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Music and Video as Distractors for Boys with ADHD in the Classroom: Comparison with Controls, Individual Differences, and Medication Effects

William E. Pelham Jr · Daniel A. Waschbusch · Betsy Hoza · Elizabeth M. Gnagy · Andrew R. Greiner · Susan E. Sams · Gary Vallano · Antara Majumdar · Randy L. Carter

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Abstract This study examined the effects of music and video on the classroom behavior and performance of boys with and without attention deficit hyperactivity disorder (ADHD) and examined the effects of 0.3 mg/kg methylphenidate (MPH). In one study, 41 boys with ADHD and 26 controls worked in the presence of no distractor, music, or video. Video produced significant distraction, particularly for the boys with ADHD, and MPH improved the performance of boys with ADHD across distractor conditions.There were individual differences in response to the music such that some boys were adversely affected and others benefited relative to no-distractor.In a second study, music and MPH were assessed

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W. E. Pelham Jr · D. A. Waschbusch (✉) · E. M. Gnagy · A. R. Greiner
Department of Psychology, Center for Children and Families, Florida International University,
AHC1 Room 140, 11200 SW 8th Street,
Miami, FL 33199, USA
e-mail: dwaschbu@fiu.edu

W. E. Pelham Jr
e-mail: wpelham@fiu.edu

B. Hoza
Department of Psychology, University of Vermont,
Burlington, VT 05405, USA

A. Majumdar · R. L. Carter
Department of Biostatistics, University at Buffalo - SUNY,
252-A1 Farber Hall, 3435 Main Street,
Buffalo, NY 14214, USA

S. E. Sams
Allegheny Intermediate Unit, DART Program,
475 East Waterfront Drive,
Homestead, PA 15210, USA

G. Vallano
Western Psychiatric Institute and Clinic,
2432 Greensburg Pike,
Pittsburgh, PA 15221, USA

Present Address:
A. Majumdar
Bristol-Myers Squibb Company,
Brooklyn, NY, USA

in an additional 86 boys with ADHD to examine further the music results. In the presence or absence of music, MPH improved performance relative to placebo. Similar individual differences were found as in Experiment 1.

Keywords ADHD · Distraction · Stimulant medication · Classroom · Video distractor · Music distractor · Individual differences

There has long been controversy regarding the degree to which children with attention-deficit hyperactivity disorder (ADHD) are distractible. "Easily distracted" has been a defining symptom of ADHD in the *Diagnostic and Statistical Manual of Mental Disorders* since DSM-III (American Psychiatric Association 1980, 1987, 1994). However, studies of children with ADHD in laboratory settings have often failed to support the hypothesis that children with ADHD are more distractible than controls (Douglas 1999; Douglas and Parry 1983). Indeed, some researchers have argued that children with ADHD do not have a straightforward attention deficit at all (Barkley 1997; Huang-Pollock and Nigg 2003; Sergeant et al. 1999).

Other investigators have argued that distractors might actually have an enhancing effect on the performance of children with ADHD on cognitive tasks and in classroom settings. In the cognitive-energetic model of ADHD, arousal, activation and effort are hypothesized to modulate children's information processing abilities (Sergeant et al. 1999; van der Meere 2005). As described by van der Meere(2005), the arousal system is an individual's "what is it?" response to a stimuli, the activation system is an individual's "what is to be done?" response, and the effort system helps compensate for suboptimal arousal in the arousal and activation systems. An implication of this theory is that how children process stimuli will depend, in part, on whether their current state of arousal/activation matches their optimal arousal. Thus, children who are under-aroused will have enhanced performance if new stimuli serve to increase these systems. Consistent with this theory, Zentall (1977) has hypothesized that children with ADHD suffer from under-arousal and that when they are given increased external stimulation, their stimulation-seeking behaviors are reduced. Similarly, Sikstrom and Soderland (2007) argue that background noise induces dopaminergic release, thereby boosting dopamine to a more optimal level in children with ADHD, who are otherwise low, and this in turn improves their cognitive performance.

There is support for these hypotheses. Studies by Zentall and colleagues found that the addition of stimulation normalized activity level and task performance of children with ADHD, particularly during boring, familiar tasks (Lee and Zentall 2002; Zentall 1979; Zentall and Zentall 1983). Other studies have shown that background music significantly improves performance on cognitive tasks for children with ADHD but does not impact or negatively impacts the performance of non-ADHD controls (Abikoff et al. 1996; Soderland et al. 2010; Soderland et al. 2007). Children with ADHD also performed better on a computerized attention task when novel stimuli were present but not when standard stimuli were present, presumably because the novel stimuli increased their activation and arousal to more optimal levels (van Mourik et al. 2007). Despite these research findings, classroom teachers and the committees that revise the DSM continue to report and conclude that children with ADHD are more easily distracted than children without ADHD, and that distractors have only negative effects.

A few studies have examined conditions under which children with ADHD display higher levels of distractibility than control children. Rosenthal and Allen (1980) and Radosh and Gittleman (1981) both showed that when highly salient distractors such as colorful pictures were used, children with ADHD were more distracted and showed greater impairment on task performance than did control children. Of note is that only the highly salient distractors had this effect; distractors that were less salient did not change the children's performance. Douglas (1999) points out that these results support a stimulation-seeking hypothesis of distractibility and summarizes factors that are likely to lead to distractibility in children with ADHD, including the degree of boredom or difficulty associated with a task and the salience of the distractor. In support of Douglas's hypothesis, Lee and Zentall (2002) showed that increased visual stimulation (color added to a computerized math task) improved the performance of children with ADHD; however, introducing a competing distractor (cartoons on a second computer monitor) produced a performance decrement. Various types of distractors may also have differential effects on children's distractibility. For example, task-relevant distractors (e.g., visual distractors in figures to be copied; linguistic distractors during reading tasks) have been shown to cause performance decrements (Zentall and Shaw 1980; Zentall et al. 1978), whereas other research found that novel stimuli but not standard stimuli increased the orienting response in children with ADHD and thus improved their performance (van Mourik, et al. 2007). The content of a distractor may thus be a factor in producing distractibility, and the effect of this distraction may be either positive (improving performance) or negative (decreasing performance).

A limitation of these laboratory studies of distraction is that they did not use an ecologically valid task setting, such as a classroom setting. In contrast, Whalen et al. (1979) studied the effects of noisy distractors and methylphenidate (MPH) on boys with ADHD in a naturalistic classroom setting. Whalen et al. found that the presence of a radio playing during the class period resulted in higher rates of off-task behavior and behaviors signifying arousal (activity, verbalization, noise).

They also found that MPH reduced the effects of the distractor. These results appear to be at odds with Zentall's underarousal hypothesis. However, Whalen et al.'s procedure involved four consecutive periods, and the noisy periods always occurred later in the day than the quiet periods, thereby making it impossible to separate the effects of the radio from the effects of time on task. This is an important confound because time-course studies have shown that off-task behavior and rule violations in children with ADHD increase over the course of an 8–12 h day (Pelham, Gnagy et al. 2001; Swanson et al. 1998). In addition, according to the cognitive-energetic model, time on task is a key factor that influences children's ability to regulate themselves, with less optimal levels of arousal and activation occurring as children spend more time on task (van der Meere 2005).

We undertook the present investigation to address some of the limitations of previous studies. The purpose of this investigation was to examine the effects of two highly salient and ecologically valid distractors, popular music and movie videos, on the behavior and academic performance of children with ADHD. In an attempt to further increase ecological validity, the study was conducted in a classroom setting instead of a laboratory. This enabled us to approximate a replication of Zentall's (1977) pioneering study, which suggested that children with ADHD were not distractible in a classroom setting. We extended Zentall's study in five ways, by: (1) including two types of distractors; (2) conducting the study for 23 days instead of 2 days, using a within-subject design; (3) analyzing individual differences in response to distractors; (4) including control boys in the study; and (5) examining the effects of methylphenidate (MPH, 0.3 mg/kg) on the boys with ADHD and their responses to distraction.

Experiment 1

Method

Participants Participants were 41 boys with ADHD and 26 normal comparison boys ranging in age from 7.7 years to 12.6 years (M=9.8 years). All participants were enrolled in the 1992 Summer Treatment Program (STP) at Western Psychiatric Institute and Clinic.[1] Forty-one participants met criteria for a DSM-III-R diagnosis of attention-deficit hyperactivity disorder (ADHD), using a compilation of information provided by a structured, parental interview consisting of the DSM descriptors of ADHD, ODD and CD (freely available online at http://casgroup.fiu.edu/CCF/pages.php?id=1401) and conducted by a trained clinician, and teacher ratings on the Disruptive Behavior Disorders rating scale (Pelham, Gnagy et al. 1992). Twenty-four participants met criteria for a concurrent DSM III-R diagnosis of oppositional defiant disorder (ODD), and 11 participants met criteria for conduct disorder (CD). The sample was 86% Caucasian. Two participants were in full-time special education placement and three participants were in part-time special education placement; the remaining participants came from regular classrooms. Full scale IQs were measured using the Wechsler Intelligence Scale for Children—Revised (Wechsler 1974). Boys who had an IQ of lower than 80 were excluded.

Control participants were recruited to participate in the STP free of charge in exchange for their participation in research projects. Twenty-six boys who had never been referred for treatment of behavior problems were chosen to participate in the project. Controls were screened using the Child Behavior Checklist (Achenbach 1991a) and the Teacher's Report Form (Achenbach 1991b); children who received T-scores of 70 or higher on the Internalizing or Externalizing scale were excluded. Table 1 includes means and standard deviations for several measures of participant characteristics. Result of analyses, including means and standard deviations of dependent measures, are summarized in Tables 2, 3, 4, 5, and 6.

Procedures

Overview All procedures were approved by the Institutional Review Board at Western Psychiatric Institute and Clinic. Written consent was obtained from parents and assent from children prior to their participation.

As part of their daily activities during the STP, each group of 12, age-matched children attended a 60-minute academic class, conducted by a teacher and an aide, during which this study was conducted. The study design consisted of three distractor conditions (no distractor, music, and video) crossed with two groups (ADHD and control). The first 2 weeks of the STP served as a period of adaptation for the children and staff; the distractor manipulation was introduced in the third week and continued on Mondays through Thursdays throughout the remainder of the 8-week program for a total of 24 days (8 days in each distractor condition). Distractor conditions were randomly assigned, varying on a daily basis with the restriction that each distractor condition occurred at least once each week. In addition, 36 of the boys with ADHD received two medication conditions, placebo and 0.3 mg/kg MPH, to study the relationship between medication and the effect of

[1] Thirty-six of the boys with ADHD in Study 1 and 65 of the boys in Study 2 were simultaneously enrolled in a larger studythat examined the effects of 0.3 mg/kg MPH on measures of behavior, task performance, and cognitions (Pelham et al. 1997; Pelham et al. 2002; Pelham, Waschbusch et al. 2001). Likewise, the control participants were simultaneously enrolled in an investigation comparing boys with and without on measures of behavior, task performance, and cognitions (Hoza et al. 2001, 2000).

Table 1 Means and standard deviations for participant characteristics

Item	Experiment 1				Experiment 2	
	ADHD		Control		ADHD	
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Age in Years	9.8	(1.3)	9.8	(1.2)	9.5	(1.4)
Full Scale IQ[a]	104.8	(15.1)	110.8	(17.8)	103.7	(14.2)
WJ Achievement[b]						
Reading	105.2	(13.5)	117.9	(17.7)	106.6	(16.0)
Arithmetic	109.2	(16.0)	123.9	(15.0)	110.1	(14.5)
Written Language	97.1	(12.8)	107.7	(11.6)	95.5	(13.2)
DSM III-R Items Endorsed						
ADHD	11.3	(2.4)	–	–	12.3	(2.2)
ODD	5.3	(2.8)	–	–	6.3	(2.4)
CD	0.3	(0.6)	–	–	1.6	(1.6)
Abbreviated Conners Rating Scale[c]						
Parent	19.6	(5.1)	–	–	19.7	(6.3)
Teacher	16.2	(7.0)	–	–	18.8	(5.9)
IOWA Conners Teacher Rating Scale[d]						
Inattentive-Impulsive-Overactive	9.5	(3.2)	–	–	10.9	(2.7)
Oppositiona-defiant	5.4	(4.2)	–	–	7.0	(4.7)
Teacher DBD Rating[e]						
ADHD	1.7	(0.7)	–	–	1.8	(0.6)
ODD	1.3	(0.7)	–	–	1.4	(0.8)

[a] WISC-R (Wechsler 1974).
[b] Achievement cluster standard scores for the Woodcock-Johnson Psychoeducational Battery (Woodcock 1989).
[c] (Goyette et al. 1978).[d] (Pelham et al. 1989; Waschbusch and Willoughby 2008). [e] (Pelham, et al. 1992). In experiment 1, the groups differed significantly on the three Woodcock-Johnson Achievement scores, *ts*=−3.23, −3.67, −3.35, respectively; *ps*<0.001.

the distractors (Pelham et al. 2002). These boys' data from placebo days were used for the analyses comparing boys with and without ADHD.

The participants in this study were distributed across seven different classes.[2] During each class period, children worked on five seatwork assignments for 45 min, during which the distractor manipulation was implemented. Assignments were in the areas of math, reading comprehension, spelling or writing, and language arts. The order of subject assignments was randomized by group and varied daily. The teacher and aide implemented the behavior modification procedures described below, assisted the children with their work, and corrected papers.

Distractors The study involved two types of distractors – music and video. At the beginning of the STP, each group of children voted for a contemporary music radio station and a list of age-appropriate movie or cartoon videotapes. The selected radio stations and videotapes varied across groups; however, all groups chose radio stations that played rock or rap music, and the videos all consisted of cartoons, animated movies or similar age-appropriate movies. Each group listened to the same radio station throughout the course of the study. The videotapes were randomized for each group according to the group's choices and the availability of the videotape. Groups did not watch any movie that they had not selected, and did not watch the same tape more than once. If the length of a videotape exceeded the class period, it was completed on subsequent video days. If the videotape was shorter than the seatwork period, the teacher immediately began playing that group's next scheduled videotape to insure the presence of the distractor for the full seatwork period.

The volume level remained consistent between the music and the videos, and between different videos. All music and videos were played at 64–74 dB, as measured by a General Radio Sound Level Meter. The teacher turned on the music or started the video when he or she instructed the children to begin their seatwork, and turned off the distractor at the end of the seatwork period.

Behavioral Intervention A behavior modification program, which has been described in detail elsewhere (Carlson et al. 1992; Pelham et al. 1993), was used in the classroom throughout the study. The program included a point system with reward and response-cost components, classroom rules, time out, social reinforcement, contingent privileges, and a home-based daily report program. Classroom teachers

[2] There were four control boys in each group of 12 children, except for one group that included six control children, and another group that did not include any control children. Teachers and aides did not know which of the boys were controls and which were diagnosed with ADHD. Although some members of each class were not participating in the study due to exclusionary criteria, the experimental manipulation was conducted for the class as a whole.

Table 2 Experiment 1—summary of *p*-values from analyses

	Main effects			Interactions				Covariate
ADHD vs. CONTROL								
	Group	Distract	Study half	G × D	G × S	D × S	G × D × S	Classroom
Following rules	<0.0001	0.0033	0.1364	0.3244	0.2852	0.0415	0.3616	<0.0001
Prompts	<0.0001	<0.0001	na	0.0059	na	na	na	<0.0001
Seatwork Completion	0.0355	0.0013	0.0101	<0.0001	0.3489	<0.0001	0.8823	0.3027
	Group	Distract	Class half	G × D	G × CH	D × CH	G × D × CH	Classroom
On Task—observations	<0.0001	<0.0001	0.0500	0.4707	0.6633	<0.0001	<0.0001	<0.0001
MEDICATION VS. PLACEBO								
	Med	Distract	Study half	M × D	M × S	D × S	M × D × S	Classroom
Following rules	<0.0001	<0.0001	0.1329	<0.0001	0.4031	0.0010	0.2605	0.0063
Prompts	<0.0001	<0.0001	na	<0.0001	na	na	na	0.0060
Seatwork Completion	<0.0001	<0.0001	0.0049	0.0414	<0.0001	<0.0001	0.0041	0.5918
	Med	Distract	Class half	M × D	M × CH	D × CH	M × D × CH	Classroom
On Task—observations	<0.0001	<0.0001	0.0012	<0.0001	0.3388	0.1453	<0.0001	0.5418

Values in table are significance levels (*p*-values). *G* Group (ADHD vs. control); *D* Distractor (none vs. music vs. video); *S* Study Half (1st half vs. 2nd half); *CH* Classroom Half (1st half vs. 2nd half; *M* Medication (placebo vs. methylphenidate). *na* not applicable

Table 3 Experiment 1—means, standard deviations and effect sizes for ADHD versus control

	Control		ADHD		Effect size
	M	*SD*	*M*	*SD*	
Rules Violations					
none	0.12	0.22	2.35	3.05	−1.03
music	0.13	0.31	1.66	1.99	−1.07
video	0.23	0.39	2.93	2.92	−1.30
Teacher Prompts					
none	0.36	0.69	4.02	5.82	−0.88
music	0.36	0.52	3.37	4.78	−0.89
video	2.57	3.13	11.77	10.50	−1.19
Seatwork Completion					
none	83.63	9.91	65.37	21.99	1.07
music	82.91	10.36	68.50	16.76	1.03
video	77.00	12.95	51.86	21.74	1.41
On Task Behavior					
1st half of class					
none	95.79	4.26	85.04	13.26	1.09
music	97.18	1.69	87.02	12.64	1.13
video	84.67	13.53	56.89	23.19	1.46
2nd half of class					
none	94.40	5.32	80.65	15.43	1.19
music	94.41	5.57	83.75	13.62	1.02
video	82.87	16.08	46.91	26.62	1.64

Effect sizes are Cohen's D computed as: (control *M*—ADHD *M*)/ Pooled *SD*

were certified special-education teachers. Teachers and aides underwent a week-long intensive training session in the STP classroom behavioral system, and received daily supervision from the classroom coordinator to insure they implemented the behavioral procedures correctly and that assigned seatwork was appropriate for each child.

As part of the behavioral intervention, the teacher and aide gave commands and prompts as a means of keeping

Table 4 Individual response to distractors on the measure of seatwork completion

Response to music	ADHD	Control
Worsened Performance	4 (9%)	1 (4%)
No Effect	25 (61%)	25 (96%)
Improved Performance	12 (29%)	0 (0%)
Response to video	ADHD	Control
Worsened Performance	23 (56%)	6 (23%)
No Effect	13 (32%)	20 (77%)
Improved Performance	5 (12%)	0 (0%)

An increase or decrease in performance was defined as a 20% change from baseline (no distractor condition)

Table 5 Experiment 1—means, standard deviations and effect sizes for placebo versus medication

	Placebo		Medication		Effect size
	M	*SD*	*M*	*SD*	
Rules Violations					
none	2.37	3.16	0.43	1.14	−0.82
music	1.58	1.93	0.37	0.69	−0.83
video	2.89	2.98	1.34	2.06	−0.61
Teacher Prompts					
none	3.89	5.95	1.34	2.68	−0.55
music	3.09	4.69	1.07	1.57	−0.58
video	11.41	10.56	7.70	9.20	−0.37
Seatwork Completion					
none	66.89	22.02	84.53	15.71	0.92
music	69.23	17.09	85.94	15.09	1.04
video	53.14	22.47	70.66	22.19	0.78
On Task Behavior					
1st half of class					
none	84.86	13.78	93.21	7.81	0.75
music	86.80	13.11	94.47	5.90	0.75
video	56.52	23.71	71.32	20.03	0.67
2nd half of class					
none	81.88	14.03	91.11	8.24	0.80
music	85.06	12.05	92.50	7.36	0.75
video	46.67	27.03	68.44	24.78	0.84

Effect sizes are Cohen's D computed as: (medication *M*—placebo *M*)/Pooled *SD*

the children on task. During the first half of the study, there was no limit to the number of prompts that could be given to a child. However, there was some concern that teachers would unintentionally limit the magnitude of the distractor effect by increasing the number of prompts and commands they gave on distractor days. Therefore, during the last 3 weeks of the study (i.e., the last half of the study), the number of commands or prompts was limited. The mean number of prompts or commands given to each child on no-distractor days was computed (Controls: $M=0.5$, $SD=1.0$; ADHD: $M=4.8$, $SD=5.5$) and was used as the maximum number of prompts that could be given to that child on any day during the last half of the study.

Medication Thirty-six of the boys with ADHD were concurrently participating in a clinical medication assessment during the STP (Pelham, et al. 2002). Each child received 0.3 mg/kg MPH and placebo for 12 days each, randomized on a daily basis. The medication assessment was introduced in the third week of the STP. Medication conditions were randomly assigned with the restriction that each drug condition occurred at least once each week. Due to the number of combinations of distractor and drug conditions, it was not possible to include every combination each week. The average dose of MPH administered was 10.4 mg (range: 6.25 mg to 17.5 mg). Medication and placebo were disguised in gelatin capsules and were prepackaged in weekly pill reminders by a research pharmacy. The children attended the academic classroom during peak medication hours (beginning 60–120 min post-ingestion).

Measures

Dependent Measures The dependent measures were those employed in numerous studies in this setting (e.g., Carlson, et al. 1992; Chronis et al. 2004; Fabiano et al. 2007; Pelham, et al. 1993; Pelham, Gnagy, et al. 2001; Pelham et al. 1999; Pelham, et al. 2002; Pelham et al. 1990; Waschbusch et al. 2007). They have been shown to be sensitive to treatment effects and have acceptable reliability. Means and standard deviations for all dependent measures are summarized in Table 3 (for ADHD vs. Control) and Table 5 (for Placebo vs. MPH).

Behavioral Measures The effects of the distractors on classroom behavior were assessed in two ways. First, as part of the behavioral program described above, children received a fixed sum of points at the beginning of each class period, and lost points when they violated any of the posted classroom rules (obey adults, respect others, work quietly, use materials appropriately, stay in assigned seat,

Table 6 Experiment 2—means, standard deviations and effect sizes for placebo versus medication

	Placebo		Medication		Effect size
	M	*SD*	*M*	*SD*	
Rule Violations					
none	2.55	2.79	0.82	1.60	−0.76
music	2.36	2.58	0.68	1.17	−0.84
Seatwork Completion					
none	78.63	35.53	90.38	16.90	0.42
music	78.94	32.27	91.92	14.43	0.52
On Task Behavior					
1st half of class					
none	93.10	11.99	97.32	4.88	0.46
music	93.68	11.05	97.30	4.92	0.42
2nd half of class					
none	92.01	13.73	96.76	5.87	0.45
music	92.50	12.94	97.11	5.26	0.47

Effect sizes are Cohen's D computed as (medication *M*—placebo *M*)/Pooled *SD* raise hand to speak). The percentages of behavioral points that children kept were recorded as a measure of following rules in the classroom. For analysis purposes, these percentages were converted to numbers of rule violations (range=0 to 10). In addition, children were observed directly for on-task and disruptive behavior, using procedures and observational codes adapted from the COCADD Observation Scheme (Atkins et al. 1988), as described in detail elsewhere (Carlson, et al. 1992; Pelham, et al. 1993; Pelham, Gnagy, et al. 2001). Observers recorded behaviors that met criteria for any of six disruptive behavior categories and whether each child was "on task" (i.e., attending to the ongoing activity). The six disruptive behavior categories were combined for analysis. Reliability observations were conducted for approximately 25% of the observation periods, and kappa statistics were computed to measure interobserver reliability. The average kappa for on-task behavior was 0.88 (SD=0.07), and the average kappa for disruptive behavior was 0.91 (SD=0.17). Only the measure of on-task behavior was analyzed because the disruptive behavior measure was highly correlated with classroom rule violations. For analysis purposes, on task was converted into a dichotomous measure due to a highly skewed distribution.

Seatwork Completion As described above, children worked on five academic seatwork assignments daily. Academic productivity was measured by computing the percentage of assigned seatwork that the child completed. For analysis purposes, the percentage was dichotomized due to a highly skewed distribution.

Prompts The numbers of commands and prompts given to each child during the first 3 weeks of the study were recorded and served as dependent measures. The numbers of prompts or commands given in the latter half of the study were recorded, but were not analyzed because of the forced limit that was placed on the number.

Analytic Plan

Overview Three sets of analyses were performed. The first set of analyses examined differences between boys with ADHD and control boys. For these analyses, the boys with ADHD were evaluated on days they were unmedicated. The second set of analyses examined medication effects in the subset of boys with ADHD by comparing their performance on days when they received placebo with days when they were medicated. The third set of analyses examined individual differences in seatwork completion as a function of distractor condition. All data were examined with one of three different statistical models, depending on the nature of the dependent measure: (1) Poisson log-linear mixed models were used to evaluate rule violations and teacher prompts, which were represented as count variables; (2) Binomial mixed modes with canonical link were used to evaluate the dichotomized measures of seatwork completion and on-task observations; and (3) Fisher's exact test was used to examine individual differences in seatwork completion.

ADHD/Control Analyses The between-groups comparisons consisted of repeated measures on each child for up to 24 days (depending on number of unmedicated days and attendance). Data were analyzed using Generalized Linear Mixed Models in the form of two-level hierarchical models using SAS 9.1 NLMIXED. This analytic approach was selected due to the hierarchical structure of the data, the unbalanced sample sizes, and the observed histograms. It was assumed (based on the estimated sample correlation matrix) that, given the subject specific coefficients, the repeated measures on each child were independent. Level 1 consisted of subject specific coefficients as a function of the within-subject predictors Distractor (none vs. music vs. video) and Study Half. Level 2 consisted of subject specific coefficients as a function of the between-subjects predictor Group (control vs. ADHD). Classroom (1 through 7) was also included in Level 2 as a covariate.

For on-task behavior, half of class was included as a Level 1 within-subjects factor in place of Study Half. It was not possible to include both Study Half and Class Half in a single model because of limitations on the number of factors that could be included in the analyses. Class Half was selected over Study Half because it allowed for an examination of whether children's distractibility changed across time on-task. Other dependent measures were recorded only for the class period as a whole and thus did not allow for analysis at the level of class half.

Medication Analyses[3] The second set of analyses examined whether children with ADHD differed as a function of medication. The same analytic strategy was used as described above except that only children with ADHD were included and Medication (placebo vs. MPH) was used as a within-subjects, Level 1 factor in place of the between-subjects Group factor.

Individual Differences To examine individual differences in response to distractors, children (both ADHD and control)

[3] Five boys with ADHD who were included in the ADHD/Control analyses were not included in these analyses because they were unmedicated throughout treatment. When the Group x Distractor analyses were recomputed without these five boys, the results did not differ.

were grouped by their performance on the measure of seatwork completion. Specifically, children were grouped by whether their performance *improved* by 20% over the no-distractor condition, *worsened* by 20%, or showed no effect of the distractor. This was done separately for the music and video distractor conditions. Only unmedicated days were used in computing these groups. For Experiment 1, the resulting 2 (Group: ADHD vs. control) × 3 (Change: improve vs. no change vs. worse) tables were evaluated using Fisher's Exact Test. Experiment 2 did not include control children so the percent of children with ADHD in each Change group (improve vs. no change vs. worse) are presented descriptively.

Results

ADHD vs. Control Analyses

Overview Table 2 summarizes the significance levels (*p*-values) of all effects for all dependent measures. Analyses showed that there were several significant Group x Distractor interactions but Study Half never interacted with Group. Following the primary purpose of the study, and for the sake of parsimony, only significant effects involving Group are discussed. When both main effects and interactions involving Group are significant, only the highest order interaction is discussed. Means (*M*), standard deviations (*SD*) and effect sizes (*ES*) are summarized in Table 3 for all dependent measures as a function of Group and Distractor, with *M* and *SD* presented in the original metric for ease of interpretation. Effect sizes are Cohen's D computed as (control *M* - ADHD *M*)/pooled *SD*.

Rule Violations There was a significant Group main effect (see Table 2) which showed that the rate of breaking rules was higher for children with ADHD than for controls (control: $M=0.16$, $SD=0.22$; ADHD: $M=1.63$, $SD=1.67$; $ES=1.23$).

Teacher Prompts There was a significant Group x Distractor interaction (see Table 2). Follow up tests and examination of means and effect sizes (see Table 3) showed that children with ADHD required significantly more prompts than controls in all distractor conditions, but the mean difference was largest when video was present [none: $t(65)=2.61$, $p=0.0111$; music: $t(65)=2.53$, $p=0.0138$; video: $t(65)=2.50$, $p=0.0150$].

Seatwork Completion There was a significant Group × Distractor interaction (see Table 2). Follow up tests and examination of means and effect sizes (see Table 3) showed that children with ADHD completed less seatwork than controls in all conditions, but significantly so when video was present [none: $t(63)=-1.64$, $p=0.1058$; music: $t(63)=-1.28$, $p=0.2054$; video: $t(65)=-2.11$, $p=0.0388$].

On-Task Behavior There was a significant Group x Distractor x Class Half interaction (see Table 2). Follow up tests and examination of means and effect sizes (see Table 3) showed that children with ADHD were significantly more off task than controls in all distractor conditions in both the first half of class [none: $t(65)=-2.77$, $p=0.0072$; music: $t(65)=-2.60$, $p=0.0115$; video: $t(65)=-2.91$, $p=0.0049$] and the second half of class [none: $t(65)=-3.07$, $p=0.0031$; music: $t(65)=-2.71$, $p=0.0087$; video: $t(65)=-3.72$, $p=0.0004$], but the mean difference was largest when video was present and in the second half of class.

Medication Analyses

Overview The significance levels (*p*-values) are summarized in Table 2, with means, SDs and effect sizes summarized in Table 5. Only significant effects involving Medication were followed up, and when both main effects and interactions were significant only the highest order interaction is presented. Effect sizes (*ES*) were Cohen's D computed as (medication *M*—placebo *M*)/Pooled *SD*.

Rule Violations There was a significant Medication x Distractor interaction (see Table 2). Follow up tests and examination of means and effect sizes (see Table 5) showed that children had more rule violations on placebo in all distractor conditions [none: $t(32)=-3.37$, $p=0.0017$; music: $t(32)=-3.24$, $p=0.0024$; video: $t(32)=-3.35$, $p=0.0018$], but rule violations were especially high when video was present.

Prompts There was a significant Medication x Distractor interaction (see Table 2). Follow up tests and examination of means (see Table 5) showed that teachers gave children marginally more prompts to stay on task on placebo in all distractor conditions [none: $t(33)=-1.83$, $p=0.0756$; music: $t(33)=-1.81$, $p=0.0793$; video: $t(33)=-1.81$, $p=0.0799$], but prompts were especially high when video was present.

Seatwork Completion There was a significant Medication x Distractor x Study Half interaction (see Table 2). As shown in Fig. 1, children completed significantly or marginally significantly more seatwork on medication in both the first half of the study [none: $t(32)=2.21$, $p=0.0343$; music: $t(32)=2.02$, $p=0.0521$; video: $t(32)=2.88$, $p=0.0070$] and the second half of the study [none: $t(32)=1.68$, $p=0.1025$; music: $t(32)=1.66$, $p=0.1063$; video: $t(32)=3.01$, $p=0.0051$]. Figure 1 also shows that seatwork completion declined between the first and second half of the study when

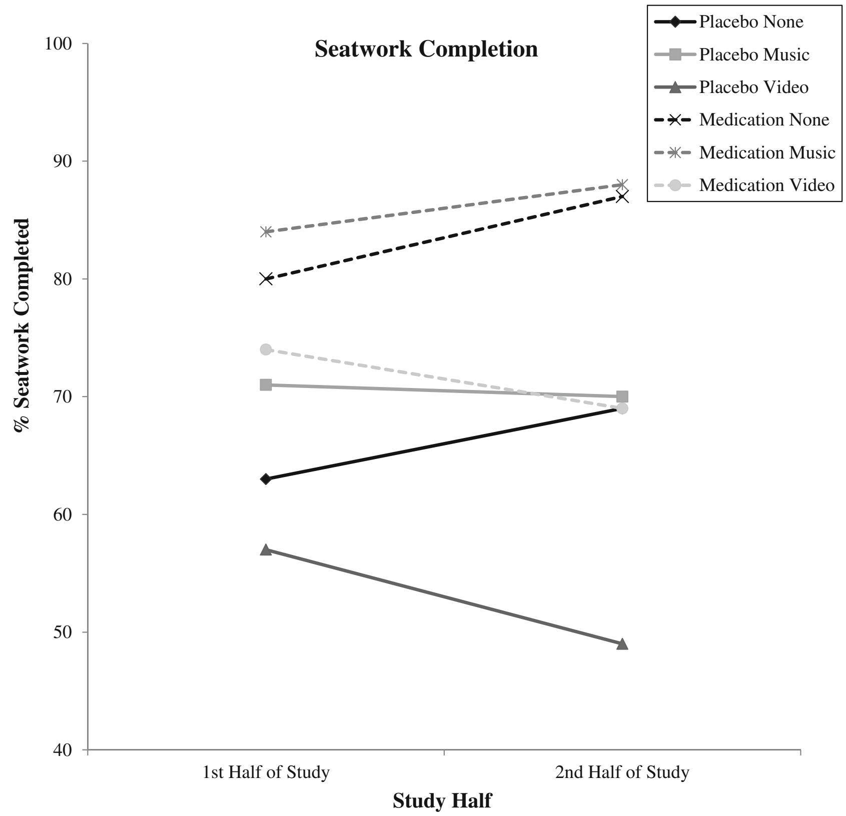

Fig. 1 Seatwork completion as a function of medication, distractor and study half

video was present, but not when music or no distractor was present.

On-Task Behavior There was a significant Medication x Distractor x Class Half interaction (see Table 2). Follow up tests and examination of means and effect sizes (see Table 5) showed that children were more on task on medication in both the first half of class [none: $t(32)=2.71$, $p=0.0108$; music: $t(32)=2.63$, $p=0.0131$; video$t(32)=3.11$, $p=0.0040$] and the second half of class [none: $t(32)=2.72$, $p=0.0105$; music: $t(32)=2.47$, $p=0.0189$; video: $t(32)=3.27$, $p=0.0026$], with lowest rates of on-task when the video was present.

Individual Difference in Seatwork Completion Analyses

Individual differences in seatwork completion are summarized in Table 4, which shows rates of change (improved, no change, or worse) in seatwork completion in response to music and video distractors, separately for each group (ADHD vs. control). Fisher's Exact Test analyses showed that rates of change differed across the two groups for both music ($p=0.0052$) and video ($p=0.0018$). As shown in Table 4, most control boys were unaffected by music (only one boy showed worsened performance and none improved), whereas boys with ADHD showed a mixed pattern of response to music: 10% of the boys' seatwork completion worsened, 61% did not change, and 29% improved. In the video condition, participants were generally more likely to do worse when video was present (56% of boys with ADHD and 23% of controls), but the boys with ADHD again showed a mixed response, with 32% showing no effect of the video and 12% showing improved performance over baseline.

Experiment 2

We were intrigued by the individual difference analyses, which revealed that some children with ADHD appeared to benefit from the presence of the radio in the classroom, so we sought to replicate those results in a new sample. We eliminated the video condition to provide more days of data for the music condition.

Method

Participants Participants were 86 boys ranging in age from 8 to 13 years ($M=9.47$, $SD=1.39$). All participants were in the 1993 or 1994 Summer Treatment Program at Western Psychiatric Institute and Clinic. All participants met criteria for a DSM-III-R diagnosis of ADHD, using measures described in Experiment 1. Forty-seven participants met DSM III-R criteria for a concurrent diagnosis of ODD and 22 participants met criteria for CD. Sixty-five of the boys were concurrently undergoing medication assessments as described in Experiment 1.

Procedures Procedures were identical to those described in Experiment 1, with the following exceptions: (1) there were two rather than three distractor conditions: no distractor and music; (2) conditions varied on a weekly basis, with no distractor in Week 1, the music distractor in Week 2, and alternating thereafter; and (3) there were no control participants. Dependent measures were identical to those in Experiment 1, except that prompts to stay on task were not analyzed because teachers were limited in how many they could use for each student.

Results

Medication Analyses

Overview Data were analyzed using the same procedures as used in the Medication analyses of Experiment 1. The outcome variables were repeated measures on each child for 24 days (with some missing observations). Analyses were conducted using SAS procedure NLMIXED version 9.1. Study half was not included as a factor because teachers were limited to three on-task prompts throughout Experiment 2. Cohen's D effect sizes (ES) were computed as in Experiment 1: (medication *M* – placebo *M*)/Pooled *SD*.

Rule Violations There was a significant main effect of Medication, $t(80)=-18.02$, $p<0.0001$, but not Distractor or Classroom, nor was there a Medication x Distractor interaction. The Medication main effect showed that boys violated more rules on placebo (placebo: $M=2.43$, $SD=2.59$; medication: $M=0.74$; $SD=1.28$; $ES=-0.65$).

Seatwork Completion There was a significant main effect of Medication, $t(80)=-18.02$, $p<0.0001$, but this was qualified by a significant Medication x Distractor interaction, $t(80)=6.51$, $p<0.0001$. Follow up tests and examination of means and effect sizes (see Table 6) showed that children completed significantly more seatwork on medication in both distractor conditions [none: $t(80)=6.82$, $p<0.0001$; music: $t(80)=6.67$, $p<0.0001$].

On Task Behavior There were significant main effects of Medication, $t(80)=35.61$, $p<0.0001$, Distractor, $t(80)=4.08$, $p<0.0001$, and Class Half,$t(80)=-6.85$, $p<0.0001$, and a significant Medication x Distractor interaction,$t(80)=-2.76$, $p=0.0072$, but this was qualified by a significant Medication x Distractor x Class Half interaction, $t(80)=2.90$, $p=0.0048$. Follow up tests and examination of means and effect sizes (see Table 6) showed that children were more on task on medication in all conditions [first class half, none: $t(80)=-5.41$, $p<0.0001$; first class half, music: $t(80)=-5.37$, $p<0.0001$; second class half, none: $t(80)=-5.52$, $p<0.0001$; second class half, music: $t(80)=-5.47$, $p<0.0001$].

Individual Differences in Seatwork Completion Analyses

As in Experiment 1, children were grouped by whether their performance in the music condition *improved* by 20% over the no-distractor condition, *worsened* by 20%, or showed no difference. Similar to Experiment 1, 7 children (8%) had worse performance in the presence of music, 66 children (76%) had no change, and 13 children (15%) had improved performance.

General Discussion

This study examined the effect of distractors (music, video, or none) on the classroom performance of boys with ADHD. Results showed that boys with ADHD were generally more disruptive, less productive, and more distracted than controls, but this was exacerbated by the presence of a video distractor (movies). In contrast, neither boys with ADHD nor controls were (as a group) significantly distracted by music. There were, however, individual differences in response to music (see Table 4 and Experiment 2); the majority of the boys with ADHD were unaffected by music, but some appeared to improve while others got worse. Finally, examination of medication effects (0.3 mg/kg methylphenidate) on the boys with ADHD showed that medication improved their ability to remain on task in the presence of the distractors.

Perhaps the most robust finding is that although children with ADHD had generally worse behavior and performance than controls in the classroom setting, the difference was exacerbated by a video distractor (see Table 3).That is, when a movie was playing in the classroom, the behavior and productivity of all children suffered, but the amount of decline was significantly greater for children with ADHD than for controls. These results seem to argue against assertions that children with ADHD are not more distractible than controls (Douglas 1999; Douglas and Parry 1983). However, not all of our findings support this assertion. Specifically, music did not distract either the boys with ADHD or the control boys as a group (see Table 3). Thus, results of this study provide mixed evidence as to whether children with ADHD are more distractible than controls because the extent to which the groups were differentially debilitated was contingent on the type of distractor. This is consistent with past research demonstrating that cognitive performance of children with ADHD is highly context dependent, varying as a function of factors such as type of background noise (Sikstrom and Soderland 2007; Soderland, et al. 2010; Soderland, et al. 2007) and speed of stimulus presentation (van der Meere et al. 2010; van der Meere et al. 2009).

Why was music significantly less distracting than the television? Armstrong and Chung (2000) review several possible ways that distractors may operate, including: (a) capacity interference, in which each person has a limited amount of general attentional capacity that can be allocated at a given time (Kahneman 1973); (b) structural interference, in which simultaneous cognitive tasks that are similar in type may interfere with each other regardless of overall attentional capacity (Armstrong 1993); (c) orienting responses elicited by the salient, attention-demanding cues from the distractor (e.g., Lang 1990); and (d) increasing physiological arousal past an optimal level (Armstrong and Greenberg 1990). In any of these four ways, videos can be seen as a more demanding distractor than music, particularly for children with ADHD. Likewise, as described earlier, Douglas (1983) has discussed several factors that may elicit distractibility in children with ADHD: boredom, distaste or difficulty associated with the task, salience of the distractor, and failure to inhibit responding to irrelevant stimuli. The fact that video was arguably more salient (visual plus auditory versus auditory only) suggests that this too may explain why video was a more potent distractor for children with ADHD. In fact, previous research has demonstrated that differences between ADHD and controls emerge only for salient distractors (Rosenthal and Allen 1980).

An important caveat is that there were considerable individual differences in response to the distractors (see Table 4 and Experiment 2). Specifically, although most boys showed no change in seatwork completion when music was present, some improved and others got worse. Other research has also shown that there are individual differences among children with ADHD in response to music as a distractor (van Mourik, et al. 2007). Consistent with theory (Sergeant, et al. 1999; van der Meere 2005; Zentall 1977), one explanation for this pattern is that the individual differences in response to the distractors may reflect differences in underlying arousal. Thus, our findings may suggest that there are three subgroups of boys with ADHD: (1) boys who are under-aroused and are helped by the addition of a low-level stimulus; (2) boys for whom a low-level stimulus has neither positive nor negative effects; and (3) boys for whom even a low-level extraneous stimulus has distracting effects. Consistent with this explanation, other research shows that differences in response to background music on cognitive task performance is associated with other differences, namely introversion versus extraversion (Furnham and Bradley 1997). Future studies of distractibility (and by implication, sustained and other types of attention) may benefit from similar individual difference analyses among the children with ADHD.

Our results also showed that stimulant medication (methylphenidate) significantly reduced the distractor effects in children with ADHD, bringing their functioning to the level of the control children on most measures. These effects are consistent with those reported in many other studies that have examined medication effects on cognitive task performance and on classroom functioning (see Swanson et al. 1995 for a general review). The current study adds to these by examining effects of medication on different types of distractors as evaluated in a naturalistic classroom situation.

In one sense, the ecological validity of our distractors was not high because music and videos are not typically found in elementary school classrooms. In another sense, however, our results may be generalizable to the home environment as most school students report that they play a radio or watch television while doing homework, and observational studies have confirmed this (Patton et al. 1986). Several studies have examined the effects of radio and television on solitary study assignments in older, normal populations, and have found results that support the generalizability of our results (Armstrong and Chung 2000; Cool et al. 1994; Pool et al. 2003; Pool et al. 2000). For example, past research found minimal effects of radio on completing homework assignments, but a significant negative impact of television (Pool, et al. 2003; Pool, et al. 2000).

There are several limitations to this investigation. First, the no-distractor condition was not as purely non-distracting as in other research. In fact, the classrooms used in this study had posters and other decorations on the walls, name tags on the desks and other stimuli which could serve as distractors. Also, the teachers give public feedback to students throughout the period, and independent classroom observers were present and were visible to the children. Further, the majority of children in each class were diagnosed with ADHD and could be quite disruptive, which may have been an additional salient distractor at times (Felmlee et al. 1985). Therefore, differences between the no-distractor and distractor conditions may have been minimized. Second, seatwork measures were designed to be at children's current independent seatwork ability level and largely asked about factual information. Our results can only be generalized to situations where children are completing similar types of seatwork. Likewise, the boys in this study worked on a variety of assignments including math worksheets, reading, spelling, and language arts during each daily classroom period but our methodology does not allow us to assess the effects of the distractors on each different type of assignment. Third, as is common in studies comparing children with ADHD to controls, the groups differed on measures of academic achievement (see Table 1). It is therefore possible that differences in response to the distractors partially reflect differences in achievement rather than ADHD. Assignments were individualized to children's ability levels to control for these differences, but achievement cannot be ruled out as a contributing factor to our reported group differences.

There are several possible directions for future research. In addition to assessing effects of the distractors on different types of tasks, a wider variety of distractors could be studied. For example, comparing a video recording of a news broadcast to video movies, familiar versus unfamiliar music, or comparing different types of music could clarify whether they have differential enhancement/distraction effects on children's attention. The video movies and radio broadcasts we used in this study were of distinct subject matter in addition to modality. Pool et al. (2003), in a study of homework completion in normal eighth-grade students, compared radio music, music videos, and a narrative television program, and showed that only the narrative TV program affected students' performance on their homework assignments. Comparing a "book on tape" to a video movie of the same book, or a radio broadcast with music videos, could help to identify what is and is not a potent distractor in an ADHD sample.

Finally, there are potential clinical implications of this study. Our individual-difference findings seem to support the theory that some children with ADHD require a more stimulating environment to maximize their behavior and performance (Zentall 1977). Thus, rather than recommending that children with ADHD perform homework in complete silence, our results suggest that listening to music while studying will not hurt most and may help some children with ADHD. Rather than isolating a child with ADHD in a stimulus-free environment, these findings suggest that providing the child with headphones on which he or she could listen to music while working may enhance the classroom productivity of some children with ADHD.

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