Implication of Right Frontostriatal Circuitry in Response Inhibition and Attention-Deficit/Hyperactivity Disorder

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ABSTRACT

Objective: To examine the relation between specific frontostriatal structures (prefrontal cortex and basal ganglia) and response inhibition deficits observed in attention-deficit/hyperactivity disorder (ADHD). **Method:** Children with ADHD and age-matched normal controls were scanned using magnetic resonance imaging (MRI) and tested on three response inhibition tasks. Behavioral performance was correlated with MRI-based anatomical measures of frontostriatal circuitry (prefrontal cortex and basal ganglia) implicated in ADHD. **Results:** First, significant differences in performance by children with ADHD and normal volunteers were observed on all three response inhibition tasks. Second, performance on these tasks correlated only with those anatomical measures of frontostriatal circuitry observed to be abnormal in children with ADHD (e.g., the region of the prefrontal cortex, caudate, and globus pallidus, but *not* the putamen) in the authors' previous study. Third, significant correlations between task performance and anatomical measures of the prefrontal cortex and caudate nuclei were predominantly in the right hemisphere, supporting a role of right frontostriatal circuitry in response inhibition and ADHD. **Conclusion:** The data suggest a role of the right prefrontal cortex in suppressing responses to salient, but otherwise irrelevant events while the basal ganglia appear to be involved in executing these behavioral responses. *J. Am. Acad. Child Adolesc. Psychiatry,* 1997, 36(3):374–383. **Key Words:** attention-deficit/hyperactivity disorder, basal ganglia, prefrontal cortex, response inhibition.

Attention-deficit/hyperactivity disorder (ADHD) is the most prevalent behavioral disturbance among children (Weiss and Hechtman, 1979), affecting as many as 5% of school-age children (Szatmari, 1992; Weiss and Hechtman, 1979) and accounting for just under 50% of clinical referrals (Anderson et al., 1987; Bird et al., 1988; Offord et al., 1987). Furthermore, as many as 50% of these children go on to experience ADHD symptoms in adolescence and adulthood (Gittelman et al., 1985; Mannuzza et al., 1993; Weiss and Hechtman, 1979; Weiss et al., 1985).

Converging lines of evidence suggest that the core deficit in ADHD is the failure to inhibit or delay behavioral responses (described as impulsivity) (Barkley, 1994; Trommer et al., 1991; Van der Meere and Sergeant, 1988) and that prefrontal cortex and frontal striatal circuits are implicated in this dysfunction (Baxter et al., 1988; Zametkin et al., 1990). Furthermore, neglect (Heilman and van den Abell, 1980; Heilman et al., 1991; Weintraub and Mesulam, 1987) and neuroimaging studies (Corbetta et al., 1991; Pardo et al., 1990) suggest that right frontal circuitry in particular is involved in response inhibition (i.e., the suppression of an attentional or behavioral response to salient but irrelevant events).

The anatomy of ADHD has been studied with magnetic resonance imaging (MRI) by several groups, although preliminary studies have been limited by small sample size and lack of volumetric measures (Giedd

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et al., 1994; Hynd et al., 1990; Semrud-Clikeman et al., 1994). More recently, studies using volumetric measures and large samples report significantly smaller volumetric measures of both prefrontal and basal ganglia structures in ADHD boys relative to matched controls (Castellanos et al., 1994, 1996). In these studies, both the caudate nucleus and globus pallidus, but not the putamen, were reported to be significantly smaller in 57 ADHD boys relative to 55 healthy matched controls. Furthermore, the differences between groups observed in these nuclei of the basal ganglia and in the prefrontal cortex were predominantly in the right hemisphere.

The following study examines the relation between specific frontostriatal structures (prefrontal cortex and basal ganglia) and performance on three response inhibition tasks in children with ADHD and normal controls. Our hypotheses were that (1) performance on the response inhibition tasks would discriminate children with ADHD from normal controls; (2) attentional performance on response inhibition tasks would be correlated with the size of the MRI-based measures of frontostriatal structures, such that the more similar these structures in ADHD subjects to matched controls, the more similar their performance to that of matched controls; and (3) anatomical correlates of attentional performance would be predominantly observed in the right hemisphere.

METHOD

Subjects

The subjects consisted of 52 males and were a subset of a sample recently studied specifically for MRI-based anatomical abnormalities (see Castellanos et al., 1996). Males with ADHD (n = 26, mean age = 9.69 years, SD = 1.99, range = 5.75 to 12.75) were recruited for a National Institute of Mental Health ADHD pharmacotherapy study within a specialized day treatment program. Of the 26 males, 23 had been previously treated with psychostimulants, and 25 participated in a 12-week double-blind trial of methylphenidate, dextroamphetamine, and placebo described elsewhere (Elia et al., 1991). Inclusion criteria were a history of hyperactive, inattentive, and impulsive behaviors that were impairing in at least two settings (home, school, or day program) and a Conners Teacher Hyperactivity rating greater than 2 SD above age mean (Werry et al., 1975). The *DSM-III-R* diagnosis of ADHD was based on Diagnostic Interview for Children and Adolescents with a parent and the patient, and Conners Parent and Teacher Rating Scales (Goyette et al., 1978). Exclusion criteria were a Full Scale WISC-R IQ <80, evidence of medical or neurological disorders on examination or by history, Tourette's disorder, or other Axis I psychiatric disorders, with the exception of oppositional defiant disorder (n = 9). One subject met criteria for mild anxiety disorders, and two subjects had specific learning disorders, meeting Axis II diagnostic criteria confirmed for reading disorder by discrepancy ($z > 1.65$) between Woodcock-Johnson Psychoeducational Battery and WISC-R standard scores (Frick et al., 1991; Reynolds, 1984).

Healthy male subjects (n = 26, mean age = 9.8 years, SD = 1.7, range = 6.3 to 12.68) were recruited from the community. Screening included telephone interview, parent and teacher rating scales, and in-person assessment which included physical and neurological examinations, the 12 handedness items from the Revised Physical and Neurological Examination for Subtle Signs (Denckla, 1985), structured psychiatric interview using the Child and Parent Diagnostic Interview for Children and Adolescents (Welner et al., 1987), Child Behavior Checklist (Achenbach et al., 1983), Conners Parent and Teacher Rating Scales, the Vocabulary and Block Design subtests of the WISC-R (Wechsler, 1974), and Wide Range Achievement Test-Revised (Jastak and Wilkinson, 1984). Family psychiatric history for first- and second-degree relatives was ascertained from one or both parents. Individuals with physical, neurological, or lifetime history of psychiatric abnormalities or who had any first-degree relatives or greater than 20% of second-degree relatives with major psychiatric disorders were excluded. Approximately five candidates were screened for every one accepted, with the most common exclusions being family psychiatric history, Conners Teacher Hyperactivity ratings greater than 1 SD above published age norms (Werry et al., 1975), and probable psychiatric diagnosis based on structured interviews.

Subjects were group-matched for age, weight, height, Tanner stage, and handedness. The matching variables were selected to control for individual differences in body size (Andreasen et al., 1993) and developmental stage (Jernigan and Tallal, 1990), which might be related to brain structure size.

Behavioral Paradigms

All subjects were tested on three behavioral paradigms designed to probe a unique component of inhibitory control during different stages of attentional processing (i.e., sensory selection, response selection, and response execution). Each task comprised both a control and an inhibitory condition. The control condition was typically a simple detection version of the task, while the inhibitory condition was identical but required the subject to inhibit attention to salient but otherwise irrelevant stimuli. Stimulus presentation and response collection were controlled by an IBM-compatible computer using an experimental design software package (Schneider, 1988).

The sensory selection task was a forced-choice discrimination task (Casey et al., 1993, 1994) that required the subject to select which of three objects presented in the center of a computer screen was unique based on stimulus attributes of color and shape. In the control condition, the unique attribute was constant across trials. In the inhibitory condition, the unique (target) attribute changed from trial to trial. Stimuli were presented in the center of the screen and remained on the screen until the subject responded by pressing one of three buttons that corresponded to the three object locations. The location of the target was randomized across the three object locations across 2 blocks of 36 trials (72 trials). Task condition was randomized across blocks. This task assesses inhibition of attention to the sensory attribute just attended, in order to attend to the current attribute of relevance.

The response selection task (Casey et al., 1993, 1994) consisted of selecting responses to specific stimuli that were based on compatible or incompatible mappings. In the compatible mapping or control condition, the subject was presented with either the digit 1, 2, 3, or 4, presented in the center of a computer screen. The subject was instructed to press the corresponding first, second, third, or fourth button on a response box. In the incompatible mapping condition, the subject was instructed to reverse his or her responses so that when a "2" was presented the third button was pressed, when a "1" was presented the fourth button was pressed, and so on. The stimuli remained visible until the subject responded. Each of the four digits was presented centrally in a random order an equal number of times. Task condition was randomized across 2 blocks of 20 trials each. This task assesses inhibition of a competing motor response (i.e., the tendency to respond with a compatible mapped response during the incompatible mapping condition).

The response execution task consisted of subjects responding whenever a single tone occurred and not responding when a double tone occurred. The task consisted of 2 blocks of 20 trials. Targets and nontargets were randomized across trials. The control trials consisted of rare targets similar to a vigilance or continuous performance tasks with 25% targets and 75% nontargets. In the inhibitory condition, 75% of the trials consisted of targets and 25% of the trials consisted of nontargets to build up a prepotent response similar to a go-no-go task. Tone duration was for 500 milliseconds with a 1,500-millisecond intertrial interval. This task assesses inhibition of the prepotent response (i.e., to respond even in the absence of a target).

Scanning Procedure

All subjects were scanned on a GE 1.5 Tesla Signa scanner located at the NIH Clinical Center. T1-weighted sagittal images with contiguous 1.5-mm slices in the axial and sagittal planes and 2.0-mm slices in the coronal plane were obtained using three-dimensional spoiled gradient recalled echo in the steady state (3D SPGR, TE = 5, TR = 24, flip angle = 45 degrees, acquisition matrix = 192 × 256, NEX = 1, FOV = 24 cm). Head position was standardized by assuring that three external markers (vitamin E capsules in the meatus of each ear and one taped to the left inferior orbital ridge) were visible in the same axial reference plane. Subjects were scanned in the evening to facilitate sleep. Furthermore, foam padding was placed on both sides of the head to minimize head movement.

All scans were evaluated by a clinical neuroradiologist. No gross abnormalities were found in any subjects. "Image," an image analysis Macintosh software package (NIH Public Domain developed by Wayne Rasband), was used to display the MRIs and quantify specific brain regions.

Image Analysis

Quantification of Cerebrum and Prefrontal Region. Spatial orientation was standardized using anterior and posterior commissures and the interhemispheric fissure. A segmentation algorithm developed by Snell et al. (1995) was used to separate the image of the brain from the surrounding intracranial cavity and to quantify the cerebrum. Once each brain's spatial orientation was standardized, the left and right cerebral hemispheres were further subdivided on the basis of internal landmarks. The prefrontal region was defined as all brain matter in front of the anterior-most point of the corpus callosum, excluding the temporal lobes. Further details are provided elsewhere (Giedd et al., 1996; Snell et al., 1995).

Subcortical Gray Matter Quantification. The caudate and putamen were manually outlined from coronal slices on a Macintosh II FX workstation using NIH Image (Rasband, 1993). Since the sum of areas from the odd-numbered slices for the first 20 subjects correlated highly with the sum of the areas from the even-numbered slices (intraclass correlation coefficient [ICC] = .98), subsequent outlining was done on every other slice and then multiplied by a slice thickness of 4 mm to derive volume. Interrater reliability (ICC = .88 and .84 for the caudate and putamen, respectively) was assessed initially and periodically during the analyses to monitor potential "drifts" in operator measurements. The globus pallidus, bounded medially by the internal capsule and laterally by the putamen, was also measured on coronal sections, but included every slice, beginning 2 mm anterior to the anterior commissure and proceeding posteriorly for a total of 14 mm. Limiting sampling to this domain, which encompassed almost the entire globus pallidus in the majority of subjects, was necessary to achieve adequate interrater reliability (ICC = .82). Manual outlining of basal ganglia structures by experienced raters was judged to be superior to a variety of automated techniques examined by our group.

Because the size of each brain structure is directly related to the overall brain size, each of the frontal and basal ganglia volume measures was corrected for overall brain size using the cerebrum measure described above. In addition, symmetry measures were calculated for each region of interest as the degree to which each measure represented a greater right-to-left asymmetry ([right − left]/{[right + left] × 0.5}) as defined in Castellanos et al. (1996).

RESULTS

Group Differences

Group differences on measures of response inhibition and subject variables, including age and estimated Full Scale IQ, were assessed with *t* tests. First, there were no significant differences between the ADHD and control subjects in mean age or estimated IQ (Table 1). Second, the children with ADHD had significantly slower mean reaction times and lower mean accuracy rates during the inhibitory trials of the behavioral paradigms, whereas only slower mean reaction times were observed during the control condition.

Developmental and Estimated IQ Correlates

Correlational analyses were performed to examine the relation between age and estimated Full Scale IQ on the measures of interest (attention and MRI measures) for each group (Fig. 1). Significant correlations between mean reaction times and age revealed faster responses as a function of age for both groups across all three tasks ($r > -.53$, $p < .01$). While there were no significant correlations between attention

TABLE 1
Group Differences Between 26 Boys With ADHD and 26 Matched Controls

	ADHD		NV			
	Mean	SD	Mean	SD	*t*	*p*
Age (yr)	9.7	1.9	9.7	1.7	−0.16	.87
Estimated Full Scale IQ	113.6	19.2	121.9	14.8	−1.75	.09
Sensory selection task						
Control trials						
RT (msec)	1303	584	1033	272	2.14	.04*
ACC (%)	94	0.08	96	0.07	−0.84	.41
Inhibitory trials						
RT (msec)	1401	563	1090	330	2.42	.02*
ACC (%)	92	0.13	97	0.03	−2.04	.05*
Response selection task						
Control trials						
RT (msec)	1117	496	801	239	2.93	.006*
AAC (%)	93	0.07	96	0.07	−1.53	.13
Inhibitory trials						
RT (msec)	1341	511	1048	314	2.45	.01*
AAC (%)	88	0.11	92	0.07	−1.37	.18
Response execution task						
Control trials						
RT (msec)	619	264	465	115	2.7	.01*
ACC (%)	92	0.18	97	0.05	−1.2	.24
Inhibitory trials						
RT (msec)	601	237	464	117	2.60	.01*
ACC (%)	89	0.14	97	0.03	−2.67	.01*

Note: ADHD = attention-deficit/hyperactivity disorder; NV = normal volunteers; RT = reaction time; ACC = accuracy.
* $p < .05$.

measures and estimated IQ, there were two significant correlations between subject and MRI variables. First, the volume of the right caudate nucleus was negatively correlated with age for control subjects ($r = -.51$, $p < .008$), but *not* the ADHD subjects ($r = .19$, $p < .35$), and slopes were significantly different between groups ($z = 2.81$, $p < .003$). While there was a significant positive correlation between estimated Full Scale IQ and the prefrontal cortex for ADHD subjects ($r = 50$, $p < .009$), this correlation was not significant for normal controls ($r = .21$, $p < .30$). However, groups did not differ significantly in slope ($z = 1.06$, $p < .15$).

Anatomical Correlates of Response Inhibition

Partial correlational analyses were performed examining the relation between the attention and MRI measures while controlling for age, estimated Full Scale IQ, and cerebrum volume. Hemisphere and asymmetry for each region of interest were correlated with reaction times and accuracy rate for each task. Error rate was controlled familywise, treating each region of interest (i.e., prefrontal cortex, caudate nucleus, globus pallidus, and putamen) as a family (i.e., $p < .0125$). For significant correlations, tests for parallelism in slopes between groups were performed (Kleinbaum and Kupper, 1978). The results are presented by behavioral paradigm below.

Sensory Selection. Behavioral performance on the sensory selection task correlated with caudate and prefrontal measures (Fig. 2). Furthermore, these correlations were predominantly observed for the right hemisphere. Specifically, for the ADHD subjects, right caudate volume was positively correlated with mean accuracy ($r = .60$, $p < .003$) during the control trials, while both left and right caudate volume measures were negatively correlated with mean reaction times ($r = -.59$ and $-.66$, respectively, $p < .004$) for these trials. Thus, faster mean reaction times and higher mean accuracy corresponded with larger caudate volume. This significant pattern of results for the ADHD subjects is the reverse of that observed for their matched controls. Slower mean reaction times and lower mean accuracy rates were observed as a function of larger caudate volume (r = .48 and −.43, respectively, p < .05) for the matched controls, and slopes were significantly different between groups (z = 4.17 and 3.52, respectively, p < .0004). For the inhibitory trials, right prefrontal cortex volume and mean accuracy were positively correlated for the normal (r = .62, p < .001), but not the ADHD boys, and the groups differed significantly in slope (z = 2.41, p < .008).

Response Selection. Behavioral performance during the response selection task correlated with volume of the left globus pallidus and caudate symmetry (Fig. 3). For the control trials, the volume of the left globus pallidus was positively correlated with mean reaction time for the normal controls (r = .57, p < .005). A significant, but less robust, positive correlation was also observed between left globus pallidus volume and accuracy (r = .47, p < .05), suggesting that slower but more accurate responses were observed for control subjects with larger left globus pallidus. This pattern did not hold for the boys with ADHD. However, only significant differences in slopes for the two groups was observed for the correlation between left globus pallidus and mean reaction time (z = 3.6, p < .0007). For the inhibitory trials, there was a positive correlation between caudate symmetry (right greater than left) and mean accuracy for the boys with ADHD (r = .51, p < .01), but the groups did not differ in slope (z = 1.42, p < .08).

Response Execution. Behavioral performance during the response execution task correlated with caudate symmetry (right greater than left), right prefrontal, and left globus pallidus measures (Fig. 4). Faster mean reaction times during the control trials were correlated with greater caudate symmetry (r = −.58, p < .01) for the ADHD subjects only. For inhibitory trials, there was a positive correlation between left globus pallidus volume and mean reaction time (r = .57, p < .005) for controls, but not for the boys with ADHD. There was a significant negative correlation between right prefrontal volume and mean accuracy (r = −.52, p < .01) for the ADHD subjects. However, only the basal ganglia correlations (left globus pallidus and caudate symmetry) revealed significant differences between groups in slope (z = 2.19 and 2.22, respectively, p < .02).

DISCUSSION

Response inhibition measures from three attentional tasks were correlated with anatomical measures of frontostriatal brain structures implicated in ADHD. The response inhibition measures included three tasks which tap response inhibition at different stages of attentional processing (sensory selection, response selection, and response execution). Performance differences between

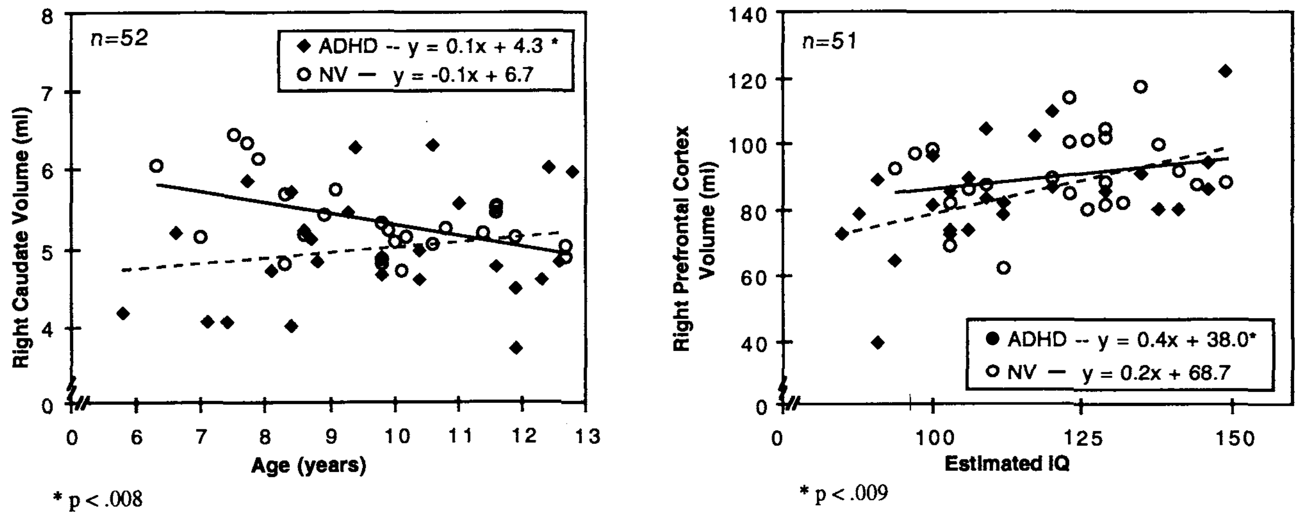

Fig. 1 Scatterplots of right caudate volume as a function of age (*left panel*) and right prefrontal cortex volume as a function of estimated IQ (*right panel*) for boys with attention-deficit/hyperactivity disorder (ADHD) and normal volunteers (NV) with regression lines, corresponding formulas, and significant correlations denoted.

the boys with ADHD and controls were observed for each of the three response inhibition tasks. Specifically, significant differences in mean reaction times during task performance were observed during all three tasks for both control and inhibition trials, whereas only significant differences between groups in mean accuracy were observed for the inhibitory trials. The observed longer and more variable reaction times across both simple control trials and more complex inhibitory trials are consistent with the ADHD literature (Swanson et al., 1991; Zahn et al., 1991).

There were two general findings from the correlational analyses of the response inhibition and MRI-based anatomical measures. First, the prefrontal cortex, caudate nucleus, and globus pallidus volumetric measures correlated with task performance, whereas the putamen measures did not. Frontostriatal involvement restricted to the prefrontal cortex, caudate, and globus pallidus in performance on response inhibition tasks is consistent with our previous reports of frontostriatal involvement in ADHD (Castellanos et al., 1994, 1996). Specifically, abnormalities were observed in the prefrontal cortex, caudate nuclei, and globus pallidus, and not the putamen in those studies. Second, correlations between task performance and prefrontal and caudate volume were predominantly within the right hemisphere, again consistent with our previous findings of right frontostriatal abnormalities in ADHD.

The specific role of these structures in the observed deficits in response inhibition in ADHD has been unclear, but it may be better understood by examining which structures correlated with performance on which task. While the sensory selection task performance correlated with right prefrontal and right caudate mea-

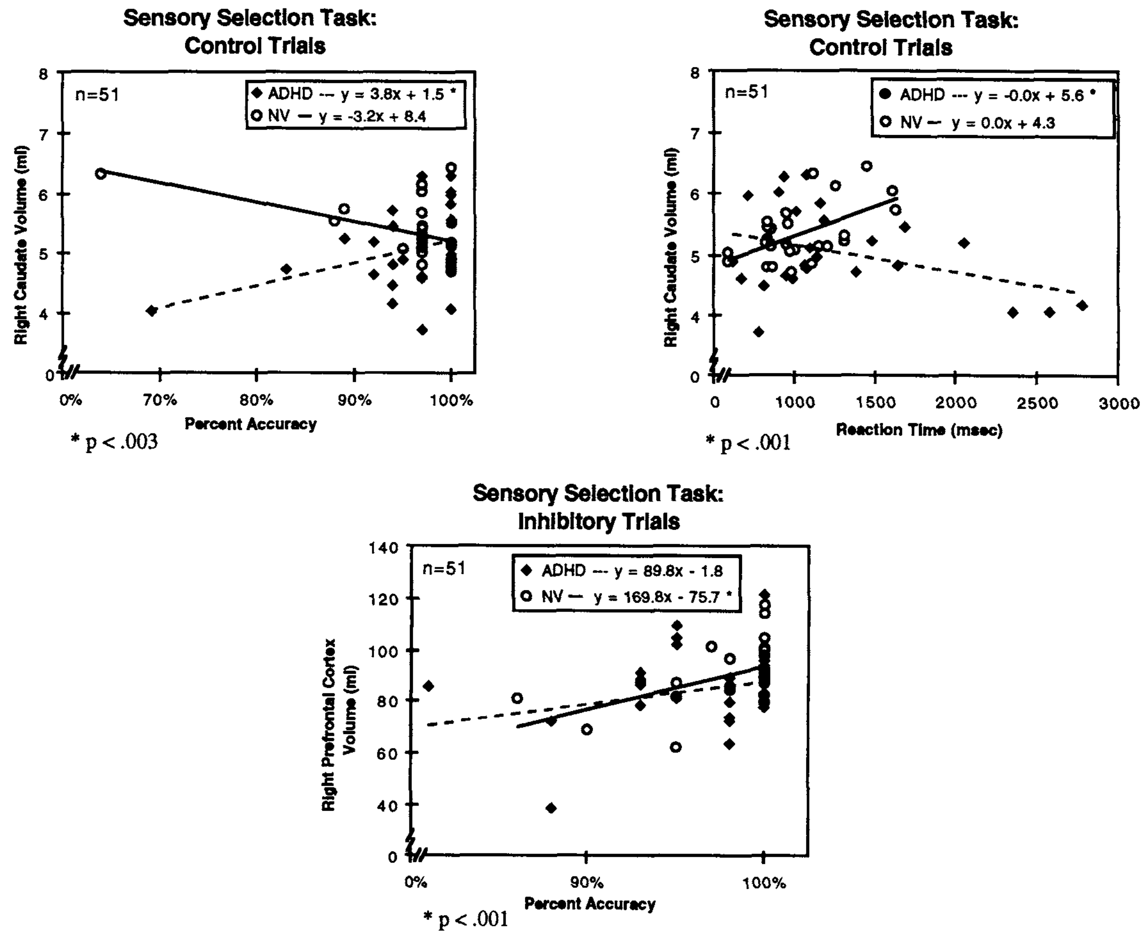

Fig. 2 Scatterplots of right caudate volume as a function of accuracy and reaction time during control trials (*top panels*) and right prefrontal cortex volume as a function of accuracy during inhibitory trials (*bottom panel*) for boys with attention-deficit/hyperactivity disorder (ADHD) and normal volunteers (NV) with significant correlations denoted.

sures, the response selection and response execution tasks correlated with caudate symmetry and left globus pallidus measures. Furthermore, only the prefrontal measures were specifically correlated with performance of inhibitory conditions of these tasks, while the caudate and globus pallidus measures were correlated with performance for both control and inhibition trials. These data suggest a role of the right prefrontal cortex in suppressing attentional and behavioral responses to salient, but otherwise irrelevant events while the basal ganglia appear to be involved in the execution of these behavioral responses. This interpretation is consistent with neuropsychological and primate studies implicating the prefrontal cortex in the performance of planned or delayed performance tasks (Fuster, 1989; Goldman-Rakic, 1987) and in modulation of the basal ganglia (Alexander et al., 1986, 1991).

Involvement of the caudate nucleus in the performance by the boys with ADHD was observed across all three tasks. Basically, the more similar the caudate measure to that of matched controls, the more similar and better performance for the boys with ADHD. This result was observed in the significant correlation between reaction times and right caudate size and symmetry for the sensory selection and response execution tasks and also in the lack of differences in slopes between groups for the relation between accuracy and caudate symmetry for the response selection task. Clearly, based on these findings and our earlier reports (Castellanos et al., 1994, 1996), the right caudate nucleus appears to be involved in the observed symptomatology of ADHD.

Finally, the globus pallidus measure, particularly the left globus pallidus, was associated with slower reaction times and higher accuracy (i.e., faster and less accurate performance as a function of smaller globus pallidus volume) on the response selection and response execution tasks. One interpretation of this pattern of results is that the left globus pallidus is related to speed-accuracy trade-off behavior, especially with regard to performance of response selection and execution tasks. This interpretation cannot be validated given the current data, and it would need to be empirically tested. Furthermore, our globus pallidus measure includes both medial and lateral segments, which may further limit our interpretation of its involvement in these behaviors.

There were two important developmental findings. First, consistent with our previous reports, there was a significant negative correlation between age and right caudate volume for the matched controls but not the boys with ADHD (Castellanos et al., 1994, 1996; Giedd et al., 1996). Specifically, previous studies reported significant decreases in caudate volume in normal volunteers across the ages of 4 to 18 years and smaller right caudate volumes and no significant decrease in caudate volume as a function of age in boys with ADHD. Second, performance on all three tasks improved as a function of age for both groups. This finding is consistent with the developmental literature

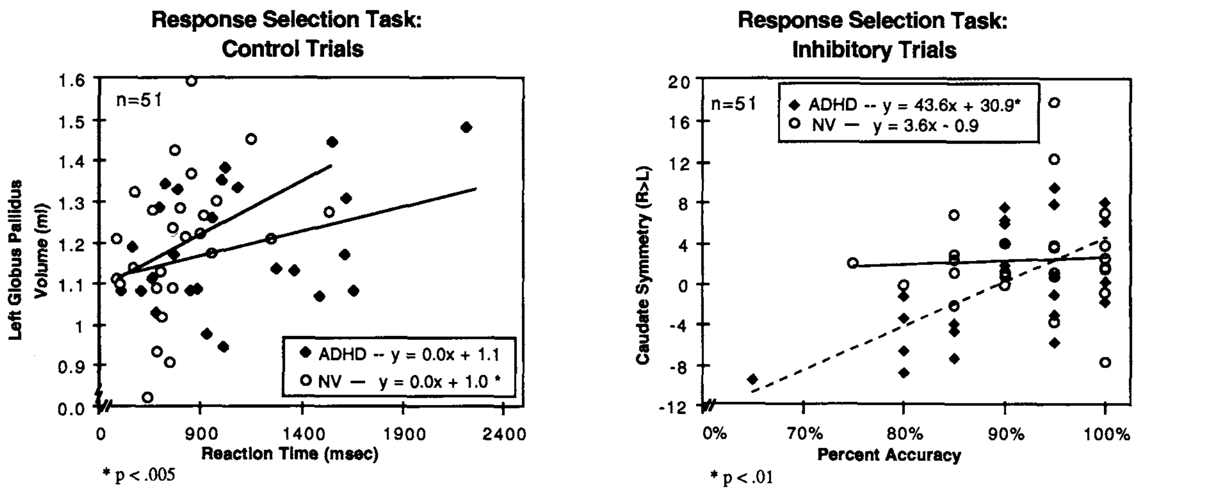

Fig. 3 Scatterplots of left globus pallidus volume as a function of reaction time during control trials (*left panel*) and caudate symmetry as a function of percent accuracy during inhibitory trials (*right panel*) for boys with attention-deficit/hyperactivity disorder (ADHD) and normal volunteers (NV) with significant correlations denoted.

(Hale, 1990; Kail, 1988; Keating and Bobbitt, 1978) in that as children get older, they also get faster on both simple reaction time tasks and complex cognitive tasks. One suggestion for this increased speed is that the older child becomes more efficient with practice or experience and certain aspects of the tasks may become automatic or require very little attentional capacity.

Finally, there was a significant correlation between our measure of right prefrontal cortex volume and estimated IQ for the ADHD subjects but not the matched controls. Our previous study with more than 100 subjects revealed a significant correlation between right prefrontal measures and estimated Full Scale IQ for both ADHD subjects and matched controls. A similar correlation was reported in an earlier study (Casey et al., in press) of normal subjects between the ages of 5 and 16 years. The descriptive statistics reported for the current sample indicate that the range of estimated IQs for our ADHD sample was larger than that for our matched controls (19.2^2 and 14.8^2, respectively). Therefore, if there is a significant relation between size of right prefrontal cortex and estimated IQ, the limited range in our measure for this sample of matched controls prevents its detection.

While the previous findings are somewhat provocative, clearly the associations between attentional performance and MRI-based anatomical measures of structure size are very crude. A more promising approach would be to more directly assess structure–

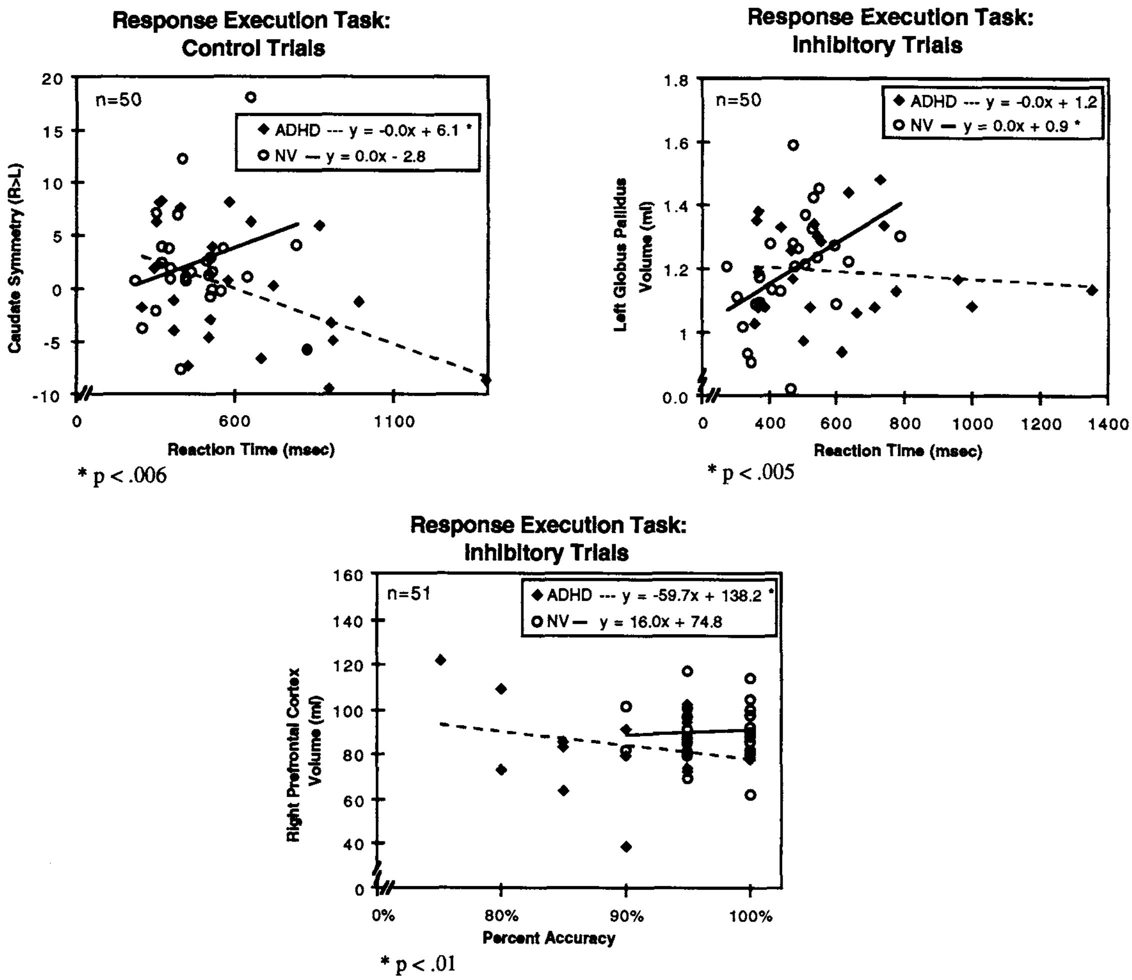

Fig. 4 Scatterplots of caudate symmetry and left globus pallidus volume as a function of reaction time during control trials (*top panels*) and right prefrontal cortex volume as a function of accuracy during inhibitory trials (*bottom panel*) for boys with attention-deficit/hyperactivity disorder (ADHD) and normal volunteers (NV) with significant correlations denoted.

function relations with the use of a recently developed technique of noncontrast functional MRI. This technique records changes in blood flow and oxygenation state of brain tissue, thereby indexing brain activation. Recently, we have had success in applying this methodology to the study of normal pediatric populations (Casey et al., 1995) using similar tasks. It is our hope to examine further the role of right frontostriatal circuitry in the observed deficits in response inhibition in ADHD using this technique.

Clinical Implications

Our findings suggest that the distractibility and impulsivity characteristics of children with ADHD reflect deficits in response inhibition. Furthermore, the observed associations of prefrontal regions with attentional control and the basal ganglia with motor control suggest that the beneficial effect of stimulant medication on distractibility and impulsivity may be mediated through improvement in response selection at two distinct levels.

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