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## Verbal Dichotic Listening in Boys at Risk for Behavior Disorders

[Article]

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### Abstract

Objective: The association between deficits in verbal processing skills and disruptive

psychopathology remains one of the most frequently replicated findings in all of child psychiatry. This study uses a dichotic consonant-vowel listening test to examine the potential neural basis for this association.

**Method:** A series of 87 young boys recruited from a sample at risk for disruptive disorders received standardized psychiatric, neuropsychological, and language skills assessments. Approximately year later, these boys received a reassessment of their psychiatric status and a test that assesses the neural basis of language-processing ability, a dichotic consonant-vowel listening test.

**Results:** Disruptive psychopathology predicted reduced right ear accuracy for dichotic syllables, indicative of a deficit in left hemisphere processing ability. Deficits in reading and language ability also correlated with right ear accuracy for dichotic syllables.

**Conclusions:** Boys with disruptive behavior disorders, relative to at-risk but nondisruptive boys, exhibit a deficit in verbal processing abilities on dichotic listening tasks. This deficit in verbal processing ability is also manifested as low scores on standardized tests of reading achievement and language comprehension. *J. Am. Acad. Child Adolesc. Psychiatry*, 1997, 36(10):1465-1473.

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Key Words: lateralization, dichotic listening, disruptive psychopathology, children.

The association between disruptive psychopathology and a deficit in verbal skills is one of the most frequently replicated findings in all of child psychiatry. As reviewed by Moffit (1993) [19], the most consistent evidence for this association derives from research using verbal intelligence quotient (VIQ), as assessed with standardized intelligence tests. An association between disruptive behavior and a deficit in VIQ has been found in at least 20 studies. It is found in both clinical and epidemiological samples across three continents (e.g., Moffit and Silva, 1987; Rutter and Giller, 1983) [20,29]. This association appears in studies that use a variety of research designs and that employ diverse measures of disruptive behavior, including self-report, official records, and parent or teacher reports.

Schonfeld et al. (1988) [30] summarized the three most frequently posited mechanisms for the association between a VIQ deficit and childhood disruptive behavior. First, disruptive children may fail to learn early in school, setting up a cycle of declining school performance and an eventual deficit in VIQ. This mechanism has been considered unlikely, since deficits in VIQ are associated with disruptive behavior very early in life, perhaps even before the beginning of school (Richman et al., 1982) [28]. Second, a VIQ deficit might contribute directly to the development of childhood disruptive behavior. For example, low VIQ might impair children's ability to perceive social cues, setting in motion experiences that lead directly to childhood aggression (Dodge et al., 1990) [12]. Schonfeld et al. (1988) [30] note that this hypothesis receives modest support in the literature. Third, the association between VIQ and childhood disruptive behavior might result from the effects of third antecedent factors that are causally related to both VIQ and disruptive behavior. For example, Pine et al. (1997) [24] suggest that both a VIQ deficit and disruptive behavior might result from common biological antecedents.

If this association between low VIQ and disruptive behavior results from biological factors, children with disruptive disorders might exhibit abnormalities in neural systems important for language processing. Dichotic listening tests measure lateralized brain functions by assessing an individual's ability to perceive competing stimuli presented simultaneously to the two cerebral hemispheres. The integrity of language-relevant systems can be assessed by simultaneously presenting different consonant-vowel syllables to each ear as part of a dichotic listening test. Hare and McPherson (1984) [15] showed that adult psychopaths exhibited poor left hemisphere language-processing skills on such tests, findings that were extended to adolescents by Raine et al. (1990) [27] and Becker et al. (1993) [4]. These studies suggest that dichotic listening performance may be associated with disruptive behavior in

young children.

To our knowledge, no prior study considers the relationship between dichotic listening performance and disruptive behavior disorders in young children. This study examines this issue in the context of an ongoing high-risk study (Wasserman et al., 1996) [35]. Prior studies show that disruptive behavior in both adolescents and adults is related specifically to reduced right ear (left hemisphere) advantage for consonant-vowel pairs (Hare and McPherson, 1984; Raine et al., 1990) [15,27]. Therefore, we hypothesize the existence of a similar association in preadolescent boys. Furthermore, the current report also examines relationships among dichotic listening test performance, age, cognitive ability, and language ability, while also considering these variables' effects on associations between dichotic performance and disruptive psychopathology.

## **METHOD**

### **Subjects**

Court records for nearly 1,200 consecutively adjudicated delinquents were reviewed to identify a set of 126 high-risk boys, all of whom were the younger brothers, aged 6 to 10 years, of adjudicated delinquents (Wasserman et al., 1996) [35]. Families who participated did not differ on any measure for which we had data from families who refused participation. All 126 boys received an initial psychiatric, neuropsychological, and language assessment in 1992-1993 (time 1). In 1994-1995 (time 2), 110 boys who could be tracked (87%) received follow-up psychiatric assessments. All 110 were invited to participate in an assessment of lateralized brain functions; 100 (91%) participated. Thirteen boys were excluded from the study, six because of a hearing loss and seven because they were unable to perform the dichotic listening test. There were no statistically significant differences on any variable for which we had data between the 87 boys examined in the current report and the 39 boys without dichotic listening data.

Participating boys were 8.6 +/- 1.6 years old on average at time 1 and 9.7 +/- 1.6 years old on average at time 2, with a range from 6 to 13 years old at time 2. The sample included 57 African-American, 27 Hispanic, and three Caucasian boys. As discussed in Wasserman et al. (1996) [35], most boys came from low-income households, with high rates of environmental adversity.

### **Procedures**

This study was approved by the institutional review board, and all families provided informed consent. Boys received psychiatric, neuropsychological, language, and dichotic listening assessments in this study.

**Psychiatric Assessments.** As described by Wasserman et al. (1996) [35], psychopathology was assessed at both time 1 and time 2 using parental reports on the Child Behavior Checklist (CBCL) and the Diagnostic Interview Schedule for Children (DISC-P 2.3), administered by trained lay interviewers. Both measures exhibit acceptable psychometrics, particularly for disruptive psychopathology (Achenbach, 1991; Jensen et al., 1995; Schwab-Stone et al., 1996) [1,16,31]. Time 1 assessments were conducted during home visits; time 2 assessments were conducted during day-long visits to our center. The same caretaker was the informant at both assessments.

**Neuropsychological and Language Assessments.** The neuropsychological and language assessments were conducted approximately 2 weeks after the time 1 psychiatric assessment. We selected three tests for the current report that assessed constructs linked previously to both lateralized brain functions and disruptive psychopathology. These include a measure of language ability-the Grammatical Understanding subscale of the Test of Language Development (TOLD-2P) (Newcomer and Hammill, 1988) [21]; a measure of intelligence-the Wechsler Intelligence Scale for Children (WISC-III); and a measure of reading ability-the Reading Achievement score from the Wechsler Individual Achievement Test

(WIAT-III) (Psychological Corporation, 1992) [26]. Each measure possesses satisfactory reliability and is a standard measure of childhood language or cognitive ability. All boys were tested in English by a master's-level psychologist; there were no statistically significant differences on any measure between Hispanic children and children of other ethnicity.

**Dichotic Listening.** Dichotic listening tests were conducted during time 2 visits to Columbia University. Subjects spent 2 hours in our biopsychology laboratory, where they received a series of tests, including audiometric evaluations, the Edinburgh Handedness Inventory (Oldfield, 1971) [22], quantitative EEGs, and verbal dichotic tests.

The audiometric evaluation was used to exclude boys with hearing loss > 30 dB at 500, 1,000, 2,000, or 4,000 Hz or between-ear hearing differences > 10 dB. Subjects who passed this audiometric evaluation (n = 94; 94%) were tested using a dichotic consonant-vowel identification test (Berlin et al., 1973) [6], played on a reel-to-reel tape deck through balanced TDH-49 headphones. Headphones were calibrated to yield 75-dB SPL outputs from each phone; midway through the test the earphone orientation was reversed to further ensure balanced output. The dichotic test consisted of randomly paired stop consonant-vowels (ba, da, ga, ka, pa, ta). Dichotic pairs consisted of simultaneously presented different syllables to each ear. The six consonant-vowel stimuli were paired with each of the others an equal number of times, resulting in 15 trials that were repeated in a second sequence to form 30 trials. These 30 trials were presented a second time with the ear presentation reversed.

Dichotic listening tests were administered in a quiet room by an experimenter who was blind to the boys' status on other variables. Boys received detailed explanations of the procedures, and 16 monaural practice trials were presented to determine accuracy in each ear. Seven boys (7.4%) were excluded who could not perform this task accurately. Fourteen dichotic practice trials were then administered to the 87 boys who are the subjects of the current report, followed by the first 30 dichotic test trials. A 5-minute rest was given before completing the final 30 trials.

To record responses, boys were provided with a multiple-choice answer sheet containing a random sequencing of the six possible syllables presented during the test. Boys indicated their responses immediately after the stimuli were presented by marking the two syllables they perceived. Boys were told to guess when necessary.

The dichotic consonant-vowel test yields three accuracy scores: (1) percentage single right ear correct (number of correct reports of right ear syllables/total syllables presented); (2) percentage single left ear correct (number of correct reports of left ear syllable/total syllables presented); and (3) percentage double correct (number of correct reports of both right and left ear syllables/total trial number). These three variables served as the study's dependent measures.

While the acoustic pathways are bilateral, dominant pathways for language run contralaterally, from the right ear to the left hemisphere, and the ipsilateral pathway, from the left ear to the left hemisphere, is suppressed during the processing of dichotic consonant-vowel syllables. Therefore, beginning in early childhood, subjects typically exhibit higher scores on single right than single left measures, indicative of the left hemisphere's dominance for language (Berlin et al., 1973; Kimura, 1961) [6,17]. This is described as the "right ear/left hemisphere advantage" for consonant-vowel syllables in literature on lateralized brain functions. In contrast to the right ear correct score, the double correct score is thought to assess the integrity of more complex brain circuitry, which relates to total information-processing capacity (Berlin et al., 1973; Porter and Berlin, 1975) [6,25], as well as language ability. These circuits mature later than the circuit associated with right ear advantage. As a result, double correct scores reach adult levels around age 9, at least 4 years later than the right ear advantage for single correct scores.

There is good evidence to support the validity of the dichotic listening test as an index of language dominance. Studies using carotid sodium Amytal test to determine language dominance find that right

ear advantage is associated with left hemisphere dominance (Zatorre, 1989) [36]. Brain-related potentials to consonant-vowel syllables are greater over the left than right parietotemporal regions in adults, and right ear advantage for dichotic consonant-vowel syllables is associated with activation of left parietotemporal regions (Ahonniska et al., 1993; Davidson and Hugdahl, 1996) [2,10]. Finally, individuals with lesions in left hemisphere language systems exhibit deficits on verbal dichotic tasks (Bruder, 1991) [8].

## Statistical Analyses [↗](#)

The main analyses considered the relationship between disruptive behavior and the three dichotic listening performance measures. We rely exclusively on a categorical rather than a continuous approach to psychiatric data. A continuous approach would consider the relationship between dichotic performance and psychiatric symptoms, as distributed throughout the population, whereas we were specifically interested in psychopathology, as an abnormal condition. Prior studies on dichotic listening performance have adopted the categorical approach (Becker et al., 1993; Bruder et al., 1987; Raine et al., 1990) [4,7,27]. The categorical approach to our data facilitates comparisons with preexisting studies.

The 87 boys were dichotomized on measures of disruptive psychopathology using two coding schemes: one based on the DISC and another on the CBCL. We considered various schemes for integrating dichotomous data from times 1 and 2. Since there are differences between persisting and remitting disorders, regression models were fit that included time 1 data alone, time 2 data alone, both time 1 and time 2 data, as well as their interaction. In general, similar associations emerged for time 1 and time 2 data treated separately, but analyses considering the independence of these associations or the interaction between time 1 and time 2 classifications were complicated by multicollinearity.

In the analyses presented below, boys were classified using both the time 1 and time 2 assessments by considering any boy as "affected" if he met preset criteria at either time 1 or time 2 and by considering any boy as "unaffected" if he failed to meet these criteria at both time 1 and time 2. This approach is consistent with the observation that children with disruptive disorders may fluctuate around the diagnostic threshold for a disorder (Lahey et al., 1995) [18]. It would be misleading to classify a boy who met criteria only at time 1 in the same category as a boy who met criteria at neither time 1 nor time 2. Results using other classification schemes are available on request.

For the DISC, the categorization scheme considered boys to be "affected" when they met criteria for at least one of the three disruptive behavior disorders: attention-deficit hyperactivity disorder (ADHD), oppositional defiant disorder (ODD), or conduct disorder (CD). For the CBCL, the categorization scheme considered boys to be "affected" if they scored above the 95th percentile on the national norms for either the Attention Problems, Aggression, or Delinquency subscales at either time 1 or time 2. These three scales were selected as they correspond to the three disruptive behavior disorders assessed by the DISC.

Two sets of multivariate analyses of variance (MANOVAs) were performed using psychiatric group as the independent variable, as defined on the DISC or CBCL, and percent correct right, percent correct left, and percent double correct as the dependent measures. Significant MANOVAs were followed by analysis of variance for dependent measures. Finally, post hoc analyses considered associations with more narrowly defined psychiatric constructs (i.e., ADHD on the DISC or elevated Delinquency score on the CBCL).

In a set of secondary analyses, relationships among dichotic performance and measures of cognitive or language function were examined using Pearson correlations and multivariate regression analyses. Each measure of dichotic performance was regressed on relevant developmental, cognitive, and language measures. These analyses were followed by a series of analyses of covariance (ANCOVAs), examining the association between disruptive psychopathology and dichotic performance, while

covarying for neuropsychological and language function.

## RESULTS <sup>‡</sup>

### Sample Characteristics <sup>‡</sup>

A total of 28 (32%) boys met criteria for a disruptive behavior disorder, including 20 with ADHD, 17 with ODD, and six with CD. ODD and CD were combined in the data analysis, as the two disorders have been considered developmentally related constructs in young children (Wasserman et al., 1996). Among these 28 boys, 7 had only ADHD, 4 had only ODD/CD, and 17 had both ADHD and ODD/CD.

On the CBCL, 24 boys (28%) scored above the 95th percentile on either the Attention Problems, Delinquency, or Aggression subscales, including 17 with an elevated Attention Problems score, 19 with an elevated Delinquency score, and 24 with an elevated Aggression score. There was considerable overlap among these categories. Only 4 boys had elevated scores on a single subscale; 8 had elevated scores on two subscales; and 12 had elevated scores on all three.

As a group, boys in the current sample exhibited the expected profile on the consonant-vowel dichotic listening test. Namely, the percentage correct for the right ear (58 +/- 12) was significantly higher ( $t[87] = 7.6, p < .001$ , paired t test) than for the left ear (44 +/- 11). As noted above, since dominant neural pathways from the ear to the cortex are contralateral, this "right ear advantage" reflects the left hemisphere specialization for language. Nearly half of the boys exhibited signs of language delay on the TOLD-2P. Thirty-eight boys (45%) scored below the 10th percentile on national norms for this measure, and 21 boys (15%) scored below the 5th percentile.

### Performance and Disruptive Behavior <sup>‡</sup>

DISC Categorization. Results from the analyses comparing dichotic listening performance between groups of boys with and without DISC disruptive diagnoses are presented in [Table 1](#). A MANOVA of these data revealed an overall difference in accuracy between groups ( $F[3,83] = 5.4, p = .002$ ) which arose from disruptive boys' poorer ability to perceive sounds presented to the right ear. Subsequent post hoc analyses examined dichotic performance in both ADHD and ODD/CD groups, relative to boys with neither ADHD nor ODD/CD. While either diagnosis predicted reduced right ear advantage, the sample included only four boys with ODD/CD but without ADHD. Therefore, there are insufficient cases to allow consideration of diagnostic specificity for reduced right ear advantage in ADHD versus ODD/CD diagnoses.

DISC Categories	% Double Correct		% Left Correct		% Right Correct	
	Score	Statistic <sup>b</sup>	Score	Statistic <sup>b</sup>	Score	Statistic <sup>b</sup>
No disruptive diagnosis <sup>a</sup> ( <i>n</i> = 59)	20 ± 8		44 ± 10		60 ± 12	
Any disruptive diagnosis <sup>a</sup> ( <i>n</i> = 28)	18 ± 7	$F(1,85) = 0.7$	44 ± 12	$F(1,85) = 0.0$	52 ± 10	$F(1,85) = 10.2^{**}$
ADHD ( <i>n</i> = 20)	20 ± 8	$F(1,77) = 0.0$	44 ± 11	$F(1,77) = 0.2$	53 ± 12	$F(1,77) = 6.6^{**}$
ODD/CD ( <i>n</i> = 19)	17 ± 7	$F(1,76) = 1.6$	44 ± 13	$F(1,76) = 1.6$	52 ± 12	$F(1,76) = 7.9^{**}$
Multivariate tests						
Omnibus test for difference across the three dichotic measures		Comparison of no disruptive vs. any disruptive: $F(3,83) = 5.4^{**}$ Comparison of no disruptive diagnosis vs. ADHD: $F(3,75) = 4.4^{**}$ Comparison of no disruptive diagnosis vs. ODD/CD: $F(3,74) = 5.3^{**}$				
<p>Note: DISC = Diagnostic Interview Schedule for Children; ADHD = attention-deficit hyperactivity disorder; ODD/CD = either oppositional defiant (ODD) or conduct disorder (CD).</p> <p><sup>a</sup>Subjects with disruptive diagnosis meet criteria for ADHD, ODD, or CD at either time 1 or time 2.</p> <p><sup>b</sup><i>F</i> statistics from analysis of variance comparing no disruptive group with row (any disruptive, ADHD, or ODD/CD).</p> <p><sup>**</sup><i>p</i> &lt; .01.</p>						

Table 1 Performance on Dichotic Listening Test as a Function of DISC Diagnosis

CBCL Categorization. Similar results were found using the CBCL (Table 2). Namely, there was a significant between-group difference on the MANOVA ( $F[3,83] = 3.0, p = .02$ ), using elevated CBCL score on either Attention Problems, Delinquency, or Aggression as the grouping factor, which arose from the significantly poorer right ear performance among the boys with an elevated Attention Problems, Delinquency, or Aggression CBCL subscale score. The individual MANOVA for each of the three CBCL categories suggested that all three CBCL subscales predicted reduced right ear advantage. However, as with the DISC data, there were too few cases discordant on subscales to consider the specificity of this finding.

CBCL Categories	% Double Correct		% Left Correct		% Right Correct	
	Score	Statistic <sup>a,b</sup>	Score	Statistic <sup>a,b</sup>	Score	Statistic <sup>a,b</sup>
No elevation <sup>a</sup> on CBCL scales ( <i>n</i> = 59)	18 ± 8		44 ± 10		59 ± 11	
Elevation <sup>a</sup> on Attention Problems, Delinquency, or Aggression Scale ( <i>n</i> = 28)	18 ± 7	$F(1,83) = 0.3$	44 ± 12	$F(1,83) = 0.3$	54 ± 12	$F(1,83) = 5.5^*$
Elevation <sup>a</sup> on Attention Problems ( <i>n</i> = 17)	18 ± 7	$F(1,74) = 0.5$	45 ± 12	$F(1,81) = 0.8$	51 ± 12	$F(1,81) = 8.1^{**}$
Elevation <sup>a</sup> on Delinquency ( <i>n</i> = 19)	18 ± 7	$F(1,76) = 0.0$	44 ± 14	$F(1,76) = 0.0$	52 ± 13	$F(1,76) = 6.4^{**}$
Elevation <sup>a</sup> on Aggression ( <i>n</i> = 24)	18 ± 7	$F(1,81) = 0.3$	43 ± 14	$F(1,81) = 0.2$	53 ± 12	$F(1,81) = 5.0^*$
Multivariate tests						
Omnibus tests for difference across the three dichotic measures	Comparison of no elevation <sup>a</sup> vs. any elevation: $F(3,83) = 3.0^*$ Comparison of no elevation <sup>a</sup> vs. attention problems: $F(3,72) = 3.6^*$ Comparison of no elevation <sup>a</sup> vs. delinquency: $F(3,75) = 5.4^{**}$ Comparison of no elevation <sup>a</sup> vs. aggression: $F(3,79) = 3.6^*$					
<i>Note:</i> CBCL = Child Behavior Checklist. <sup>a</sup> Subjects with elevated score are above the 95th percentile on one of three CBCL scales (Attention Problems, Delinquency, or Aggression) at either time 1 or time 2. <sup>b</sup> <i>F</i> statistic from analysis of variance comparing group in row with group with no elevation on Attention Problems, Delinquency, or Aggression scales at both time 1 and time 2. <sup>*</sup> $p < .05$ ; <sup>**</sup> $p < .01$ .						

Table 2 Performance on Dichotic Listening Test as a Function of CBCL Categories

## Dichotic Performance, Cognitive Ability, and Linguistic Ability <sup>†</sup>

(Table 3) presents univariate correlations among each dichotic listening measure, age, and a set of cognitive measures: intelligence (WISC-III), reading achievement (WIAT-III), and language ability (TOLD-2P). Given the number of correlations in Table 3, we rely on an  $\alpha = .01$  for statistical interpretation. As shown in Table 3, both the percent double correct score and the percent right ear correct score were positively correlated with language and reading measures. It is interesting that while the percent double correct score improved across ages, neither the percent right nor the percent left ear correct scores related to age.

	DC	RC	LC	Age	FSIQ	VIQ	PIQ	READ
RC	.54**							
LC	.57**	-.13	.17					
Age	.26*	.03	.14					
FSIQ	.13	.17	.12	-.23				
VIQ	.12	.14	.13	-.23	.91**			
PIQ	.11	.15	.20	-.19	.89**	.59**		
READ	.31*	.29*	.13	-.22	.64**	.67**	.45**	
TOLDS	.29*	.29*	.18	.10	.51**	.50**	.38**	.39**

*Note:* DC = percent double correct score; RC = percent right correct score; LC = percent left correct score; FSIQ = Full Scale IQ; VIQ = Verbal IQ; PIQ = Performance IQ; READ = Reading Achievement score; TOLDS = Test of Language Development Grammatical Understanding score.  
\* $p < .01$ ; \*\* $p < .001$ .

Table 3 Correlations Among Dichotic, Psychological, and Language Test Scores

Given the correlations among percent double correct, percent right ear correct, and cognitive measures, a series of multivariate regression models were fit. In the first model, percent double correct score was regressed on age, VIQ, reading, and language scores. In this model, both older age ( $B = .77 \pm .38$ ,  $t[80] = 2.0$ ,  $p < .05$ ) and a higher WIAT-III Reading score ( $B = .13 \pm 0.04$ ,  $t[80] = 3.4$ ,  $p < .001$ ) predicted a higher percent double correct score ( $R^2 = .23$ ,  $F[4,80] = 5.8$ ,  $p < .001$ ). In the second model, percent right ear correct was regressed on age, VIQ, reading, and language scores. In this model, both a higher TOLD-2P score ( $B = .01 \pm .005$ ,  $t[80] = 2.7$ ,  $p < .01$ ) and a higher WIAT-III Reading score ( $B = .002 \pm .001$ ,  $t[80] = 2.4$ ,  $p < .01$ ) predicted a higher percent right ear correct score ( $R^2 = .17$ ,  $F[4,80] = 4.1$ ,  $p < .01$ ).

Given that reduced right ear performance on the dichotic task was associated with both increased disruptive psychopathology and poorer cognitive or language skill, associations between dichotic performance and disruptive psychopathology were reexamined, while covarying for cognitive and linguistic measures. The percent right ear correct score was compared between disruptive and nondisruptive subjects, using either the DISC or the CBCL in two separate ANCOVAs that included both cognitive and language standardized scores as covariates. Results suggested that both behavior and cognitive indices predict reduced percent right ear correct score. Defining disruptive behavior with the DISC, disruptive status remained a predictor of reduced right ear correct ( $F[1,80] = 8.8$ ,  $p = .004$ ), as did poorer reading ( $F[1,80] = 6.2$ ,  $p = .01$ ) and language skills ( $F[1,80] = 7.2$ ,  $p = .007$ ). Similarly, defining disruptive behavior with the CBCL, disruptive status remained a predictor of reduced right ear correct ( $F[1,80] = 5.3$ ,  $p = .02$ ), as did poorer reading ( $F[1,80] = 7.3$ ,  $p = .008$ ) and language skills ( $F[1,80] = 6.7$ ,  $p = .01$ ). For the above analyses, regression models were also fit that included interactions between disruptive status and language or reading performance. No significant interactions were found in any model, suggesting that associations between disruptive psychopathology and dichotic performance is not moderated by language or reading disability.

Finally, we examined correlations between dichotic performance and a series of potentially confounding variables, including measures of social class, internalizing psychopathology from the DISC or CBCL, ethnicity, and handedness. None of these measures showed any correlation with dichotic performance.

## DISCUSSION <sup>†</sup>

Three main findings emerged from this study. First, children with disruptive disorders showed neurally based signs of abnormal language-processing on a dichotic consonant-vowel listening task, manifested as a reduced ability to perceive syllables presented to the right ear. Such a reduced ability to perceive right ear syllables implicates dysfunction of the left temporal cortex (Bruder, 1991) [8]. This finding is consistent with prior studies among both adults (Hare and McPherson, 1984) [15] and adolescents (Becker et al., 1993; Raine et al., 1990) [4,27]. Second, performance on the dichotic listening

test correlated with measures of language and reading skill, results that are also consistent with prior studies (Tallal et al., 1985, 1996) [33,32]. Finally, in multivariate models, both behavioral and cognitive deficits predicted reduced right ear (left hemisphere) advantage for consonant-vowel syllables on the dichotic listening test. This suggests that behavioral and cognitive measures exhibit independent associations with lateralized brain functions.

## Clinical Implications [↗](#)

These findings raise questions about the nature of the association between disruptive psychopathology and clinically manifested language delay. Beitchman et al. (1996) [5] and Cohen et al. (1993) [9] have summarized extensive research describing comorbidity between disruptive behavior disorders and language delay. This literature calls attention to the need for speech/language assessment among children with disruptive disorders. As noted by Cohen et al. (1993) [9], communication deficits are often unrecognized and can interfere with a child's ability to benefit from treatment.

It should be noted that clinically defined language delay and deficient dichotic listening performance are related but distinct constructs. Only a subset of children with language delay exhibit dichotic listening abnormalities (Tallal et al., 1996) [32], while the associations between dichotic performance and disruptive disorders in our study was independent of linguistic skill. Similarly, there was no interaction between language performance and psychiatric status in predicting dichotic performance, suggesting that the association between disruptive behavior and dichotic performance is not moderated by language proficiency. Language delay and deficiency on dichotic tasks, therefore, may identify different clinical subgroups. There is some weak evidence that clinical language delay is most closely related to ADHD (Beitchman et al., 1996; Cohen et al., 1993) [5,9], while dichotic listening abnormalities relate to CD or ODD (Raine et al., 1990) [27]. Further study of relationships among language delay, dichotic listening performance, and each disruptive disorder is clearly indicated.

Further research might also examine the association between dichotic performance and the course of childhood disruptive behavior. The association between left hemisphere processing deficits on dichotic tests and disruptive psychopathology has now been demonstrated from preadolescence through adulthood (Becker et al., 1993; Hare and McPherson, 1984; Raine et al., 1990) [4,15,27]. Given that dichotic listening abnormalities are correlates of disruptive behavior throughout life, such abnormalities might identify disruptive children particularly at risk for continuing disruptive disorders as adolescents and adults. Future research in large, prospectively assessed samples is needed to examine critically this possibility.

Our results may also carry implications for the development of novel treatments. For example, Tallal et al. (1996) [32] recently showed that an innovative speech/ language intervention minimizes linguistic impairment in children who cannot process rapidly changing stimuli, such as dichotic consonant-vowel syllables (Tallal et al., 1996) [32]. It may be possible to develop comparable interventions designed to address underlying abnormalities in brain lateralization among children with disruptive disorders.

## Biological Implications [↗](#)

These results carry a number of biological implications. The mechanism responsible for the frequently noted association between childhood VIQ deficits and disruptive psychopathology remains incompletely understood. Two theories on the association have received modest support, one suggesting that VIQ deficits are causally linked to disruptive psychopathology (Schonfeld et al., 1988) [30] and another suggesting that the association derives from the effect of common neural antecedents (Pine et al., 1997) [24]. Our results are consistent with this latter model.

These two models carry different implications for future research. If VIQ deficits are causally linked to disruptive psychopathology, prevention research might consider the beneficial effect on disruptive

behavior of treatments which alleviate cognitive deficits in young children. Alternatively, if common neural antecedents produce the VIQ-disruptive behavior association, prevention research might target biological factors that are thought to produce the association.

A role for biological factors in the association between VIQ and CD would carry implications for ongoing genetic and neuroimaging research. For example, an inherited abnormality in brain lateralization might lead to language, cognitive, and behavioral abnormalities (Annett and Manning, 1990; Geschwind and Galaburda, 1987) [3,13]. Our results link behavioral, language, and cognitive abnormalities with a measure of lateralized brain function, raising questions on the utility of the dichotic listening test in refining phenotype definitions for genetic analyses. Similarly, our results are compatible with other research documenting brain lateralization abnormalities in children with disruptive disorders. Neuroimaging and neurophysiology studies in both children and adults suggest that disruptive behavior disorders or impulsive aggression may be associated with absence of the usual lateralized brain profile (Peterson, 1995; Ucles and Lorente, 1996) [23,34].

## Limitations and Conclusions [↗](#)

A number of factors limit the generalizability of our findings. All the children in this study were the brothers of adjudicated delinquents; most were from minority families; and the sample as a whole exhibited relatively high rates of social adversity (Wasserman et al., 1996) [35]. Moreover, nearly half of the boys had low scores on the Grammatic Understanding subscale of the TOLD-2P. Although the association between disruptive behavior and dichotic performance was independent of performance on the TOLD-2P, such associations may be most prominent in samples such as ours that exhibit relatively high rates of clinical language delay (Beitchman et al., 1996) [5].

In light of this limitation, it will be important to undertake studies in samples of girls and in samples of children from diverse social backgrounds. Nevertheless, the best evidence for generalizability derives from replication in diverse populations. The generalizability of our results is supported by the similarities with results in adolescents and adults from diverse social and ethnic groups (Becker et al., 1993; Hare and McPherson, 1984; Raine et al., 1990) [4,15,27]. Moreover, boys in the current study without disruptive disorders exhibited dichotic listening results very similar to those in similarly aged normal volunteer children studied in our laboratory (Bruder et al., 1987) [7] and in other laboratories (Berlin et al., 1973) [6].

The specificity of the association between brain lateralization abnormalities and disruptive psychopathology remains an open question. Evidence for abnormal brain lateralization is found in various disorders, including schizophrenia, affective disorders, and disruptive disorders (Bruder, 1991) [8]. Two explanations might account for the presence of lateralization abnormalities in nosologically distinct conditions. First, different abnormalities may be involved in specific disorders. For example, abnormalities in frontal asymmetries appear to be important for depressive disorders (Davidson, 1994) [11], while abnormalities in posterior asymmetries may be more important for disruptive disorders (Graae et al., 1996) [14]. Right ear advantage for dichotic consonant-vowel syllables is associated with activation of left parietotemporal regions (Ahonniska et al., 1993; Davidson and Hugdahl, 1996) [2,10]. The dichotic listening test used in the current study assesses such posterior asymmetries. Hence, our results and prior studies (Becker et al., 1993; Graae et al., 1996; Hare and McPherson, 1984; Raine et al., 1990) [4,14,15,27] might indicate a specific role for the posterior left hemisphere in disruptive disorders. Second, abnormal lateralization may underlie a broad diathesis to psychiatric disorders. For example, Geschwind and Galaburda (1987) [13] posited a role for abnormal temporal lateralization in cognitive, behavioral, and emotional problems, suggesting that posterior left hemisphere abnormalities might be present in conditions besides disruptive disorders. Prior studies in both children and adults provide some evidence of this possibility (Bruder, 1991; Bruder et al., 1987) [8,7]. Studies in larger samples of both boys and girls are needed to evaluate critically these alternative possibilities.

Questions about the specificity of the association between dichotic listening performance and the distinct disruptive behavior disorders of childhood also remain. As noted above, previous findings with dichotic listening measures are for CD or ODD (Raine et al., 1990) [27]. Clinical language delay, in contrast, seems more closely tied to ADHD, where there is also some evidence of abnormal dichotic performance (Becker et al., 1993) [4]. Given the high comorbidity among the disruptive disorders, neither the current nor prior studies provide firm data on the specificity of associations with dichotic listening performance.

In summary, considerable research finds an association between deficits in verbal ability and disruptive psychopathology. This association could arise through underlying neural abnormalities' effect on both linguistic skill and disruptive psychopathology. The current study suggests that abnormalities in brain lateralization may be important in this regard. Such findings are consistent with a growing body of research linking lateralization abnormalities in the posterior left hemisphere, including temporal brain regions implicated in language, to the development of disruptive behavior disorders.

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