classroom rule violations. On the academic productivity measure, children completed between 15% and 31% more seatwork problems when medicated relative to baseline functioning. A 0.15 mg/kg dose of stimulant medication resulted in a substantial increase in work completed, with modest increases obtained with increasing doses, and this dose accounted for 50% of the improvement from medication on the rule violations measure. This is an important finding, as virtually all studies of academic productivity in the classroom used a dose twice as high. The present results show that half (i.e., 0.15 mg/kg) of the standard dose used in most studies (i.e., 0.30 mg/kg) was pharmacologically active and the dose–response curve began to flatten at the 0.30 mg/kg level of medication. Notably, Werry and Sprague (1974) and Pelham et al. (1985)

used a similar low dose many years ago and also reported substantial effects.

Previous studies in the STP classroom setting have reported diminishing returns in improvements in classroom behavior as medication dosage increases (e.g., Evans et al., 2001; Pelham et al., 1999), and this study replicates those findings, with one qualification. When the background classroom setting includes NBM, increasing doses of medication result in increased effects. These results suggest that in prior studies conducted in STP settings, the background behavioral treatments affected the medication effects, such that the dose–response curve was flattened at lower doses (e.g., Pelham et al., 1999) more than would have been the case in the *absence* of behavior modification. Thus, in situations *without* a background of systematically implemented behavior modification, higher doses of medication may be required to obtain acceptable effects.

Comparisons Between Behavior Modification and Medication

Comparisons of effect sizes obtained with each of the treatment conditions yielded interesting outcomes. In general, LBM was equal to other interventions except those that included the highest dose of medication or the HBM condition combined with medication. Likewise, 0.15 mg/kg MPH was equal to other treatments except 0.60 mg/kg combined with LBM or any of the HBM plus medication conditions. Other comparisons between different levels of behavior modification and medication suggest no differences in effectiveness.

Figure 1 illustrates these comparative effects quite convincingly. Both LBM and HBM conditions alone were as good as or better than 0.15, 0.30, and 0.60 mg/kg of MPH alone on measures of classroom rule violations. These results appear to demonstrate that when these treatments are administered without the potential confound of a background behavioral intervention, there is relative equivalence between the two treatment modalities on clinically meaningful classroom-based behaviors. Our use of a NBM condition provides a contact control group for behavior modification that is equivalent to a no-medication condition for evaluating drug effects. These results also suggest that prior studies of comparative effects of behavior modification versus medication in classroom settings may have inadvertently biased results toward medication because background levels of behavior modification may have been present even in the classrooms that did not include study-implemented behavior modification (e.g., Klein & Abikoff, 1997; MTA Cooperative Group, 1999). These results replicate the large effects of behavior modification and medication obtained in single-case design studies (e.g., Abramowitz et al., 1992; Gulley et al., 2003; Northup et al., 1999).

This report is therefore one of the first to provide an unconfounded comparison between behavior modification and medication treatments (see also Kolko et al., 1999; Northup et al., 1999; Pelham, Burrows-MacLean et al., 2005). The results suggest that previous conclusions regarding the comparative effectiveness of these two treatments need revision. For example, a prominent meta-analysis that included a consideration of comparative treatment effects stated, "Despite the limitations of the individual studies, the results indicate consistently that stimulants are more effective than nonpharmacological interventions when compared head-to-head" (Jadad, Boyle, Cunningham, Kim, & Schachar, 1999, p. 5).

The present study indicates the single effects of treatment were generally equivalent to each other. Furthermore, unlike between-group studies included in meta-analyses in which medication was administered during end-point assessments but behavioral interventions were discontinued or faded (e.g., MTA Cooperative Group, 1999; Pelham, 1999), this study provides a more accurate test of the efficacy of each unimodal treatment. This is in contrast to treatment models that include fading behavioral treatments after a specified course of school consultations (e.g., Klein & Abikoff, 1997; MTA Cooperative Group, 1999), and current research on classroom interventions suggests that teachers stop implementing behavioral procedures as intended once consultant contact is reduced or eliminated (Martens & Ardoin, 2002). Thus, given the present results, innovative approaches to classroom consultations need to be developed and evaluated to ensure maintenance of adequate classroom management procedures throughout the school year. Further, researchers who plan and implement clinical trials investigating comparative effects should include end-point assessments in which either both treatments are faded or both treatments are actively implemented. Such designs should reduce the heterogeneity of results that has clouded the ADHD treatment literature for over 30 years.

Combined Behavior Modification and Medication

The results of the combined treatment analyses illustrated multiple interactive effects and a major new finding. For example, LBM combined with a low dose of medication (0.15 mg/kg) was equivalent to a high dose of medication or high behavior modification used alone. Most improvement in combined treatments occurred at the low doses of treatment, with increasing doses of either BMOD or medication resulting in modest improvement. This is particularly true in HBM, where improvement was nearly maximized at the 0.15 mg/kg dose of medication, and this finding needs to be cast in the light of similar studies in which the lowest dose was twice as high—0.30 mg/kg. To obtain the comparable effects across the school day of a low dose of medication combined with a behavioral treatment (on average 10 mg per school day), *four times* as much medication was required (on average 40 mg per school day) if the medication was used alone. This is an important outcome, as higher doses are clearly linked to greater side effects (MTA Cooperative Group, 2004; Pelham et al., 1999).

This study is the first large treatment study (i.e., $n > 10$) to simultaneously manipulate behavioral and medication treatment intensities on multiple levels. The results are provocative—clearly combined treatment yielded positive and clinically meaningful effects in the classroom setting, and the results replicate those of published case studies (Abramowitz et al., 1992; Atkins et al., 1989; Northup et al., 1999). Specifically, a very low dose of medication combined with simple contingency management procedures was as effective as high doses of medication used alone. Further, when combined with low doses of medication, simple behavior modification procedures close to a clinical intervention (e.g., daily report card) appeared to be as effective as more complex contingency management procedures used in the classroom setting.

Limitations

Although these results are promising and serve to extend the literature on treatments for ADHD, the study has limitations. First, the study was conducted in an analogue classroom setting. Although other reports suggest the results obtained in the STP classroom generalize to community classroom settings (Pelham et al., 2002), these results need to be replicated in regular classrooms. Further, the treatments used were of short duration (i.e., the entire study lasted only 9 weeks). Future studies that investigate the effect of these unimodal treatments actively implemented over sustained time periods (i.e., years) are sorely needed. These long-term studies of treatment effectiveness are urgently needed because of the clinical practice of discontinuing behavioral treatments rather than implementing them chronically (i.e., MTA Cooperative Group, 1999). Notably, medication use is also discontinued for most children with ADHD during childhood or adolescence (Meichenbaum, Gnagy, Flammer, Molina, & Pelham, 2001). Because behavior modification is rated as more palatable by parents (Pelham, Erhardt et al., 2007), combining it with low doses of medication may help families to maintain the intervention as long as is needed.

Additional limitations are related to study methods. First, observers and raters were blind to medication conditions, but not to behavior modification conditions. It is possible that the knowledge of the behavioral condition being implemented influenced results.

However, because the pattern of results for objective measures such as the amount of seatwork completed was similar to the ratings, it does not appear that this lack of blindness to the behavioral condition influenced results. Second, because the order of behavioral treatments was not balanced, it cannot be determined whether the age of the child, the order in which behavioral treatments were administered, or both, affected response to the behavioral or combined treatments. However, this report includes results from the first year of a 3-year study. Over the 3 years, order of behavioral treatments was balanced across age of the children in each group, and the results are comparable to those reported herein (Pelham, Gnagy et al., 2007).

Clinical Implications

The results of the combined treatment analyses have important implications for the treatment of ADHD in schools. These results suggest that parents who are using medication to treat their child's ADHD may be able to substantially reduce the overall need for medication or the dose needed for effectiveness by working with the teacher to institute simple behavioral interventions (e.g., DRCs, consistent feedback regarding academic productivity and classroom deportment). Physicians and school psychologists involved in medication trials should also routinely survey the effectiveness and extent of behavioral procedures used in a classroom, as most classrooms currently have the infrastructure to support behavioral interventions for children with ADHD (Walker et al., 2003–2004). In many cases, working with the teacher to implement effective classroom management procedures based on the principles of behavior modification, or to implement school-wide behavior modification procedures (e.g., DuPaul & Stoner, 2003; Fabiano & Pelham, 2003; Pelham, Massetti et al., 2005; Sugai et al., 2000; Waschbusch, Pelham, Massetti, & Northern Partners in Action for Children and Youth, 2005; Walker, Colvin, & Ramsey, 1995), may effectively reduce problems related to ADHD (e.g., rule violations) and increase prosocial behaviors (e.g., seatwork completion). Contingency management procedures are also effective, but are more costly, oftentimes requiring special education services and placements.

Thus, schools may need to investigate the appropriateness of various choices parents have in the treatment of a child with ADHD: (a) special education services or Section 504 accommodation plans that implement contingency management procedures (Schnoes, Reid, Wagner, & Marder, 2006) for parents who wish to forego stimulant medication; (b) remain in general education on high doses of stimulants with the potential for adverse side effects (MTA Cooperative Group, 2004); or (c) clinical behavior therapy interventions (i.e., a DRC) combined with low doses of stimulants in a general education setting. Because of concerns regarding side effects, parental preferences (no medication) may at times conflict with school district preferences (no special education due to high costs), and future studies of cost-effectiveness of treatments and their combination are needed. Because the educational costs of ADHD number in the billions, with special education and medication costs representing the most expensive portion of the cost (Forness & Kavale, 2002; Pelham, Foster, & Robb, 2007), future critical questions concern the cost-effectiveness of combining low doses of intervention in general classroom settings compared to using high doses of either unimodal treatment.

Supplementary Material

For additional materials about the interventions described in this article, go to http://www.ccf.buffalo.edu.

References

Abramowitz, A. J., Eckstrand, D., O'Leary, S. G., & Dulcan, M. K. (1992). ADHD children's responses to stimulant medication and two intensities of a behavioral intervention. *Behavior Modification, 16,* 193–203.

Alberto, P. A., & Troutman, A. C. (2003). *Applied behavior analysis for teachers* (6th ed.) Upper Saddle River, NJ: Merrill Prentice Hall.

American Academy of Pediatrics. (2001). Clinical practice guideline: Treatment of the school-aged child with attention-deficit/hyperactivity disorder. *Pediatrics, 108,* 1033–1044.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Atkins, M. S., Pelham, W. E., & White, K. J. (1989). Hyperactivity and attention deficit disorders. In M. Hersen (Ed.), *Psychological aspects of developments and physical disabilities: A casebook*. (pp. 137–156). Thousand Oaks, CA: Sage Publications.

Berliner, D. C., & Rosenshine, B. (1977). The acquisition of knowledge in the classroom. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), *Schooling and the acquisition of knowledge* (pp. 375–396). Hillsdale, NJ: Lawrence Erlbaum Associates.

Burrows-MacLean, L., Pelham, W. E., Coles, E. K., Wymbs, B. T., Chacko, A., Walker K., et al. (2003, November). *Behavioral and pharmacological treatment for children with ADHD in the home setting.* Poster presented at the Association for Advancement of Behavior Therapy Conference, Boston, MA.

Carlson, C. L., Pelham, W. E., Milich, R., & Dixon, J. (1992). Single and combined effects of methylphenidate and behavior therapy on the classroom performance of children with ADHD. *Journal of Abnormal Child Psychology*, *20,* 213–232.

Chronis, A. M., Fabiano, G. A., Gnagy, E. M., Onyango, A. N., Pelham, W. E., William, A., et al. (2004). An evaluation of the Summer Treatment Program for children with attention-deficit/hyperactivity disorder using a treatment withdrawal design. *Behavior Therapy, 35,* 561–585.

Chronis, A. M., Pelham, W. E., Gnagy, E. M., Roberts, J. E., & Aronoff, H. R. (2003). The impact of late-afternoon stimulant for children with ADHD: Impact on parent and parent-child domains. *Journal of Clinical Child Psychology, 32,* 118–126.

Conners, C. K. (2002). Forty years of methylphenidate treatment in attention-deficit/hyperactivity disorder. *Journal of Attention Disorders, 6*(Suppl. 1), 17–30.

Conners, C. K., Epstein, J. N., March, J. S., Angold, A., Wells, K. C., Klaric, J., et al. (2001). Multimodal treatment of ADHD in the MTA: An alternative outcome analysis. *Journal of the American Academy of Child and Adolescent Psychiatry, 40,* 159–167.

DuPaul, G. J., & Eckert, T. L. (1997). The effects of school-based interventions for attention deficit hyperactivity disorder: A meta-analysis. *School Psychology Review, 26,* 5–27.

DuPaul, G. J., & Stoner, G. (2003). *ADHD in the schools, assessment and intervention strategies* (2nd ed.). New York: Guilford Press.

Evans, S. W., Allen, J., Moore, S., & Strauss, V. (2005). Measuring symptoms and functioning of youth with ADHD in middle schools. *Journal of Abnormal Child Psychology, 33,* 695–706.

Evans, S., Pelham, W. E., Smith, B., Bukstein, O., Gnagy, E. M., Greiner, A. R., et al. (2001). Dose-response effects of methylphenidate on ecologically valid measures of academic performance and classroom behavior in adolescents with ADHD. *Experimental and Clinical Psychopharmacology, 9,* 163–175.

Fabiano, G. A., & Pelham, W. E. (2003). Improving the effectiveness of behavioral classroom interventions for attention-deficit/hyperactivity disorder: A case study. *Journal of Emotional and Behavioral Disorders, 11,* 122–128.

Fabiano, G. A., Pelham, W. E., Coles, E. K., Gnagy, E. M., Chronis, A. M., & O'Connor, B. (2007). *A meta-analysis of behavior modification treatments for ADHD.* Unpublished manuscript.

Fabiano, G. A., Pelham, W. E., Manos, M., Gnagy, E. M., Chronis, A. M., Onyango, A. N., et al. (2004). An evaluation of three time out procedures for children with attention-deficit/hyperactivity disorder. *Behavior Therapy, 35,* 449–469.

Fabiano, G. A., Pelham, W. E., Waschbusch, D., Gnagy, E. M., Lahey, B. B., Chronis, A. M., et al. (2006). A practical impairment measure: Psychometric properties of the Impairment Rating Scale in samples of children with attention-deficit/hyperactivity disorder and two school-based samples. *Journal of Clinical Child and Adolescent Psychology, 35,* 369–385.

Forness, S. R., & Kavale, K. A. (2002). Impact of ADHD on school systems. In P. S. Jensen & J. R. Cooper (Eds.), *Attention deficit hyperactivity disorder: State of the science, best practices* (pp. 24–1–24–20). Kingston, NJ: Civic Research Institute.

Fuchs, D., Mathes, P. G., & Fuchs. L. S. (1993). *Peabody classwide peer tutoring reading methods.* Unpublished teacher's manual.

Gottfredson, G. D., & Gottfredson, D. C. (2001). What schools do to prevent problem behavior and promote safe environments. *Journal of Educational and Psychological Consultation, 12,* 313–344.

Greenhill, L. L., & Ford, R. E. (2002). Childhood attention-deficit/hyperactivity disorder: Pharmacological treatments. In P. E. Nathan & J. M. Gorman (Eds.), *A guide to treatments that work* (2nd ed., pp. 25–55). New York: Oxford University Press.

Gulley, V., Northup, J., Hupp, S., Spera, S., LeVelle, J., & Ridgway, A. (2003). Sequential evaluation of behavioral treatments and methylphenidate dosage for children with attention deficit hyperactivity disorder. *Journal of Applied Behavior Analysis, 36,* 375–378.

Horner, R. H., Sugai, G., Todd, A. W., & Lewis-Palmer, T. (2000). Elements of behavioral support plans: A technical brief. *Exceptionality, 8,* 205–215.

Hoza, B., Pelham, W. E., Sams, S. E., & Carlson, C. (1992). An examination of the "dosage" effects of both behavior therapy and methylphenidate on the classroom performance of two ADHD children. *Behavior Modification, 16,* 164–192.

Jadad, A. R., Boyle, M., Cunningham, C., Kim, M., & Schachar, R. (1999). *Treatment of attention-deficit hyperactivity disorder. Evidence Report/Technology Assessment No. 11.* Rockville, MD: Agency for Healthcare Research and Quality.

Kazdin, A. E. (1982). *Single-case research designs: Methods for clinical and applied settings.* New York: Oxford University Press.

Klein, R. G., & Abikoff, H. (1997). Behavior therapy and methylphenidate in the treatment of children with ADHD. *Journal of Attention Disorders, 2,* 89–114.

Kolko, D. J., Bukstein, O. G., & Barron, J. (1999). Methylphenidate and behavior modification in children with ADHD and comorbid ODD and CD: Main and incremental effects across settings. *Journal of the American Academy of Child and Adolescent Psychiatry, 38,* 578–586.

Loney, J., & Milich, R. (1982). Hyperactivity, inattention, and aggression in clinical practice. In *Advances in Developmental and Behavioral Pediatrics, 3,* 113–147.

Madsen, C. H., Becker, W. C., & Thomas, D. R. (1968). Rules, praise, and ignoring: Elements of elementary classroom control. *Journal of Applied Behavior Analysis, 1,* 139–150.

Martens, B. K., & Ardoin, S. P. (2002). Training school psychologists in behavioral support consultation. *Child and Family Behavior Therapy, 24,* 147–163.

Meichenbaum, D. L., Gnagy, E. M., Flammer, L., Molina, B., & Pelham, W. E. (2001, April). *Why stop success? Exploration of long-term use of medication in a clinical ADHD sample from childhood through young adulthood.* Paper presented at the 8th Florida Conference on Child Health Psychology, Gainesville, FL.

MTA Cooperative Group. (1999). 14-Month randomized clinical trial of treatment strategies for attention deficit hyperactivity disorder. *Archives of General Psychiatry, 56,* 1073–1086.

MTA Cooperative Group. (2004). National Institutes of Mental Health Multimodal Treatment Study of ADHD follow-up: Changes in effectiveness and growth after the end of treatment. *Pediatrics, 113,* 762–769.

Northup, J., Fusilier, I., Swanson, V., Huete, J., Bruce, T., Freeland, J., et al. (1999). Further analysis of the separate and interactive effects of methylphenidate and common classroom contingencies. *Journal of Applied Behavior Analysis, 32,* 35–50.

O'Leary, K. D., Becker, W. C., Evans, M. B., & Saudargas, R. A. (1969). A token reinforcement program in a public school: A replication and systematic analysis. *Journal of Applied Behavior Analysis, 2,* 3–13.

O'Leary, K. D., Pelham, W. E., Rosenbaum, A., & Price, G. H. (1976). Behavioral treatment of hyperkinetic children. *Clinical Pediatrics, 15,* 510–515.

Pelham, W. E. (1993). Pharmacotherapy for children with attention-deficit hyperactivity disorder. *School Psychology Review, 22,* 199–227.

Pelham, W. E. (1999). The NIMH Multimodal Treatment Study for Attention Deficit Hyperactivity Disorder: Just say yes to drugs alone? *The Canadian Journal of Psychiatry, 44,* 981–990.

Pelham, W. E., Aronoff, H. R., Midlam, J. K., Shapiro, C. J., Gnagy, E. M., Chronis, A. M., et al. (1999). A comparison of Ritalin and Adderall: Efficacy and time-course in children with ADHD. *Pediatrics, 103*(4), e43. Available from http://www.pediatric.orglegi/content/full/10314/e43

Pelham, W. E., Bender, M. E., Caddell, J., Booth, S., & Moorer, S. H. (1985). Methylphenidate and children with attention deficit disorder. *Archives of General Psychiatry, 42,* 948–952.

Pelham, W. E., Burrows-MacLean, L., Gnagy, E. M., Coles, E. K., Wymbs, B. T., Chacko, A., et al. (2003, November). *A dose ranging study of behavioral and pharmacological treatment for children with ADHD.* Poster presented at the Association for Advancement of Behavior Therapy Conference, Boston, MA.

Pelham, W. E., Burrows-MacLean, L., Gnagy, E. M., Fabiano, G. A., Coles, E. K., Tresco, K. E., et al. (2005). Transdermal methylphenidate, behavioral, and combined treatment for children with ADHD. *Experimental and Clinical Psychopharmacology, 13,* 111–126.

Pelham, W. E., Carlson, C., Sams, S. E., Vallano, G., Dixon, J., & Hoza, B. (1993). Separate and combined effects of methylphenidate and behavior modification on boys with ADHD in the classroom. *Journal of Consulting and Clinical Psychology, 61,* 506–515.

Pelham, W. E., Erhardt, D., Gnagy, E. M., Greiner, A. R., Arnold, L. E., Abikoff, H. B., et al. (2007). *Parent and teacher evaluation of treatment in the MTA: Consumer satisfaction and perceived effectiveness.* Manuscript submitted for publication.

Pelham, W. E., & Fabiano, G. A. (2007). *Evidence-based treatments for children and adolescents with ADHD: An update.* Manuscript submitted for publication.

Pelham, W. E., Fabiano, G. A., Gnagy, E. M., Greiner, A. R., & Hoza, B. (2005). Comprehensive psychosocial treatment for ADHD. In E. Hibbs & P. Jensen (Eds.), *Psychosocial treatments for child and adolescent disorders: Empirically based strategies for clinical practice* (pp. 377–410). Washington, D.C.: American Psychological Association.

Pelham, W. E., Fabiano, G. A., & Massetti, G. M. (2005). Evidence-based assessment of attention-deficit/hyperactivity disorder in children and adolescents. *Journal of Clinical Child and Adolescent Psychology, 34,* 449–476.

Pelham, W. E., Foster, E. M., & Robb, J. A. (2007). The economic impact of attention deficit hyperactivity disorder in children and adolescents. *Journal of Ambulatory Pediatrics, 7*(Suppl.), 121–131.

Pelham, W. E., Gnagy, E. M., Burrows-Maclean, L., Williams, A., Fabiano, G. A., Morrissey, S. M., et al. (2001). Once-a-day Concerta™ methylphenidate versus t.i.d. methylphenidate in laboratory and natural settings. *Pediatrics*, *107,* e105. Available from http://www.pediatrics.org/cgi/content/full/107/6/e105

Pelham, W. E., Gnagy, E. M., Fabiano, G. A., Coles, E. K., Wymbs, B. T., Chacko, A., et al. (2007). *Comparative and combined dosage effects of treatments for ADHD.* Unpublished manuscript.

Pelham, W. E., Gnagy, E. M., Greenslade, K. E., & Milich, R. (1992). Teacher ratings of DSM-III-R symptoms of the disruptive behavior disorders. *Journal of the American Academy of Child and Adolescent Psychiatry, 31,* 210–218.

Pelham, W. E., Greiner, A. R., & Gnagy, E. M. (1998). *Children's Summer Treatment Program manual.* Buffalo, NY: CTADD.

Pelham, W. E., & Hoza, B. (1996). Intensive treatment: A summer treatment program for children with ADHD. In E. Hibbs & P. Jensen (Eds.), *Psychosocial treatments for child and adolescent disorders: Empirically based strategies for clinical practice* (pp. 311–340). New York: APA Press.

Pelham, W. E., Hoza, B., Pillow, D. R., Gnagy, E. M., Kipp, H. L., Greiner, A. R., et al. (2002). Effects of methylphenidate and expectancy on children with ADHD: Behavior, academic performance, and attributions in a summer treatment program and regular classroom settings. *Journal of Consulting and Clinical Psychology, 70,* 320–335.

Pelham, W. E., Lang, A. R., Atkeson, B., Murphy, D. A., Gnagy, E. M., Greiner, A. R., et al. (1998). Effects of deviant child behavior on parental alcohol consumption. *The American Journal on Addictions, 7,* 103–114.

Pelham, W. E., Massetti, G. M., Wilson, T., Kipp, H., Myers, D., Newman Standley, B. B., et al. (2005).

Implementation of a comprehensive schoolwide behavioral intervention: The ABC Program. *Journal of Attention Disorders*, 9, *248–260.*

Pelham, W. E., & Murphy, H. A. (1986). Attention deficit and conduct disorder. In M. Hersen (Ed.), *Pharmacological and behavioral treatment: An integrative approach.* (pp. 108–148). New York: Wiley.

Pelham, W. E., Wheeler, T., & Chronis, A. (1998). Empirically supported psychosocial treatments for attention deficit hyperactivity disorder. *Journal of Clinical Child Psychology, 27,* 190–205.

Pfiffner, L. J., & O'Leary, S. G. (1987). The efficacy of all-positive management as a function of the prior use of negative consequences. *Journal of Applied Behavior Analysis, 20,* 265–271.

Psychological Corporation. (1991). *Wechsler Individual Achievement Test.* San Antonio, TX: Author.

Rapport, M. D., Murphy, H. A., & Bailey, J. S. (1982). Ritalin vs. response cost in the control of hyperactive children: A within-subject comparison. *Journal of Applied Behavior Analysis, 15,* 205–216.

Rowland, A. S., Umbach, D. M., Stallone, L., Naftel, J., Bohlig, M., Sandler, D. P. (2002). Prevalence of medication treatment for attention-deficit/hyperactivity disorder among elementary school children in Johnston County, North Carolina. *American Journal of Public Health, 92,* 231–234.

Schloss, P. J., & Smith, M. A. (1998). *Applied behavior analysis in the classroom.* Boston: Allyn & Bacon.

Schnoes, C., Reid, R., Wagner, M., & Marder, C. (2006). ADHD among students receiving special education services: A national survey. *Exceptional Children, 72,* 483–496.

Stage, S. A., & Quiroz, D. R. (1997). A meta-analysis of interventions to decrease disruptive classroom behavior in public education settings. *School Psychology Review, 26,* 333–368.

Sugai, G., Horner, R. H., Dunlap, G., Hieneman, M., Lewis, T. J., Nelson, C. M., et al. (2000). Applying positive behavioral support and functional behavioral assessment in schools. *Journal of Positive Behavioral Interventions, 2,* 131–143.

Swanson, J. M., McBurnett, K., Christian, D. L., & Wigal, T. (1995). Stimulant medication and treatment of children with ADHD. In T. H. Ollendick & R. J. Prinz (Eds.), *Advances in clinical child psychology* (Vol. 17, pp. 265–322). New York: Plenum.

Walker, H. M., Colvin, G., & Ramsey, E. (1995). *Antisocial behavior in school: Strategies and best practices.* Pacific Grove, CA: Brooks/Cole.

Walker, H. M., Ramsey, E., & Gresham, F. M. (2003–2004). Heading off disruptive behavior: How early intervention can reduce defiant behavior—and win back teaching time. *American Educator,* pp. 6–21.

Waltz, J., Addis, M. E., Koerner, K., & Jacobson, N. S. (1993). Testing the integrity of a psychotherapy protocol: Assessment of adherence and competence. *Journal of Consulting and Clinical Psychology, 61,* 620–630.

Waschbusch, D. A., Pelham, W. E., Massetti, G. M., & Northern Partners In Action for Children and Youth. (2005). The Behavior Education Support and Treatment (BEST) school intervention program: Pilot project data examining school-wide, targeted-school, and targeted-home approaches. *Journal of Attention Disorders, 9,* 313–322.

Wechsler, D. (1991). *Wechsler Intelligence Scale for Children: Third Edition Manual.* San Antonio, TX: Psychological Corporation.

Werry, J., & Sprague, R. (1974). Methylphenidate in children: Effect of dosage. *Australian and New Zealand Journal of Psychiatry, 8,* 9–19.

Wolraich, M. L., Greenhill, L. L., Pelham, W. E., Swanson, J., Wilens, T., Palumbo, D., et al. (2001). Randomized, controlled trial of OROS methylphenidate once a day in children with attention-deficit/hyperactivity disorder. *Pediatrics, 108,* 883–892.

Wolraich, M. L., Hannah, J. N., Baumgaertel, A., & Feurer, I. D. (1998). Examination of DSM-IV criteria for attention-deficit/hyperactivity disorder in a county-wide sample. *Developmental and Behavioral Pediatrics, 19,* 162–168.

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