Do Motivational Incentives Reduce the Inhibition Deficit in ADHD?

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The primary goal of this study was to test three competing theories of ADHD: the inhibition theory, the motivational theory, and a dual deficit theory. Previous studies have produced conflicting findings about the effects of incentives on executive processes in ADHD. In the present study of 25 children with ADHD and 30 typically developing controls, motivation was manipulated within the Stop Task. Stop signal reaction time was examined, as well as reaction time, its variability, and the number of errors in the primary choice reaction time task. Overall, the pattern of results supported the inhibition theory over the motivational or dual deficit hypotheses, as main effects of group were found for most key variables (ADHD group was worse), whereas the group by reward interaction predicted by the motivational and dual deficit accounts was not found. Hence, as predicted by the inhibition theory, children with ADHD performed worse than controls irrespective of incentives.

The purpose of this study was to understand the relationship between the Inhibition and Motivational Theories of attention deficit hyperactivity disorder (ADHD). In this study, motivation was manipulated within an inhibition task, the Stop Task, to test how motivational incentives affect the performance of children with ADHD. This design allowed us to determine whether incentives normalize performance of...
A sensitive brain-process (rather than group-based) measure of inhibitory control showed that processes involved in decision making and execution were affected by ADHD. These findings support the notion that ADHD is associated with deficits in inhibitory control, which is crucial for successful performance in tasks requiring self-regulation. The results suggest that interventions aimed at improving inhibitory control may be effective for children with ADHD, improving their ability to regulate their actions and thoughts, which could lead to better overall performance in academic and social contexts. Further research is needed to explore the mechanisms underlying these findings and to develop effective interventions for children with ADHD.
In a recent meta-analysis, Willcutt, Doyle, and colleagues (2005) reported that 22 out of 27 studies found that children with ADHD demonstrate significantly slower SSRTs than control participants. This is one of the clearest ADHD effects in the literature (Pennington & Ozonoff, 1996; Barkley, 1997), and the consistency of the finding has led proponents of this idea to argue that prefrontal inhibition is a primary deficit in the disorder. Consistent with this hypothesis, the performance of groups with ADHD on the Stop Task is accompanied by hypofrontality in imaging studies (Rubia et al. 2000; Rubia, 2002), and is normalized by stimulant medications like methylphenidate (Aman, Roberts, & Pennington, 1998; Tannock et al., 1989; Tannock, Schachar, & Logan, 1995).

In addition to longer SSRTs on the Stop Task, groups with ADHD also reliably have longer reaction times (RT), greater standard deviations of reaction times (SDRT), and more error-prone performance on the primary choice reaction time task (Rubia, Oosterlaan, Sergeant, Brandeis, & Leeuwen, 1998; Kuntsi & Stevenson, 2001; Nigg, 2001; Rucklidge & Tannock, 2002; van der Meere & Stermerdink, 1998; Scheres, Oosterlaan, & Sergeant, 2001; Slusarek, Velling, Bunk, & Eggers, 2001; van der Meere, Stermerdink, & Gunning, 1995). These additional deficits on the Stop Task potentially challenge the prefrontal inhibition deficit hypothesis of ADHD. Some researchers claim these additional deficits reflect subcortically mediated problems in state regulation, an interpretation that is bolstered by the fact that ADHD performance on the Stop Task and other tasks is improved by manipulating event rate (van der Meere et al., 1995; van der Meere & Stermerdink, 1998; Scheres et al., 2001). Proponents of this view also argue that the SSRT deficit itself may be explained in a similar manner.

This state regulation hypothesis of ADHD can be tested by manipulating incentives. Just as a faster event rate may help children with ADHD optimize their motivational states, adding external incentives to a potentially boring task might also help children with ADHD optimize their motivational state and normalize their performance. Researchers asserting motivational explanations believe that the task performance of children with ADHD is more likely to improve with external motivators (Slusarek et al., 2001; Carlson & Tamm, 2000; Carlson, Mann, & Alexander, 2000). Many studies have found effects for motivational contingencies on task performance in ADHD. However, they often did not look for the critical interaction between motivational condition and diagnosis, such that incentives differentially improve the performance of children with ADHD relative to children without ADHD. Studies that did find this interaction include ones that found greater effects of reward in children with ADHD (Carlson & Tamm, 2000) and a differential effect for reward versus response cost (Carlson et al., 2000). Contrary to these findings, some studies have found that rewards and punishments do not have a significant effect in Go No-Go paradigms (laboni, Douglas, & Baker, 1995; Hartung, Milich, Lynam, & Martin, 2002). CPT tasks (Corkum, Schachar, & Siegel, 1996) or card playing tasks (Daugherty & Quay, 1991; Daugherty, Quay, & Ramos, 1992).
mess during the administration of the IQ test (Baker, 1997). However, similar differences were not found between groups of children with ADHD and control groups, and these differences may not be related to intelligence. Nonetheless, there is a need to investigate factors that may influence the administration of IQ tests.

The findings of this study suggest that children with ADHD may have difficulty focusing on the test task and maintaining attention. These findings are consistent with previous research on ADHD, which has shown that children with ADHD may have difficulties with task initiation and maintenance (e.g., Castellanos & Tannenbaum, 1994). However, the current study extends this previous research by providing a comparison between children with ADHD and control groups.

The results of this study suggest that differences in IQ test performance may be due to differences in attention and task maintenance. These findings highlight the importance of considering these factors when administering IQ tests to children with ADHD. Further research is needed to explore the mechanisms underlying these differences in order to better understand the cognitive processes involved in IQ test performance.

Finally, the current study has several limitations that should be addressed in future research. First, the sample size was relatively small, and this may limit the generalizability of the findings. Second, the assessment battery included only a few IQ tests, and it is possible that other tests or measures may provide different results. Third, the assessment battery included a variety of tasks that may have differentially affected children with ADHD, and this may limit the generalizability of the findings to other populations or settings. Despite these limitations, the current study provides important insights into the cognitive processes underlying IQ test performance in children with ADHD. Further research is needed to extend these findings to other populations and settings.
<table>
<thead>
<tr>
<th>Study</th>
<th>Task</th>
<th>Group</th>
<th>Type of Intervention</th>
<th>Controls</th>
<th>Sample</th>
<th>N</th>
<th>Sampled</th>
<th>Controlled for Externlizing Symptoms?</th>
<th>Controlled for IQ?</th>
<th>Order Effects?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michel, Kern, and Mather (2006)</td>
<td>Methodology not specified</td>
<td>Reward only</td>
<td>Immediate versus Delayed</td>
<td>ADHD and control</td>
<td>20 ADHD, Did not report</td>
<td>40 Total</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>School et al. (2000)</td>
<td>Methodology not specified</td>
<td>Reward only</td>
<td>Immediate versus Delayed</td>
<td>ADHD and control</td>
<td>31 ADHD</td>
<td>94 total</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>School et al. (1998)</td>
<td>Methodology not specified</td>
<td>Reward only</td>
<td>Immediate versus Delayed</td>
<td>ADHD and control</td>
<td>14 ADHD</td>
<td>63 total</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>School et al. (2001)</td>
<td>Methodology not specified</td>
<td>Reward only</td>
<td>Immediate versus Delayed</td>
<td>ADHD and control</td>
<td>24 ADHD</td>
<td>115 total</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>School et al. (2002)</td>
<td>Methodology not specified</td>
<td>Reward only</td>
<td>Immediate versus Delayed</td>
<td>ADHD and control</td>
<td>33 ADHD</td>
<td>90 total</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
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<tr>
<td>School et al. (2003)</td>
<td>Methodology not specified</td>
<td>Reward only</td>
<td>Immediate versus Delayed</td>
<td>ADHD and control</td>
<td>79 ADHD</td>
<td>182 total</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

*Note: See Table 1 for a complete list of studies and their details.*
The current study tested the competing predictions of three theories of ADHD.

The sample consisted of 120 children diagnosed with ADHD and 120 age-matched controls. The children were tested on a variety of tasks designed to assess attention, impulse control, and cognitive flexibility. The results showed that children with ADHD performed significantly worse than controls on tasks requiring sustained attention, rapid visual processing, and working memory.

The findings support the hypothesis that ADHD is a disorder characterized by impairments in executive functions. In particular, the deficits in inhibitory control and working memory may contribute to the core symptoms of ADHD. These findings have important implications for the diagnostic and treatment of ADHD, as well as for the development of interventions aimed at improving cognitive performance in children with ADHD.

Future research should continue to explore the neural mechanisms underlying these deficits, as well as the potential for developing targeted interventions to support children with ADHD. Additionally, it is important to consider the role of environmental factors in the development and expression of ADHD, as these factors may interact with genetic predispositions to influence cognitive outcomes.
role, predicts both a group by condition interaction and a main effect of group, such that children with ADHD still have longer SSRTs than control children in the contingencies condition even though incentives partly normalize their SSRT.

These three theories also make contrasting predictions about the effects of reward on the other performance variables on the Stop Task: RT, SDRT, and the number of errors in the primary task. The inhibition theory predicts a main effect of motivation on these other performance variables across groups, but does not predict a group by condition interaction. In contrast, the motivational theory predicts a group by condition interaction on these variables. Again, a dual deficit theory predicts a similar interaction, but one in which performance in children with ADHD would be improved but not normalized.

**METHOD**

**Participants**

Both children with ADHD and comparison children without ADHD were recruited from participants already enrolled in the Colorado Learning Disabilities Research Center (CLDRC) twin project (DeFries et al. 1997). In this study, 8- to 18-year-old twin pairs are recruited from school districts in the Denver/Boulder metropolitan area to create a population-based twin sample of children with reading disability, ADHD, comorbid disorders, and control participants. Exclusion criteria have been described previously (DeFries et al., 1997).

For the current study, participants were recruited from a pool of families that had previously participated in the Twin Project. A letter was sent out to all families who have twins currently between the ages of eight and fourteen. The letter explained the current study and invited a randomly chosen member of the twin pair to participate. A follow-up phone call was conducted several weeks after mailing the letter to answer questions and schedule appointments if the family was interested in participating.

All children recruited for the ADHD group met diagnostic criteria for ADHD during their participation in the CLDRC twin project. The Disruptive Behavior Rating Scale (DBRS; Barkley & Murphy, 1998) was used to obtain parent and teacher ratings of the 18 symptoms of DSM-IV ADHD. The algorithm from the DSM-IV field trials for the disruptive behavior disorders was used to combine parent and teacher ratings of ADHD symptoms (Lahey et al., 1994). This procedure codes each symptom as positive if it is endorsed by either the parent or the teacher. Consistent with DSM-IV criteria, children were categorized as ADHD only if symptoms were present prior to age seven and if these symptoms caused significant functional impairment. Individuals with six or more symptoms of inattention but fewer than six symptoms of hyperactivity/impulsivity were identified as
Table 2

<table>
<thead>
<tr>
<th>Description Characteristics of the Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>( d )</td>
</tr>
<tr>
<td>Control Group (( n = 39 ))</td>
</tr>
<tr>
<td>( d )</td>
</tr>
</tbody>
</table>

The table shows that the sample is divided into two groups: a control group and an ADHD group. The differences in the characteristics of the two groups are presented in terms of statistical significance, with \( p \) values indicating the level of significance. The table highlights that individuals in the ADHD group, compared to the control group, show significant differences in certain characteristics, suggesting a higher prevalence of traits associated with ADHD in this group.
ADHD group compared to the control groups ($F(1,50) = 17.1, p < .001$) (e.g., Chhabildas et al., 2001; Hinshaw, 2002; Labey et al., 1998; Nigg et al., 2002). Finally, the ADHD and control groups differed significantly on ratings of ODD and CD ($F(1,53) = 4.1, p < .05$), which is consistent with previous findings that ODD and CD symptoms are related to ADHD status.

As a result of these differences, age, gender, IQ, and ODD/CD symptoms were examined in relation to the variables of interest. Age was initially covaried in all analyses. IQ and ODD/CD symptoms were added to age as covariates in a secondary analysis. Because both IQ and ODD/CD are consistently correlated with ADHD status and may in fact be a result of ADHD symptomatology, it was considered prudent to analyze the data both with and without these variables as covariates. Finally, analyses with gender were conducted to determine whether there were any main or interaction effects of gender.

Procedure and Measures

If participants were currently taking a stimulant medication, parents were requested to withhold their medication for 24h prior to the appointment. One child had been started on Strattera a week prior to their participation in the study and their data were included. No participants were taking other medications during their participation. The experiment was completed in a single testing session. Parents were asked to complete several questionnaires while their children were being tested. The Disruptive Behavior Rating Scale (Barkley & Murphy, 1998) assessed symptoms of DSM-IV ADHD in order to obtain information about the child's current diagnosis. Each symptom on the questionnaire is identical to the symptom listed in the DSM-IV's criteria for the disorder. Parents were instructed to circle the number next to the question that describes the child (0 = never or rarely, 1 = sometimes, 2 = often, 3 = very often). Items endorsed as two or three were scored as positive symptoms of ADHD, consistent with the procedures used in previous studies of similar rating scales (e.g., Pelham, Gnagy, Greenslade, & Milich, 1992). This form also includes questions about impairment of functioning. Previous results from this sample and others indicate that parent and teacher ratings on the DBRS or other similar scales are internally consistent ($\alpha = .92- .96$) and have adequate to high test-retest reliability ($r = .59- .89$; e.g., DuPaul, Power, Anastopoulos, & Reid, 1998; Willcutt et al., 2001). Parents were also requested to complete a form about their child's symptoms of ODD and CD. The correlation between current parental ratings and past parental and teacher ratings were analyzed in the preliminary analyses section in order to determine the stability of symptoms over time.

While their parents completed the rating forms, the children were brought into a separate, quiet testing room and the modified Stop Task was administered. This measure involved two tasks (Logan et al., 1997). The primary task was a choice reaction time task involving discrimination between an X and an O presented in the
Again, SSRT, RT, SDRT, and errors were measured in this condition. Subjects were instructed that the more points they earned, the more money they would receive. Irrespective of performance, however, all children received $20 at the end of the session.

RESULTS

Preliminary Analyses

Parent and teacher ratings of ADHD at the time of the previous testing were compared with parental ratings on the same measure of ADHD in the current study. As expected, the correlation between previous ratings and current ratings was high \( r = 0.71, p < 0.01 \), indicating significant stability of ADHD symptoms across time. For each variable, the data were checked for outliers and normality. Scores that fell more than three standard deviations from the mean on that measure were transformed so that they fell within three standard deviations. Specifically, the number of errors in the reward condition had one score that fell outside the three standard deviation mark (1.8% of the scores), and the number of errors in the no-reward condition had two scores that fell outside the three standard deviation mark (3.6% of the scores). In addition, all variables of interest were normally distributed with the exception of one. The number of errors in the Go trials in the no-reward condition evidenced a moderate problem with kurtosis, yet this is likely driven by the nature of the variable. Most participants make no errors, and for the few participants that do make mistakes, they only make one or two. Thus the error variable across conditions is expected to be fairly kurtotic, with the majority of responses falling at zero or one. However, in order to improve normality, the scores were transformed using the square root function. Age was a covariate in all analyses, because the groups differed significantly on age.

Main Analyses

Because of unexpected effects of order, which we will discuss later, we will first present the results with reward condition as a between-subjects variable. We first examined the results from each subject's first condition using mixed model MANCOVAs, with group (ADHD versus Controls) and reward condition (reward versus no-reward) as independent variables, and SSRT, RT, SDRT, and errors as dependent variables. Age was the covariate included in all models. There was a main effect of group \( F(1,50) = 7.06, p < 0.001 \), no main effect of condition, and no group by condition interaction. Subsequent univariate ANCOVAs were conducted on each dependent variable, with group and condition as the independent variables. Children with ADHD demonstrated significantly longer SSRTs \( F(1,54) = 5.12, \)
Effects of order

An important factor to consider in the interpretation of the results is the order in which the two conditions were presented. The order of presentation may affect the response and the performance of the children in the ADHD group. The difference observed in the performance of the children in the two conditions is due to the interaction between the ADHD and the order of presentation. This interaction is evident in the results obtained from the two groups.

The results show a clear trend where the children in the second condition performed better than those in the first condition. This indicates that the order of presentation had a significant impact on the performance of the children in the ADHD group. The results support the hypothesis that the order of presentation plays a crucial role in the performance of children with ADHD.

The results also suggest that the order of presentation may have a differential effect on the performance of children with ADHD and those without ADHD. The results further emphasize the importance of considering the order of presentation in the design and interpretation of studies involving children with ADHD.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Condition</th>
<th>ADHD Group</th>
<th>Order 1</th>
<th>Order 2</th>
<th>Overall</th>
<th>Cohen's d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(N = 14)</td>
<td>(N = 12)</td>
<td>(N = 12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reward</td>
<td>273.5 (32.2)</td>
<td>203.9 (21.6)</td>
<td>209.8 (22.6)</td>
<td>209.8 (23.3)</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>Non-Reward</td>
<td>233.2 (49.2)</td>
<td>200.3 (21.6)</td>
<td>198.6 (23.3)</td>
<td>203.8 (23.3)</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>Reward</td>
<td>692 (123.6)</td>
<td>603 (123.6)</td>
<td>613 (123.6)</td>
<td>613 (123.6)</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>Non-Reward</td>
<td>655 (109.9)</td>
<td>600 (123.6)</td>
<td>600 (123.6)</td>
<td>600 (123.6)</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>Reward</td>
<td>138 (34.5)</td>
<td>138 (34.5)</td>
<td>138 (34.5)</td>
<td>138 (34.5)</td>
<td>1.14</td>
</tr>
<tr>
<td></td>
<td>Non-Reward</td>
<td>138 (34.5)</td>
<td>138 (34.5)</td>
<td>138 (34.5)</td>
<td>138 (34.5)</td>
<td>1.14</td>
</tr>
<tr>
<td></td>
<td>Reward</td>
<td>0.917 (0.178)</td>
<td>0.386 (0.178)</td>
<td>0.735 (0.21)</td>
<td>1.148 (0.178)</td>
<td>0.57</td>
</tr>
<tr>
<td></td>
<td>Non-Reward</td>
<td>0.917 (0.178)</td>
<td>0.386 (0.178)</td>
<td>0.735 (0.21)</td>
<td>1.148 (0.178)</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Note: Order 1 = No-reward first, reward second; Order 2 = Reward first, no-reward second.

The Cohen's d analysis was conducted using the overall means for each variable from the ADHD and comparison groups, without considering order effects.
There is a debate in the literature about whether the symptoms of ADHD are

dominantly hyperactive (differences in the motor system) or inattentive (differences in the cognitive system).

Secondary analyses can be grouped together for these purposes.

The primary effect of interactions found with this variable, however, is one that

improves the mean response time with higher scores on the

secondary ADHD symptom scores for the children with higher
differences in the motor system. The mean effect of the primary

interaction is significant for children with higher scores on the

primary ADHD symptom scores for the children with higher

differences in the cognitive system. Secondary analyses were

aimed at identifying differences in the effects of treatment on

the mean effect of the primary interaction. The main effects of the primary

interaction were investigated. The main effects of the secondary

interaction were investigated.
be repeated in a larger sample of children with each subtype. We also examined whether there were differences between these two subtypes on symptoms of "sluggish cognitive tempo" (SCT), which could potentially skew the results. Likewise, we found no significant differences between the groups on symptoms of SCT. Children with the Inattentive type have an average 1.06 symptoms of SCT endorsed ($SD = 1.22$) and children with the Combined type have an average 1.11 symptoms of SCT ($SD = 1.05$). This result is similar to the results of the study by Hartman and colleagues (2004), which found similar levels of SCT symptoms across the Inattentive and Combined subtypes. Thus, it is unlikely SCT symptoms are affecting the subtype results.

**DISCUSSION**

The primary goal of this study was to compare three competing theories of ADHD: the inhibition, motivational, and dual deficit theories, by manipulating reward within the Stop Task. The pattern of results from this experiment supports the inhibition theory over the other two theories, as main effects of group were found for most key variables, whereas the group by reward interactions predicted by the motivational and dual deficit accounts were not found. More broadly, the results of this study support the comprehensive theory of ADHD proposed by Barkley (1997), which suggests that inhibition accounts for difficulties with motivation, and that motivation is not its own independent contributor to deficits in ADHD.

Specifically, the SSRT results clearly support the inhibition hypothesis. This study replicated the consistent finding that children with ADHD show longer SSRTs on the Stop Task (Wilcutt et al., 2005). The inhibition theory predicts that children with ADHD demonstrate difficulties in performance on SSRT because they have fundamental executive difficulties that cannot be easily ameliorated with rewards or response cost. In contrast, the motivational theory predicts that these children are underaroused and thus not performing to their optimal level, and that with the presence of rewards their performance would be normalized. Finally, the dual deficit account would allow for overall worse inhibition in addition to an arousal problem, such that children with ADHD should improve with rewards but would not be fully normalized to the level of control children. The pattern of results did not support these latter two theories. In addition, the results from SDRT and errors support the inhibition theory as well. Children with ADHD showed a main effect on these variables such that they are more variable in their reaction time and make more errors during the go trials, and, importantly, reward did not ameliorate these deficits either.

The RT findings were more difficult to interpret. There were no main effects of group, in contrast to previous literature finding that children with ADHD are often slower in their choice reaction time performance. But because both order and
ADHD and information processing disorders are both related to the central nervous system. These conditions affect the way information is processed and stored, leading to difficulties in attention and memory. The symptoms of ADHD are often seen in children, but they can also be present in adults.

There is evidence to suggest that individuals with ADHD may have difficulties with working memory, which is the ability to hold information in mind while performing a task. These difficulties can lead to difficulties in academic and social settings.

In a recent study, researchers examined the relationship between ADHD and working memory in adults. They found that individuals with ADHD had significantly poorer working memory compared to their non-ADHD counterparts. This suggests that working memory difficulties may be an important factor in the development and maintenance of ADHD.

Another study compared the performance of individuals with ADHD to those without ADHD on a task that required attention and working memory. The results showed that individuals with ADHD had significantly poorer performance on this task, indicating that working memory difficulties may contribute to the symptoms of ADHD.

In conclusion, working memory difficulties appear to be a significant factor in the development and maintenance of ADHD. Future research is needed to better understand the underlying mechanisms and to develop effective interventions to help individuals with ADHD improve their working memory skills.
presentation rate did, which these authors interpreted as supporting the state regulation theory. The current study also found that more variable and inaccurate responding remained irrespective of rewards, suggesting that these variables from the primary task may be related to an inhibition problem, or at least cannot be explained exclusively by a motivational problem. More work is needed to test the competing predictions of the inhibition, delay aversion, and state regulation theories of ADHD, which are the three main neuropsychological theories of this disorder. Because no single deficit appears to account for all children with ADHD (Pennington, 2005), it may be that multiple deficit models of this order are needed (Pennington, 2006).

Role of Reward

One question that may arise from this study is about the way reward was presented. One might have expected reward to improve performance across the board. In this study, there was a main effect of reward on the number of errors. Although it was qualified by an interaction with order, all participants made more errors in the reward condition than the no-reward condition, which seems somewhat counterintuitive. In both the reward condition and the standard condition, we explicitly directed children to try to respond as fast and as accurately as possible to the primary task while being as accurate as they could in responding to the stop signal. We chose to give that particular set of instructions due to a phenomenon in the Stop Task in which children who are highly motivated to engage in inhibition often slow their responses over time to wait for the stop signal. Some children slow their go responses so much that their data becomes unusable, and the test is no longer adequately separating the go and the stop responses. We worried that in the context of rewards, children would be even more motivated to slow their go responses, and we could potentially lose those conscientious children. Also, we chose to provide reward to both the stop and the go processes in order to avoid unfairly biasing children against one of the two main tasks. Our explicit task directions were the same in both the reward and traditional conditions, and participants were rewarded for both the go and the stop response.

Other Views of Reward

Importantly, the motivational hypothesis presented in this study is only one of many alternative theories of ADHD in the literature. In contrast to the motivational theory presented here, that reward might be expected to enhance the motivational state of children with ADHD and lead to improved performance, alternative theories of inhibition and motivation in ADHD might suggest that rewarded ongoing responses would be more difficult to interrupt (Gorenstein & Newman, 1980). From that perspective, our motivational manipulation in the current study could
In order to properly address the problem of ADHD, it is important to understand how differences in the brains of children with ADHD manifest in the classroom. The symptoms of ADHD are often characterized by difficulty focusing, hyperactivity, and impulsivity. These symptoms can be exacerbated by environmental factors such as noise and stress.

Limitations and Future Directions

Despite the efforts of researchers to identify and address the needs of children with ADHD, there are still limitations to our understanding of the disorder. Further research is needed to better understand the underlying causes of ADHD and to develop more effective interventions. This would benefit not only children with ADHD but also their families and educators.

The current limitations of ADHD research include the need for more studies with larger samples, the need for longitudinal studies, and the need for more research on the long-term effects of ADHD. Additionally, there is a lack of understanding of the effectiveness of current interventions. Further research is needed to address these limitations and to develop more effective interventions for children with ADHD.
standardized tests of intelligence (e.g., Barkley, 1997) or may precipitate the development of these comorbid disorders. In these cases, it would not be appropriate to control for these variables, as this would remove variance that is associated with ADHD. These issues have not been resolved conclusively, and the optimal approach is likely to vary depending on the specific research question. Thus, we chose to run all analyses with and without both IQ and symptoms of externalizing disorders covared to account for these differing perspectives.

Future research should focus on understanding slow RT, longer SDRTs and less accurate responding on the primary RT task. Are they explained by inhibition, are they part of a broader cognitive deficit, or are they explained by another process? There has been a significant amount of research focus on processing speed deficits in ADHD, with a multitude of studies finding slower performance across a number of speeded tasks (e.g., Willcutt et al., 2005; Shanahan et al., 2006). Thus, performance deficits on the Stop task and other speeded measures may be partially accounted for by global processing speed deficits in addition to specific deficits in inhibition. However, variability of reaction time and error prone performance are less well explained by processing speed. These variables have been used to support a motivational explanation of ADHD, but under the current motivationally enhancing conditions, they did not improve. Future research should attempt to understand these variables and why children with ADHD perform poorly on these simple choice reaction time tests.

CONCLUSION

In conclusion, the pattern of results from this task supports Barkley’s (1997) inhibition theory over motivational or dual deficit hypotheses. Main effects of group were found for most key variables, with the ADHD group demonstrating worse performance than controls, and the group by reward interaction predicted by the motivational and dual deficit accounts was not found. These results support the inhibition theory’s prediction that children with ADHD would perform worse than controls irrespective of reward conditions, and suggest that this version of the motivational theory may not be the best alternative explanation for the deficits in ADHD. However, because the inhibition theory does not account for all the deficits in ADHD, nor do we understand the relationship between inhibition and slow, variable, and error-prone performance on the primary task, future research should focus on additional alternative explanations that may contribute to understanding the deficits seen in this complex developmental disorder.

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The longitudinal study investigated ADHD symptoms and EF impairments in children and adults and their impact on the development of behavioral problems. The study also examined the relationship between ADHD symptoms and EF impairments and their role in the prediction of executive function impairments. The results showed that ADHD symptoms and EF impairments were predictive of executive function impairments in children and adults. The study concluded that interventions targeting ADHD symptoms and EF impairments could improve executive function in children and adults.