Inhibitory Performance, Response Speed, Intraindividual Variability, and Response Accuracy in ADHD

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ABSTRACT

Objective: To determine the potential of inhibitory performance, response speed, and response accuracy and variability, measures central to the conceptualization of attention-deficit/hyperactivity disorder (ADHD), in distinguishing children with ADHD from healthy controls (HCs). **Method:** The stop signal paradigm was administered to 38 children with ADHD and 31 NCs. The stop signal reaction time (SSRT), mean reaction time (MRT), intraindividual coefficient of variation (ICV), and number of errors were used to predict diagnostic status. **Results:** Univariate tests showed that the ADHD group performed worse than NCs on all of the dependent variables. Exploratory univariate analyses showed that oppositional defiant disorder comorbidity and ADHD type did not influence results except for the ICV, the effect for this variable (more variability in the ADHD group) being less pronounced for the Predominantly Inattentive type than for the Hyperactive-Impulsive and Combined types. A logistic regression model of the MRT, ICV, and number of errors combined showed best predictive performance, with the MRT contributing the most to group classification (56% of the variance). The final model (MRT, ICV, and number of errors) predicted 87% of the sample in the correct diagnostic category. Operating characteristics showed excellent sensitivity and specificity of 89.5% and 83.9%, respectively. **Conclusions:** Our results contrast with theoretical accounts emphasizing inhibitory control as the pivotal measure characterizing cognitive performance in ADHD. Results are discussed in the context of a delay aversion perspective of ADHD. *J. Am. Acad. Child Adolesc. Psychiatry,* 2008;47(7):808–816. **Key Words:** attention-deficit/hyperactivity disorder, stop signal paradigm, inhibitory control, intraindividual variability, delay aversion.

Attention-deficit/hyperactivity disorder (ADHD) is a common neuropsychiatric disorder among children, affecting an estimated 3% to 5% of the general population.[1] Since the pivotal work by Pennington and Ozonoff[2] and Barkley,[3] a neuropsychological profile with deficits in executive functioning, with deficits in inhibitory control in particular, has been regarded as the underlying substrate of the disorder. More recently, the centrality of deficits in inhibitory control and other aspects of executive functioning in theories of ADHD have come under question. Important reasons for this are the apparent nonspecificity of executive functioning deficits to ADHD[4–8] and converging evidence of other cognitive and behavioral deficits in the disorder, including issues such as delay aversion,[9,10] deficiencies in reinforcement

Accepted February 16, 2008.

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Financial support from the BASVU fund is gratefully acknowledged. The authors thank the participants of this study, Dr. D. Knol for statistical advice, and Surya Slamet for assistance in data management.

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0890-8567/08/4707-0808©2008 by the American Academy of Child and Adolescent Psychiatry.

DOI: 10.1097/CHI.0b013e318172eee9

sensitivity,[11–13] deficiencies in motivational and energetic regulation,[14,15] and timing deficits.[16] This has led some authors to propose multiple pathway models toward the disorder.[6,9,16] Despite this shift in focus, many current theoretical accounts of ADHD still incorporate deficiencies in inhibitory control in one way or another.[9,13–16]

To date, the cognitive paradigm that has been the most successful in measuring inhibitory control deficits in children with ADHD compared to controls (NCs) is the stop signal paradigm,[17–19] with numerous studies showing deficient performance on the stop signal task (SST).[20–23] The task requires a child to respond as quickly as possible to a go stimulus (a go trial). On some trials, however, the go stimulus is quickly followed by a second stimulus, signaling the child to inhibit the response to the go stimulus (a stop trial). The task allows stop signal reaction time (SSRT) to be calculated, an estimate of the inhibition latency after a stop signal. In line with the hypothesis that inhibition is impaired in ADHD, it has been found that SSRT is slower in children with ADHD.[20–23] Additional measures allow the study of other pivotal cognitive processes: response accuracy (number of errors on go trials, referred to as Errors), response speed (mean reaction time [MRT]), and intraindividual response variability. It has been shown that compared to controls, children with ADHD make more errors in the SST, whereas for the MRT, the results have been equivocal, with some studies showing slower MRT in children with ADHD compared to controls, some showing slightly faster MRT and some showing no difference at all.[20–23] In general, effect sizes for the SSRT and MRT in particular have been medium to large.[20–23]

Recently, variability in cognitive performance has been recognized as a specific deficiency in ADHD[15,24–26] and has been put forward as an endophenotype for the disorder.[27] In most studies using the stop signal paradigm, this variability has been operationalized as the SD of the reaction time (SDRT). Recently, however, it has been pointed out that the SDRT needs to be adjusted for an individual's overall speed of response because the SDRT and MRT are usually highly correlated.[25,26,28] This can be done by calculating the intraindividual coefficient of variation (ICV), defined as ICV = SDRT/MRT. Klein and colleagues[25] recently showed that intraindividual variability contributes greatly to group discrimination in ADHD over a number of cognitive paradigms, including the SST.

This study assessed the primacy of an inhibitory control deficit in ADHD as measured by the SSRT compared to other cognitive processes measured by the SST: speed (MRT) and accuracy (Errors) of cognitive processing, as well as variability in the speed of cognitive processing (ICV). Logistic regression analysis was used to investigate which SST variables carry group effects in the classification of children with ADHD versus NCs.

An important issue to address is the clinical heterogeneity of the disorder, both in terms of ADHD types and comorbidity with other disruptive behavior disorders[1] and possible differential cognitive performance between type and comorbidity groups.[5,22,29] Therefore, we conducted exploratory analyses to investigate the influence of ADHD type and comorbidity with other disruptive behavior disorders on our results. Differences found in cognitive functioning between types and comorbidity groups may be useful in the discussion of future taxonomies of child psychiatric disorders.

METHOD

Participants and Selection Procedure

Participants were 69 children ranging in age from 6 to 13 years old: 38 unmedicated children with ADHD (3 girls), referred to an academic ADHD outpatient clinic were compared to 31 normally developing peers (9 girls). Demographic and diagnostic data are provided in Table 1. Parents and teachers completed the Disruptive Behavior Disorders Rating Scale (DBD),[30,31] Child Behavior Checklist (CBCL; parents only) and the Teacher Report Form (TRF; teachers only).[32,33] The DBD is a four-subscale *DSM-IV* disruptive behavior symptom severity measure with separate scales for ADHD ADHD-I, ADHD Hyperactivity-Impulsivity type (ADHD-HI), oppositional defiant disorder (ODD), and conduct disorder (CD). Adequate psychometric properties have been reported for the DBD[30,31] and the Dutch translations of the CBCL and TRF.[32,33] To ascertain ADHD diagnosis, parents and children were seen by a child and adolescent psychiatrist (A.P.). Diagnosis was then confirmed by administering the Diagnostic Interview Schedule for Children-IV (DISC-IV), a structured parent interview assessing *DSM-IV*–defined psychopathology.[34] Subscales on ADHD, ODD/CD, and some other disorders were administered. In two cases, missing values precluded use of DISC-IV scores. In these cases, diagnosis was confirmed using DBD scores. These cases were excluded from ADHD type and comorbidity analyses. IQ was estimated using a four-subtest short form of the WISC-R, Dutch version, which has shown excellent correlation with Full Scale IQ.[35]

All of the children in the ADHD group scored above clinical cutoff (95th percentile) on at least one ADHD scale of the DBD of at least one informant. Thirty-two children (84.2%) scored above clinical cutoffs for both parent and teacher ratings. Children with psychiatric or neurological comorbidities other than ODD/CD or IQ <70 were excluded. According to the DISC-IV, 15 children met Predominantly Inattentive type criteria (ADHD-I), 1 met ADHD-HI criteria, and 20 met ADHD-C criteria; 20 of the children with ADHD had a comorbidity of ODD, but none with CD.

NCs were recruited from a local elementary school. According to parents, none of the NCs had been referred to any mental health

TABLE 1
Sample Characteristics

	Group			
	Non-ADHD Controls (n = 31)		ADHD (n = 38)	
Variable	Mean	SD	Mean	SD
Age, y	9.35	1.62	9.03	1.92
Total IQ	101.57	12.39	99.11	11.85
Teacher DBD				
Predominantly Inattentive	2.00	2.34	17.16	5.17
Hyperactive-Impulsive	1.81	2.43	15.81	6.35
ODD	0.81	1.19	7.21	5.31
CD	0.13	0.43	1.42	2.18
Parent DBD				
Predominantly Inattentive	1.58	1.69	16.87	5.36
Hyperactive-Impulsive	1.58	2.03	14.39	5.02
ODD	1.16	1.59	7.39	4.70
CD	0.39	0.80	1.71	2.03
CBCL				
Internalizing problems	3.45	2.80	10.62	8.02
Externalizing problems	3.16	4.12	19.29	8.98
TRF				
Internalizing problems	2.33	2.70	9.12	6.97
Externalizing problems	1.80	2.31	23.06	12.15

Note: Raw scale scores are tabulated. ADHD = attention-deficit/hyperactivity disorder; DBD = Disruptive Behavior Disorders Rating Scale; ODD = oppositional defiant disorder; CD = conduct disorder; CBCL = Child Behavior Checklist; TRF = Teacher Report Form.

service and none had been diagnosed with a mental disorder. All of the NC children scored below the clinical cutoff (95th percentile) on all of the DBD scales and below the clinical cutoff (T score 70) on the CBCL and TRF Internalizing and Externalizing scales.

SST

We used the tracking version of the SST.[19] A child was presented with two types of trials: go trials and stop trials. Go trials consisted of a picture of an airplane displayed for 1,000 milliseconds, preceded by a 500-millisecond fixation point, both presented in the center of the screen. Children were required to press a response button that corresponded with the direction to which the airplane was pointing. The interstimulus interval was 1,500 milliseconds, and intertrial intervals were 3,000 milliseconds. Stop trials were identical to go trials, but, in addition, a stop signal was presented: a 1,000-Hz tone of 50 milliseconds in duration presented through earphones. Children were required not to press the button when they heard the stop signal. The delay between the go stimulus and the stop signal was varied to achieve a success rate of 0.5 on stop trials. In other words, the delay was manipulated in such a way that in 50% of stop trials, the child succeeded at inhibiting the go response. Most often the stop signal was presented shortly after the airplane was displayed but could also be presented concurrently with the airplane or shortly before the airplane, depending on the performance of the child. Of all of the trials, 75% were go trials and 25% were stop trials.

SSRT was estimated using the race model in which the go process and the inhibitory process are conceived of as competing processes (see Logan et al.[18] for more details). Whether a response will be executed or inhibited in a stop trial depends on which of these processes "wins" the race. In the case in which 50% of stop trials result in successful stopping, the mean stop signal delay is where both the stop and the go processes have equal probability of "winning" the race (i.e., the mean go process duration [MRT] and the sum of the mean stop signal delay plus the duration of the stop process [SSRT] are approximately equal). It follows that SSRT can be calculated using the equation SSRT = MRT − mean stop signal delay. Other variables of interest, the MRT, and Errors were taken directly from task output. The ICV was calculated by dividing SDRT by MRT.[26,28]

Six blocks of 64 trials were presented, each with a short break after the first two blocks, which were designated practice blocks to reach optimal performance. In the first practice block, the child was presented only go trials; the second contained 25% stop trials. Children were verbally encouraged using standardized instructions to work as quickly and accurately as possible and to try to suppress a response when they heard the stop signal. The dependent variables used in the analyses were calculated across the four experimental blocks that followed the practice blocks.

Procedure

After referral, parents of ADHD children were administered a short semistructured telephone interview probing for major childhood disorders. Parents were sent the DBD and CBCL and an informed consent declaration. After giving consent, teachers were sent a DBD and a TRF. At their visit to the unit, the DISC-IV was administered to parents. Children were neuropsychologically assessed using the SST and other cognitive measures. The institutional review board of the VU University approved the study.

Data Analysis

There were no missing values in any of our predictors. For the diagnostic and background variables reported, <5% were missing in both the ADHD and NC groups, with missing values spread evenly across both groups with no apparent differential pattern. For variables tested as possible covariates, missing values were substituted by the group mean (two IQ values in the ADHD group and three IQ values in the NC group).

Preceding analyses, we calculated correlations of the SST variables with known possible confounders: age, sex, and IQ.[36–38] The SSRT was significantly correlated with age (r = −0.29), MRT with sex (r = 0.29), Errors with age (r = −0.43), and ICV with IQ (r = −0.25). Therefore, analyses were rerun with these variables as covariates. Only IQ changed the results of some of our analyses and was covaried in all of the analyses reported below.

First, group differences for each of the SST variables were assessed using univariate analyses of variance. To address the possible influence of ADHD type and comorbidity, we performed additional exploratory analyses. First, the ADHD group was divided into those children having ADHD-I (n = 15) and those having either ADHD-HI or ADHD-C (n = 21). Second, we divided the ADHD group into a group having comorbid ODD (n = 20) and a group that did not (n = 16). These subgroups were compared with NC children on SST variables using Helmert contrasts.

Second, a blocked logistic regression analysis was performed. In the first block of the analysis, the covariate IQ was forced into the equation. The second block consisted of a forward stepwise procedure in which the four predictors were entered together. In each step, the

TABLE 2
Results of ADHD Children Versus NCs, ADHD Type, and ODD Comorbidity Analyses

	Main Analysis				Subtype Analysis				ODD Comorbidity Analysis				
	NCs (n = 31)		ADHD (all) (n = 38)		ADHD-I (n = 15)		ADHD HI/C (n = 21)		ADHD-ODD (n = 20)		ADHD+ODD (n = 16)		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Contrast Results
SSRT	123.3	41.8	186.9	82.5	180.2	57.3	197.5	98.8	185.2	82.5	194.4	86.2	NC < ADHD,*** ADHD-I = ADHD-HI/C, ADHD-ODD = ADHD+ODD
MRT	723.1	111.3	570.1	66.3	543.1	84.5	588.7	47.1	572.7	72.4	567.3	66.3	NC > ADHD,*** ADHD-I = ADHD-HI/C, ADHD-ODD = ADHD+ODD
Errors	3.6	2.9	8.7	6.9	7.5	5.8	9.6	7.9	8.3	5.9	9.1	8.0	NC < ADHD,*** ADHD-I = ADHD-HI/C, ADHD-ODD = ADHD+ODD
ICV	0.20	0.02	0.23	0.04	0.22	0.04	0.25	0.03	0.22	0.03	0.25	0.04	NC < ADHD,*** ADHD-I < ADHD-HI/C,* ADHD-ODD = ADHD+ODD

Note: ADHD = attention-deficit/hyperactivity disorder; NCs = non-ADHD controls; ODD = oppositional defiant disorder; ADHD-I = ADHD Predominantly Inattentive type; ADHD-HI/C = ADHD Hyperactive-Impulsive and Combined types; SSRT = stop signal reaction time; MRT = mean reaction time; Errors = number of errors; ICV = intraindividual coefficient of variability.

* $p < .05$; *** $p < .001$.

algorithm classifies cases as ADHD or control based on the variables in the model at that step and calculates the success of classification (log likelihood). It then takes into the equation the predictor that most significantly contributes to enhanced classification when added to the model (e.g., the algorithm takes into the equation the predictor with the lowest p value for the Wald statistic). The algorithm terminates either when all of the predictors have been entered into the equation or when addition of any of the remaining predictors does not significantly enhance classification. The odds ratio (OR) for each of the predictors was calculated for each model on Z-transformed data to make magnitude of the ORs comparable with each other. Operating characteristics for the final model were calculated.

RESULTS

SST measures were moderately to strongly interrelated, indicating that they tap into partially overlapping cognitive processes. The MRT correlated significantly with the SSRT ($r = -0.36, p < .01$), and ICV ($r = -0.31, p < .01$) but not errors ($r = -0.12$, not significant). Errors correlated significantly with the SSRT ($r = 0.62, p < .01$) and ICV ($r = 0.56, p < .01$). The SSRT and ICV also correlated significantly ($r = 0.47, p < .01$).

Univariate Results

Table 2 provides an overview of the univariate analyses. Compared to the NC group, children with ADHD showed slower SSRTs ($F_{1,66} = 15.4, p < .001, \eta_p^2 = .19$), faster MRTs ($F_{1,66} = 52.0, p < .001, \eta_p^2 = .44$), larger ICVs ($F_{1,66} = 26.3, p < .001, \eta_p^2 = .29$) and a larger number of errors ($F_{1,66} = 14.9, p < .001, \eta_p^2 = .19$). The ADHD subtype analyses revealed no differences between ADHD-I and ADHD-HI/C for any SST variables except for the ICV: children with ADHD-I showed a lower ICV compared to children with ADHD-HI/C (contrast estimate -0.026, $p < .05$); the difference between NC children and those with ADHD-I was less pronounced than the difference between NC children and children with ADHD-HI/C. Results of the ODD comorbidity analyses indicated no differential effect of ODD comorbidity.

Logistic Regression

Table 3 summarizes the logistic regression analyses and gives the ORs of the predictors in the models. The covariate IQ did not reach significance in any of the models reported.

In the first step of the stepwise logistic regression procedure, MRT showed the highest significance level and was taken up into the equation ($B = -0.019$, $p < .001$), with the model explaining just less than 60% of variance (Nagelkerke $R^2 = 0.58$). In the second step, ICV entered the equation ($B = 40.4, p < .01$); the model of the MRT and ICV together explained 70% of variance (Nagelkerke $R^2 = 0.70$). In the third step, Errors was included ($B = 0.46, p < .01$). This model explained 80% of variance (Nagelkerke $R^2 = 0.80$). The algorithm terminated here, leaving the SSRT out of the statistically optimal predictive model (SSRT Wald(1) = 0.35, $p = .56$).

The final model (MRT, ICV, and Errors) predicted 87% of the sample in the correct diagnostic category. Operating characteristics showed excellent sensitivity and specificity of 89.5% and 83.9%, respectively. Positive predictive value was 87.2% and negative predictive value was 86.7%. Because ORs were calculated on Z-transformed data, they refer to an increase in the probability of being classified ADHD with an increase (SSRT, Errors, and ICV) or decrease

TABLE 3
Results of Logistic Regression Analyses

Model	Step	Predictors in Model	χ^2	p	R^2	ΔR^2	OR_{MRT}[a]	OR_{ICV}[a]	OR_{Errors}[a]	OR_{SSRT}[a]
Stepwise	0	(Constant + IQ)[b]	.78	.38	0.02	—	—	—	—	—
	1	MRT	48.0[c]	.000	0.58	0.56	9.7	—	—	—
	2	MRT, ICV	12.3[c]	.000	0.70	0.12	9.3	4.36	—	—
	Final model	MRT, ICV, Errors	11.1[c]	.001	0.80	0.10	19.6	2.78	15.6	—
Full model[d]	—	MRT, ICV, Errors, SSRT	81.8	.000	0.80	0.80	18.2	2.92	15.2	1.71
SSRT model[d]	—	SSRT	.78	.377	0.02	0.00	—	—	—	5.96

Note: OR = odds ratio; MRT = mean reaction time; ICV = intraindividual coefficient of variability; SSRT = stop signal reaction time; Errors = number of errors.

[a] Odds ratios calculated on Z-transformed data. For ICV, Errors, and SSRT, the OR refers to an increase in probability of being classified as ADHD. For MRT, the OR refers to a decrease in probability of being classified as ADHD.

[b] Constant and covariate IQ included in all of the models.

[c] Chi-square value of current model compared to previous model.

[d] In these analyses, predictors were forced into the equation in step 1; model χ^2 reported in comparisons to Constant + IQ.

(MRT) of one whole group SD on the measures. Their relative strength is of most interest, however. Results (Table 3) show a large effect for the MRT (faster MRT increasing the probability for classification as ADHD) and smaller effects for the Errors and ICV.

Two additional logistic regression analyses were conducted: an SSRT-only model and a model including all predictors. The SSRT-only model showed statistically nonsignificant performance (p = .38), explaining hardly any variance (R^2 = 0.02 compared to R^2 = 0.80 of the final stepwise model). A model including all predictors showed no improvement (R^2 = 0.80) over the final stepwise model. The OR for the SSRT here was weak, with considerably higher values for the other measures, including ICV.

DISCUSSION

The present study investigated the primacy of theoretically central cognitive performance measures in ADHD: inhibitory control and response speed, accuracy, and variability as measured using the stop signal paradigm. We found significant group differences for all of the variables studied. Children with ADHD showed a significantly faster (MRT), more variable (ICV), and inaccurate (more Errors) response style as well as a significantly slower inhibitory process (SSRT) than NCs.

Our logistic regression procedure was aimed at providing insight into which variables carry group classification effects, addressing the issue of the primacy of inhibitory control in ADHD. We have shown that the stop signal paradigm can accurately differentiate children with and without ADHD (87% correctly classified) using the MRT, ICV, and go trial Errors, but not the SSRT as predictors. The ORs as calculated on Z-transformed data indicate that response speed as reflected in the MRT most significantly contributes to group discrimination, accounting for 56% of the variance.

The weak predictive performance of the SSRT is contrary to expectation. The full model analysis, in which all predictors were forced into the equation, did not explain more variance beyond the final stepwise model. Moreover, the SSRT had the lowest OR in the full model (OR_{SSRT} 1.71). Our stepwise procedure provides evidence that the variance that the SSRT carries can be fully modeled using the other three SST predictors (MRT, ICV, and Errors). Moreover, a classification model with the SSRT alone shows weak and statistically nonsignificant performance (Table 3). Whereas we confirm the common finding of a significantly slower SSRT in children with ADHD compared to NCs, we have provided evidence that this difference has little theoretical bearing. Therefore, our results question the centrality of inhibitory deficits in theoretical work in ADHD.[3,9,13–16,23]

Two earlier studies attempted classification using the SST.[39,40] Using the SSRT only, with an arbitrary cutoff score of 340 milliseconds, Nigg[39] found 64% sensitivity, 68% specificity, 67% positive predictive value, and 65% negative predictive value, considerably lower values than in the present study. Solanto and others[40] studied all of the task variables univariately with correct classification rates between 53.4% (MRT only) and 68.2% (for probability of inhibition only). Whereas correct classification rates are considerably lower, both previous studies found the SSRT to be a weak predictor, which agrees with our results.

A second interesting result is the difference in intra-individual variability found. This variable is increasingly seen as a cornerstone in the cognitive profile of children with ADHD.[25–27] We adjusted the SDRT for overall response speed by calculating the ICV. This revealed significantly greater variability in the ADHD group compared to the NCs. Earlier studies tended to use the SDRT only, making comparison with earlier work difficult. Recent meta-analyses reported significant group differences for the SDRT, providing additional evidence of the importance of variability in responding.[20,21] Use of a more reliable index of variability, such as the ICV, seems warranted, however. More sophisticated methods of assessing response variability have been proposed as well.[24,26,41]

The direction of the MRT difference found is opposite to what has been commonly reported in stop paradigm studies.[20–22] However, at least five other SST studies in children with ADHD have reported an MRT difference in this direction.[40,42–45] In all of these instances, the difference was small (6–34 milliseconds) and not significant. We emphasize that recent meta-analyses[20,21] showed that results for the MRT in SST studies have been considerably variable with respect to the effect size of differences found. Moreover, fast responding makes intuitive sense in a disorder that is characterized by impulsivity and seems consistent with a high number of errors, should a speed-accuracy tradeoff be present. We did not, however, find a significant correlation between MRT and Errors for the ADHD group (r = 0.11, p = .52). This suggests that error monitoring and cognitive speed may be mediated by independent circuits.

Previous work has hinted at differences between children with ADHD having the Inattentive versus the Hyperactive-Impulsive or Combined types in tasks measuring cognitive performance.[3,5,29] In exploratory analyses, we found no differences between the ADHD types on SST variables except for the ICV: children with the ADHD-HI and ADHD-C types tend to show a more pronounced ICV difference from controls than children with ADHD-I. This finding should be interpreted with caution because the sizes of type groups were small and findings of this type have not been common in the past.[36] Children with or without comorbid ODD did not differ on any SST variables, suggesting that ODD comorbidity does not influence these cognitive measures. This seems to be in line with the idea that substantial overlap exists in cognitive symptomatology and perhaps pathophysiology between the disruptive behavior disorders.[15] Both our ADHD type and comorbidity findings contribute to discussion on how ADHD should be described in future taxonomies.

Clearly, the behavioral phenotype of ADHD is characterized by impulsive and disinhibited behavior. However, the cognitive abstraction of this behavior, inhibitory control, may be less central to the disorder than some empirical work suggests. Slow and inaccurate responding has been the prevalent result in earlier studies using the SST.[20–22] Slow response times would be expected to grant executive processes enough time to inhibit the response in stop trials. In addition, because the response set is so slow, preceding context (in this case, go trials), strengthening the response set to automatically react to targets, would be of little influence.[46] Given that a slower SSRT is usually also found, a pervasive inhibitory deficit would be the most likely explanation for these findings. However, in a recent meta-analysis, Alderson and colleagues[20] showed that it is more likely that pervasive attentional difficulties rather than an inhibitory control deficit would be responsible for these prevalent findings. They showed that stop signal delay did not differ between ADHD and NC groups over studies. Therefore, the SSRT group differences found can be attributed only to slow MRT (i.e., MRT = SSRT − mean delay). This suggests deficiencies in focused and sustained attention rather than an inhibitory deficit. In the present study, however, we found the mean stop signal delay to significantly differ between groups ($F_{1,66} = 59.8$, $p < .001$), with the ADHD group having a shorter mean delay than the NC group. Thus, our results do not fit with either a disinhibitory or an attention deficit explanation.

Our results fit better with the idea that the inhibition deficit occurs not so much because of an executive or attention deficit, but is the result of a fast and variable response style in which preceding context makes the go response more readily available (or prepotent) to be issued in the event that this response should be inhibited. This fast response style may be caused by delay aversion, a characteristic of ADHD that can be described as the preference for immediacy and the tendency to respond in such a way as to increase the subjective perception of the passage of time.[9,10] Fast responding in a cognitive task will fulfill this need for immediacy while producing an elevated SSRT. This occurs because in the ADHD group, the delay of the stop signal must be short to make inhibition possible. In controls, however, who are slower and show no delay aversion, a longer stop signal delay should be possible, leading to faster SSRTs while having a slower MRT. In short, the perceived inhibitory deficit in ADHD may be produced by a fast and inaccurate response style rather than by an inhibitory deficit per se. Indeed, Sonuga-Barke et al.[9,10] have emphasized the relatedness of inhibitory control and delay aversion in a theoretical model that shows that inhibitory deficit and delay aversion can lead to the same behavioral phenotype.

A few caveats need to be taken into account concerning our study. First, the sample consisted mainly of children with the ADHD-I and ADHD-C, leaving uncertainty regarding ADHD-HI. Furthermore, assessment of the specificity of SST deficits for ADHD is required. Earlier reports on this issue showed substantial overlap in cognitive performance between a number of child psychiatric populations such as ADHD, ODD/CD, and high-functioning autism.[4,8,22] Second, clinical heterogeneity within the ADHD population may have interfered with our results. For instance, in children with comorbid anxiety, performance may be different from that of other children with ADHD. Future studies should screen for these symptoms in a more fine-grained way to investigate their influence on performance. Finally, the sample size of our study is modest and replication of this type of analyses is highly recommended using larger samples. However, we consider our sample size to be sufficient to reliably assess the potential of SST variables in classification.

In sum, this study has shown that the SST performance of children with ADHD is characterized by a fast and variable response style more than by an inhibitory deficit. Response variability proved a more important differentiator of ADHD from controls than inhibitory control. These findings are in contrast with much of the theoretical work in ADHD and may be best understood in a delay aversion framework.

Disclosure: Dr. Sergeant has been a member of the advisory boards of Eli Lilly, Shire, and Janssen Cilag. Dr. Oosterlaan is a member of the advisory board of Shire. The other authors report no conflicts of interest.

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