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What is This?
Gambling, Delay, and Probability Discounting in Adults With and Without ADHD

Zhijie Dai¹,², Sarah-Eve Harrow², Xianwen Song³, Julia J. Rucklidge³, and Randolph C. Grace²,⁴

Abstract

Objective: We investigated the relationship between impulsivity, as measured by delay and probability discounting, and gambling-related cognitions and behavior in adults with and without ADHD. Method: Adults who met Diagnostic and Statistical Manual of Mental Disorders (4th ed.; DSM-IV) diagnostic criteria for ADHD (n = 31) and controls (n = 29) were recruited from the community. All completed an interview that included an assessment of psychiatric disorders, gambling questionnaires, and simulated gambling, delay, and probability discounting tasks. Results: The ADHD group was more likely to meet the criteria for problem gambling and was more impulsive than controls based on a composite discounting measure. ADHD symptoms were correlated with gambling-related cognitions and behavior. Probability, but not delay discounting, explained significant variance in gambling-related measures after controlling for ADHD symptoms. Discussion: Results confirm an association between adult ADHD and gambling, and suggest that the facets of impulsivity related to risk proneness may be an independent risk factor for problem gambling in this population. (J. of Att. Dis. XXXX; XX(X) 1-XX)

Keywords

adult ADHD, delay-discounting task, decision making, risk taking, impulsivity

ADHD is estimated to affect 4% to 5% of adults (Kessler et al., 2006) and is associated with substantial life impairments, including worse educational, occupational, economic, psychiatric, and social outcomes than non-ADHD adults (Klein et al., 2012). There is a small but consistent body of literature showing a relationship between problem gambling and ADHD symptoms. For example, Carlton, Manowitz, and McBride (1987) found that 14 pathological gamblers reported higher ratings of primary symptoms of ADHD in childhood compared with 16 controls. Carlton and Manowitz (1992) showed that although most pathological gamblers reported a childhood history of ADHD, only a subset had difficulties with behavioral restraint. Rodriguez-Jimenez et al. (2006) found that 29.1% of pathological gamblers (of a total sample of 55 pathological gamblers) had a childhood history of ADHD and performed worse on stop signal delayed gratification tasks. More recently, Breyer et al. (2009) found that young adults with ADHD who had higher rates of problem gambling reported greater law-related and employment difficulties compared with controls and individuals with ADHD in remission.

Overall, there is good evidence for a linkage between ADHD in adults and problem gambling, but more research is needed to investigate the psychological mechanisms that may be involved. The goal of the present study is to investigate whether potential deficits in delay and probability discounting (PD) in adults with ADHD may contribute to an increased likelihood of problem gambling. This possibility is suggested by prior lines of research, reviewed below, which have separately documented associations between discounting and ADHD, and discounting and gambling. Here, we report the first investigation of these variables in a single study by examining the performance of adults with and without ADHD on delay and PD tasks, and gambling-related behavior and cognition.

Delay Discounting (DD)/PD and ADHD

Impulsivity is recognized as one of the key behavioral features of ADHD (Sagvolden, Johansen, Aase, & Russell, 2005). We view impulsivity in terms of a discounting...
framework for delayed and probabilistic choice that has become an increasingly popular theory (see Green & Myerson, 2004, for review). Although there are different aspects of impulsivity, and terms such as discounting, disinhibition, and self-control may represent distinct constructs to some extent (Evenden, 1999), we assume that there is sufficient overlap such that individual differences in DD and PD are likely to correspond to differences in other aspects of impulsivity as well.

According to the discounting framework, the value of a choice outcome decreases as a function of its delay or probability of receipt, and individuals may differ in their discounting rates. Relatively high rates of DD, and low rates of PD, are associated with impulsivity. For example, an individual who steeply discounted delayed outcomes would be likely to choose a smaller, more immediate reward (e.g., $100 available now) over a larger, more delayed reward (e.g., $200 in 1 year). Someone with a low rate of PD would show insensitivity to risk (i.e., risk proneness) and would be likely to choose a less certain, larger reward (e.g., a 10% chance to win $10,000) over a more certain, smaller reward with an equal expected value (e.g., $1,000 for sure). Researchers have investigated whether there is an association between childhood ADHD and DD (see Winstanley, Eagle, & Robbins, 2006, for review). Most of these studies (e.g., Barkley, Edwards, Laneri, Fletcher, & Metevia, 2001) have found that children/adolescents with ADHD were significantly more likely than controls to choose a smaller, immediate reward over a larger, delayed reward, and thus had higher rates of DD. Relatively, few studies have examined the relationship between childhood ADHD and PD. Drechsler, Rizzo, and Steinhausen (2010) found that children aged 7 to 9 years who had been diagnosed with ADHD were more likely than controls to choose the risky option in a probabilistic choice task. Scheres et al. (2006) compared the performance of children and adolescents with ADHD to controls in delay and PD tasks. In their study, choice outcomes were small amounts of money (up to 10 cents). They found that young children showed higher DD rates than adolescents, but there were no significant differences between ADHD and controls for either delay or PD.

We are aware of only two studies that have investigated performance of adults with ADHD on DD tasks. Plichta et al. (2009) compared a male adult ADHD sample (age 19-32 years) with a group of non-ADHD adult controls. Although there was no difference between the groups in terms of preference for the smaller, more immediate reward, functional magnetic resonance imaging (fMRI) data showed reduced activation in the ventral-striatal region for the ADHD group, suggesting a diminished neural processing of delayed rewards. Hurst, Kepley, McCalla, and Livermore (2011) showed that young adults (university students) with a self-reported history of ADHD diagnosis had higher delay-discounting rates than those without ADHD. Thus, there is some evidence that ADHD in adulthood is associated with a greater impulsivity in intertemporal choice, although no studies with adults have investigated a potential link between ADHD and PD.

**DD/PD and Problem Gambling**

Research has found that problem gamblers have higher levels of impulsivity than controls (Castellani & Rugle, 1995) and self-reported impulsivity was found to predict problem gambling in a sample of New Zealand university students (Clarke, 2004). Several researchers (e.g., Dixon, Marley, & Jacobs, 2003; Petry, 2001; Petry & Casarella, 1999; see Reynolds, 2006, for review) have found that problem gamblers have increased rates of DD for smaller than for larger monetary rewards, whereas Holt, Green, and Myerson (2003) reported no difference. Dixon, Jacobs, and Sanders (2006) showed that even when problem gamblers completed the discounting task in a nongambling setting, they discounted delayed monetary rewards at a significantly higher rate than nongambling controls.

Several studies have examined the relation between PD and gambling behavior. Holt et al. (2003) reported that college student gamblers had lower rates of PD compared with a matched group of nongamblers. Shead, Callan, and Hodgins (2008) failed to find a significant negative correlation between PD rates and college student gamblers’ scores on the Canadian Problem Gambling Index (Ferris & Wynne, 2001). However, in a study with pathological gamblers and controls, Madden, Petry, and Johnson (2009) found a significant negative correlation between PD rates and scores on the South Oaks Gambling Screen (SOGS; Lesieur & Blume, 1987)). Although the differences in DD were not significant in Madden et al.’s study, results approached significance when education and ethnicity were included as covariates. Overall, there is evidence that problem gamblers are characterized by higher and lower rates, respectively, of delay and PD, compared with the controls, which is the pattern associated with impulsivity.

**The Present Study**

We compared a group of adults who met diagnostic criteria for ADHD with a non-ADHD adult control group on DD and PD tasks, psychometric measures related to gambling (SOGS; Lesieur & Blume, 1987), the Gambling-Related Cognitions Scale (GRCS; Raylu & Oei, 2004), and self-reported gambling behavior. Participants also completed a computer-based Card Playing Task (CPT) that simulated aspects of gambling (adapted from Newman, Patterson, & Kosson, 1987, 1992). We addressed three major questions: (a) whether adults with ADHD had higher levels of impulsivity than non-ADHD controls, as measured by delay and PD rates; (b) whether ADHD diagnosis and measures of
ADHD symptoms would be associated with gambling-related behavior and cognitions; and (c) whether the measures of DD, PD, or both, could explain variance in gambling-related measures after accounting for ADHD symptoms.

**Method**

**Participants**

Sixty participants were recruited for the study. The ADHD group was referred from the community, including general practitioners, psychiatric services, private psychiatrists/psychologists, databases of previous studies and self-referrals to the University of Canterbury. The participants without ADHD were recruited through advertisements in the community. The study received ethical approval from the Human Ethics Committee at the University of Canterbury and the Upper South A Regional Ethics Committee. All participants provided their written consent prior to commencing the study, and were compensated with petrol and grocery vouchers (NZ$15 total) for their participation.

**Recruitment and Screening of ADHD and Control Groups**

The following three measures were used for group allocation: (a) The Conners’ Adult ADHD Rating Scale (CAARS; Conners, Erhardt, & Sparrow, 1999), which was used to identify the presence of significant ADHD symptoms as well as provide information on their severity; (b) Conners’ adult ADHD diagnostic interview for Diagnostic and Statistical Manual of Mental Disorders (4th ed.; DSM-IV; American Psychiatric Association [APA], 1994; CAADID; Epstein, Johnson, & Conners, 2000), which is a semistructured interview assessing the developmental history of ADHD and current classification of ADHD subtypes; and (c) structured clinical interview for Diagnostic and Statistical Manual of Mental Disorders (4th ed., text revision; DSM-IV-TR; APA, 2000) Axis I disorders (SCID; First, Spitzer, Gibbon, & Williams, 1996), which was used to screen for lifetime and current psychological disorders and to ensure that the ADHD symptoms were not better accounted for by another Axis I disorder. Participants also completed a history questionnaire, which included demographic variables such as ethnicity, annual income, marital status, education, and current prescription medication.

To be included in the ADHD group, a participant had to meet each of the following four criteria: (a) exceeding a cutoff T-score of 70 on the CAARS self- and observer report on either the DSM-IV Inattentive or Hyperactive/Impulsive subscale (as recommended by Conners et al., 1999); (b) DSM-IV diagnostic criteria for ADHD based on meeting six of the nine symptoms for either inattentive or hyperactivity/impulsivity categories, established by the CAADID; (c) evidence of ADHD symptoms prior to 7 years, established either with the CAADID, interview with parent/spouse, or review of previous school report cards; and (d) evidence of impairing symptoms in everyday life.

Participants were excluded from either ADHD or control group if they had (a) an estimated IQ below 70 as measured by the block design and vocabulary subtests of the Wechsler Adult Intelligence Scale–III (WAIS-III; Wechsler, 1997), or (b) a pervasive developmental disorder, recent head injury, or psychotic disorder. Specific exclusion criteria for the non-ADHD group were (a) a history of significant problems with inattention or hyperactivity/impulsivity and (b) T-scores above 60 on the DSM-IV inattentive and hyperactive/impulsive subscales of the CAARS (observer or self-reports). These criteria resulted in four controls being excluded; one due to a recent head injury and three others due to T-scores on the CAARS above the control cutoff criteria of 60. Recruitment/screening of ADHD and control participants was conducted by the second author. All interviews were reviewed with a senior registered clinical psychologist.

**Gambling Instruments**

**SOGS.** The most commonly used instrument for assessing disordered gambling is the 20-item, self-administered SOGS (Lesieur & Blume, 1987). Scores range from 0 to 20, and individuals can be classified as probable problem gamblers or probable pathological gamblers at a typical cutoff score of 5. Although the specific cutoffs used have varied across studies (see Petry, 2005), it is clear that increased scores on the SOGS universally represent more severe gambling problems. Stinchfield (2002) found that the SOGS demonstrated adequate reliability (α = .69-.86) and was able to discriminate accurately between gambling and general population samples.

**GRCS.** The GRCS (Raylu & Oei, 2004) is a 23-item self-report questionnaire that assesses thoughts/cognitions experienced while gambling. Each statement is rated for agreement on a 7-point Likert-type scale, ranging from strongly disagree (1) to strongly agree (7). The items are divided into five subscales that correspond to five cognitive biases found in problem gamblers: Perceived Inability to Stop, Predictive Control, Gambling Expectancies, Interpretive Bias, and Illusion of Control. Higher scores indicate more agreement with the cognitive biases associated with gambling. Raylu and Oei (2004) reported that the GRCS had excellent reliability (α = .77-.91 for subscales, and α = .93 for the total score). Criterion validity was demonstrated by a positive correlation with the SOGS (r = .44).

**The CPT.** The CPT was designed as a brief gambling simulation, based on a procedure originally used by Newman.
et al. (1987, 1992). The CPT consisted of eight blocks of 10 cards each. The participants were informed that the task did not involve a standard deck of playing cards so that they could not predict how many cards of each type would appear. Red cards (hearts/diamonds) and black cards (spades/clubs) represented (hypothetical) gains and losses of $50, respectively. Participants were told that the goal was to win as much money as possible.

To play, participants made a mouse click on the screen and a card appeared, together with feedback about their gain or loss. The identity (red: black) of each card was determined pseudorandomly with the constraint that for the eight successive blocks of trials, the distributions were 6:4, 7:3, 4:6, 2:8, 5:5, 3:7, 1:9, and 0:10, respectively. Thus, participants would win money over the first two blocks, but then there was a gradual shift toward increasing losses across subsequent blocks. After each block was completed, a prompt was displayed on the screen and the participant had to decide whether to continue playing. The amount won or lost on each trial, as well as the cumulative total, was also displayed. A “quit” button was always present in the lower left corner.

**DD and PD task.** Participants completed a computer-based task to measure rates of delay and PD (see Dai, Grace, & Kemp, 2009; Grace & McLean, 2005). They were told that they would be presented with a series of questions displayed on the computer, which involved hypothetical choices between different amounts of money, and asked to answer them in a realistic and accurate manner. The program used an algorithm to generate a series of questions that would result in an indifference point: the immediate (or certain) reward that would be equally valued to the delayed (or uncertain) reward. The DD task used immediate rewards of $50 and $5,000 and probabilities of 95%, 90%, 70%, 40%, 10%, and 5%. The currency was New Zealand dollars, which at the time the research was conducted (in 2009) had an exchange rate of approximately NZ$1 = US$0.71.

**Procedure**

Each participant completed two sessions. The first (approximately 2 hr duration) consisted of the diagnostic interview (SCID for all participants with the additional questions on ADHD (CAADID) for those with ADHD symptoms) and demographic questions. All testing was conducted on a separate day (approximately 2 hr duration) consisted of the diagnostic interview at the University of Canterbury. Seven (23.3%) of the ADHD patients were on methylphenidate and were asked not to take it 24 hr prior to testing. Thirteen (43.3%) of the ADHD participants were taking antidepressant medications at the time of testing. In the control group, only 1 (3.6%) participant was taking an antidepressant.

Statistical analyses used the .05 significance level and were conducted with STATISTICA version 9.1 (StatSoft, Inc.) and SPSS Statistics v19 (IBM, Inc.).

**Results**

**Sample Characteristics**

The ADHD group comprised 31 participants (17 female, 14 male) with a mean age of 35.25 years (SD = 13.36; range = 17-64), while the control group included 29 participants (14 female, 15 male), with a mean age of 31.00 years (SD = 12.35; range = 20-57). No significant differences between the groups were found in age, $F(1, 58) = 1.97$, $p = .17$; socioeconomic status, $F(1, 56) = .003$, $p = .96$; or IQ ($M_s = 115.80$ and 119.86 for ADHD and control groups, respectively), $F(1, 56) = .93$, $p = .34$. Comparisons for demographic variables found no significant differences in gender, $\chi^2(1) = .28$, $p = .60$; ethnicity, $\chi^2(3) = 2.43$, $p = .49$; marital status, $\chi^2(4) = 3.96$, $p = .41$; home situation, $\chi^2(7) = 9.70$, $p = .21$; education, $\chi^2(7) = 8.80$, $p = .27$; and income, $\chi^2(6) = 8.97$, $p = .18$. However, there were significant differences in employment status: Thirteen (46.4%) of the control group were students compared with 7 (23.3%) of the ADHD group and 6 (20%) of the ADHD group but no controls reported being either unemployed or on sickness benefit, $\chi^2(4) = 9.31$, $p < .05$.

Psychiatric diagnoses for the ADHD and control groups are shown in Table 1. As expected, the frequency of psychiatric and behavioral disorders was greater for the ADHD group compared with the controls. The ADHD group was significantly more likely to have met diagnostic criteria in the past for Major Depressive Disorder (MDD), dysthymia, drug dependence, and alcohol abuse. They were also significantly more likely currently to meet major depressive episode (MDE) and social phobia criteria. Table 2 shows results for both groups on CAARS. As expected, self-reported frequencies of inattentive symptoms, $F(1, 56) = 269.03$, $p < .001$; hyperactive-impulsive symptoms, $F(1, 56) = 46.03$, $p < .001$; and observer reports of inattentive, $F(1, 56) = 80.90$, $p < .001$; and hyperactive-impulsive symptoms, $F(1, 56) = 28.22$, $p < .001$, were significantly higher for the ADHD group.

Results from the DD and PD tasks were assessed in terms of the area under the discounting curve (AUC). The AUC is a nonparametric method for measuring discounting...
rates that does not rely on the assumption of a specific discounting function (Myerson, Green, & Warusawitharana, 2001). Larger AUC values correspond to lower rates of discounting and vice versa. Figure 1 shows the average AUC values for the DD and PD tasks for ADHD and control groups.

### Table 1. Psychiatric Diagnoses by Group: Number (n) and Percentage (%) and Chi-Square Statistics ($\chi^2$).

<table>
<thead>
<tr>
<th>Comorbid diagnosis</th>
<th>ADHD (n = 30)</th>
<th>Control (n = 28)</th>
<th>$\chi^2(1)$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>MDE (C)</td>
<td>7</td>
<td>23.3</td>
<td>0</td>
</tr>
<tr>
<td>MDE (P)</td>
<td>23</td>
<td>76.7</td>
<td>12</td>
</tr>
<tr>
<td>Dysthymia (C)</td>
<td>2</td>
<td>6.7</td>
<td>0</td>
</tr>
<tr>
<td>Dysthymia (P)</td>
<td>5</td>
<td>16.7</td>
<td>0</td>
</tr>
<tr>
<td>Phobia (C)</td>
<td>2</td>
<td>6.7</td>
<td>0</td>
</tr>
<tr>
<td>Phobia (P)</td>
<td>2</td>
<td>6.7</td>
<td>0</td>
</tr>
<tr>
<td>PTSD (C)</td>
<td>3</td>
<td>10.0</td>
<td>0</td>
</tr>
<tr>
<td>Social phobia (C)</td>
<td>10</td>
<td>33.3</td>
<td>0</td>
</tr>
<tr>
<td>Social phobia (P)</td>
<td>4</td>
<td>13.3</td>
<td>1</td>
</tr>
<tr>
<td>GAD (C)</td>
<td>2</td>
<td>6.7</td>
<td>0</td>
</tr>
<tr>
<td>GAD (P)</td>
<td>2</td>
<td>6.7</td>
<td>0</td>
</tr>
<tr>
<td>Drug abuse (C)</td>
<td>2</td>
<td>6.7</td>
<td>0</td>
</tr>
<tr>
<td>Drug abuse (P)</td>
<td>8</td>
<td>26.7</td>
<td>2</td>
</tr>
<tr>
<td>Drug dependence (P)</td>
<td>7</td>
<td>23.3</td>
<td>0</td>
</tr>
<tr>
<td>Alcohol abuse (C)</td>
<td>4</td>
<td>13.3</td>
<td>1</td>
</tr>
<tr>
<td>Alcohol abuse (P)</td>
<td>12</td>
<td>40.0</td>
<td>3</td>
</tr>
<tr>
<td>Alcohol dependence (C)</td>
<td>4</td>
<td>13.3</td>
<td>1</td>
</tr>
<tr>
<td>Alcohol dependence (P)</td>
<td>10</td>
<td>33.3</td>
<td>2</td>
</tr>
</tbody>
</table>

Note. Only those with two or more diagnoses were included in these analyses. MDE = major depressive episode; PTSD = Posttraumatic Stress Disorder; GAD = generalized anxiety disorder; C = met current diagnosis; P = met past diagnosis.

*p < .05. **p < .01. ***p < .001.

### Table 2. Means (Ms) and Standard Deviations (SDs) of ADHD Symptoms, Symptom Severity, and Number and Percentage of ADHD Subtypes.

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADHD (n = 31)</th>
<th>Control (n = 28)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of subtypes (CAADID)</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Predominantly inattentive*</td>
<td>14</td>
<td>46.7</td>
</tr>
<tr>
<td>Hyperactive/impulsive*</td>
<td>4</td>
<td>13.3</td>
</tr>
<tr>
<td>Combined*</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td>CAARS-S (T-scores)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSM-IV Inattentive***</td>
<td>83.07</td>
<td>8.32</td>
</tr>
<tr>
<td>[80.09, 86.05]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSM-IV H/I***</td>
<td>64.27</td>
<td>14.90</td>
</tr>
<tr>
<td>[58.94, 69.60]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAARS-O (T-scores)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSM-IV inattentive***</td>
<td>68.57</td>
<td>10.01</td>
</tr>
<tr>
<td>[64.99, 72.15]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSM-IV H/I***</td>
<td>60.73</td>
<td>14.42</td>
</tr>
<tr>
<td>[55.57, 65.89]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. 95% confidence intervals for CAARS scores are shown in brackets. CAADID = Conners’ adult ADHD diagnostic interview for Diagnostic and Statistical Manual of Mental Disorders (4th ed.; DSM-IV); CAARS-S = Conners’ Adult ADHD Rating Scale–Self-Report; CAARS-O = Conners’ Adult ADHD Rating Scale–Observer-Report; H/I = hyperactive/impulsive symptoms.

*Number and percentage.

*p < .05. **p < .01. ***p < .001.
A repeated-measures ANOVA with group (control/ADHD) as a between-subjects factor and discounting task (DD/PD) and monetary amount ($50/$5,000) as within-subjects factors found a significant effect of amount, $F(1, 57) = 36.90, p < .001, \text{partial } \eta^2 = .39,$ and a significant amount x task interaction, $F(1, 57) = 134.31, p < .001, \text{partial } \eta^2 = .70.$ As Figure 1 shows, discounting rates were lower for the $5,000 reward in the DD task and for the $50 reward in the PD task. This indicates that amount had opposite effects on delay and PD rates, similar to previous research (Green, Myerson, & Ostaszewski, 1999).

The interaction between groups and tasks was significant, $F(1, 57) = 5.58, p < .05, \text{partial } \eta^2 = .09.$ As Figure 1 shows, the ADHD group had higher rates of DD (i.e., lower average AUC values) and lower rates of PD (i.e., higher average AUC) compared with the control group. Because impulsivity is associated with higher rates of DD and lower rates of PD (i.e., risk proneness), we calculated the difference between the AUC value for DD and PD as a composite measure of impulsivity ($\text{AUC}_{DD} – \text{AUC}_{PD}).$ Note that because discounting rates vary inversely with AUC, higher scores on the composite measure correspond to lower levels of impulsivity (and vice versa). Figure 2 shows $\text{AUC}_{DD} – \text{AUC}_{PD}$ separately for $\$50$ and $\$5,000$ amounts. Post hoc tests showed that the composite measure was significantly higher for the controls for $\$50$ ($p = .05$) and $\$5,000$ amounts ($p < .05$), indicating a greater level of impulsivity for the ADHD group.

Table 3 shows results from the gambling-related measures for the ADHD and control groups. Overall, the ADHD group had less money at the end of the CPT, and higher scores on SOGS and GRCS, suggesting a greater level of gambling behavior, but none of these differences were significant, $t(58) = -0.98, 0.96, \text{and } 1.33,$ respectively, all $ps > .18.$ However, there was evidence of increased prevalence of problem gambling in the ADHD group. Three (9.6%) ADHD participants met the cutoff criteria for probable pathological gambling in a lifetime (i.e., SOGS > 5), whereas none of the controls did, $\chi^2(1) = 7.61, p < .05.$ Conversely, only 11 (35.5%) of the ADHD group reported having no lifetime problems with gambling (SOGS = 0), which was significantly less than the control group ($n = 20, 76.9\%,$ $\chi^2(1) = 6.47, p < .05.$

For a more sensitive assessment of the relationship between ADHD and gambling-related measures, we conducted a correlational analysis. Table 4 shows correlations between ADHD measures (Control/ADHD, CAARS-Observer) and gambling measures (SOGS, GRCS [total score and subscales], and the total amount of money won [or lost] on the CPT). The average AUC values for DD and PD (i.e., $[\text{AUC}_{5000} + \text{AUC}_{50}] / 2$ and the composite measure $[\text{AUC}_{DD} – \text{AUC}_{PD})$ were also included.

Table 4 shows that there were significant correlations between control/ADHD and GRCS inability to stop gambling, $r = .27, p < .05,$ indicating that the ADHD group reported a greater difficulty with gambling than controls. The correlation with the composite discounting measure was also significant, $r = -.33, p < .05,$ consistent with the interaction in Figures 1 and 2. The CAARS-observer score was negatively correlated with the amount of money won (lost) on the CPT, $r = -.31, p < .05,$ average AUC DD and CD measure, $rs = -.29$ and $-.31, ps < .05,$ respectively. CAARS-observer was also positively correlated with the GRCS overall score, $r = .31, p < .05,$ and illusion of control and inability to stop gambling subscales, $rs = .32$ and .45, respectively, $ps < .05$ and .01. Finally, CAARS-observer was positively correlated with SOGS, $r = .30, p < .05.$ These results suggest that individuals with greater levels of ADHD
symptoms were more likely to report behavior and cognitions consistent with problem gambling and lost more money on the CPT. Money on the CPT was negatively correlated with average AUC probability, \( r = -.38, p < .01 \), and positively correlated with the composite discounting measure, \( r = .29, p < .05 \), indicating that participants with higher levels of risk proneness and impulsivity performed more poorly on the CPT. Thus, although group differences in gambling-related measures were not significant in Table 2, correlations in Table 4 support a linkage between ADHD and problem gambling in that intensity of ADHD symptoms was correlated with increased gambling-related behavior and cognitions and poor performance on the CPT.

Finally, we performed an analysis to determine the extent to which variance in gambling-related behavior and cognitions could be accounted for by ADHD symptoms and discounting measures. A hierarchical multiple regression was conducted in which money won (lost) on the card playing game was predicted by CAARS-observer at the first step (CAARS-self was not significantly related to money when CAARS-observer was included), and average delay and probability AUC values were added at the second step. Money was significantly predicted by CAARS-observer, \( \beta = -.32, R^2 = .10, p < .05 \) (consistent with the significant correlation in Table 4). When DD and PD measures were added to the model, the increase in variance was significant, \( R^2_{\text{inc}} = .11, p < .05, R^2_{\text{overall}} = .21, p < .01 \), and PD but not DD significantly predicted money won (lost) in the CPT, \( \beta = -.33, p < .05 \) and \( \beta = -.08, p = .53 \), respectively.

Similar regressions were conducted using the GRCS and SOGS as the outcome variables. For the GRCS, DD and PD contributed significant additional variance, \( R^2_{\text{inc}} = .10, p < .05, R^2_{\text{overall}} = .19, p < .01 \), and PD but not DD was significantly related to GRCS scores, \( \beta = .31, p < .05 \), and \( \beta = .04, p = .76 \), respectively. Results were similar for the SOGS: Both measures contributed significant additional variance, \( R^2_{\text{inc}} = .17, p < .01, R^2_{\text{overall}} = .27, p < .01 \), and PD but not DD was significantly related to SOGS scores, \( \beta = .42, p < .01 \) and \( \beta = -.11, p = .40 \), respectively.

## Discussion

The major questions addressed by the present study were whether adults who had been diagnosed with ADHD would show greater impulsivity as measured by discounting of delayed and probabilistic rewards, and increased levels of gambling-related cognitions and behavior, compared with non-ADHD controls. In addition, we asked whether DD or PD (or both) might explain the variance in gambling-related measures beyond ADHD symptoms.

Results showed that the ADHD group had significantly higher levels of impulsivity according to a composite measure of the difference between DD and PD rates. Higher values on the composite measure are associated with more rapid discounting of future outcomes, increased risk proneness, or both. In addition, a continuous measure of ADHD symptoms (CAARS-observer scale) was significantly correlated with discounting (composite and delay measures) and gambling variables, which included the SOGS and GRCS and money lost in a computer-based gambling task CPT. Multiple regressions showed that after controlling for ADHD symptoms, PD but not DD significantly predicted money lost on the CPT and higher SOGS and GRCS scores. These results are consistent with our hypothesis that adults with ADHD may be characterized as more impulsive in terms of choices between delayed or uncertain outcomes, and that the severity of ADHD symptoms is correlated with gambling-related behavior and cognitions. They also suggest a role for risk proneness, as measured by relatively low rates of PD, as a predictor of gambling behavior for adults with ADHD.

Ours is the first study, as far as we know, to use the difference between DD and PD rates as a measure of impulsivity. This was possible because we used a within-participant design, in which DD and PD were assessed for the same amounts ($50 and $5,000), for ADHD and controls. Although impulsivity is acknowledged to be a multidimensional construct (Cross, Copping, & Campbell, 2011; Evenden, 1999), it is typically assumed that higher rates of DD, and conversely, lower rates of PD correspond to aspects of impulsivity that have implications for real-world behavior. This view is supported by a large number of studies that have shown that individuals with impulse-control disorders such as substance abuse and problem gambling have higher rates of DD (e.g., Bickel, Odum, & Madden, 1999; Kirby & Petry, 2004; Kirby, Petry, & Bickel, 1999; Mitchell, 1999; Petry, 2001), whereas low rates of PD are associated with problem gambling (Holt et al., 2003; Madden et al., 2009). Because DD and PD are distinct constructs—with the former corresponding to impatience and inability to delay gratification and the latter to risk proneness—they likely...
tap into different facets of impulsivity, at least to some extent. Thus, based on a multidimensional concept of impulsivity, it is reasonable to expect that our composite measure of discounting (AUC_DD – AUC_PD) would provide a more sensitive index of impulsivity than either DD or PD alone. Our finding a larger difference between the ADHD group and the controls (d = 0.62) than either individual measures of DD or PD (d_s = 0.43 and 0.39, respectively) is consistent with this expectation.

We also found a significant association between ADHD symptoms and gambling-related behavior and cognitions in terms of correlations between the CAARS-observer and SOGS, GRCS, and CPT scores. In addition, the ADHD group was more likely than controls to have reported a lifetime prevalence of problem gambling and less likely to have reported never having had gambling-related difficulties. This result is consistent with Breyer et al. (2006) found high levels of PTSD symptoms, which was associated with greater impulsivity and more severe gambling problems (Ledgerwood & Petry, 2006). The presence of PTSD may coincide with the proposed “emotionally vulnerable” subtype of pathological gamblers (Blaszczynski & Nower, 2002), suggesting that for some pathological gamblers, the addiction serves primarily to escape emotional distress. The influence of PTSD or experience of childhood trauma and abuse may explain the higher prevalence of problem gambling among adults with ADHD, but this is a question for future research.

Although the self-reported lifetime prevalence for probable pathological gambling was significantly higher in the ADHD group (11.5%) compared with controls, the rates were generally low overall. As far as we know, ours is the first study to explore the rates of probable pathological gambling in a sample of adults with ADHD. Previous research has found that from 20% to 30% of pathological gamblers reported childhood behavioral symptoms of ADHD on a questionnaire (Rodriguez-Jimenez et al., 2006; Specker, Carlson, Christenson, & Marcotte, 1995).

### Table 4. Correlations Between ADHD, Gambling-Related Measures, IQ, and Delay and Probability Discounting Rates.

<table>
<thead>
<tr>
<th></th>
<th>Control/ADHD</th>
<th>CPT</th>
<th>GRCS</th>
<th>GE</th>
<th>IC</th>
<th>PC</th>
<th>ISG</th>
<th>IB</th>
<th>SOGS</th>
<th>IQ</th>
<th>AUC_DD</th>
<th>AUC_PD</th>
<th>AUC_DD–AUC_PD</th>
</tr>
</thead>
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<tr>
<td>CPT</td>
<td>-.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.21</td>
<td>0.19</td>
<td>-0.30*</td>
</tr>
<tr>
<td>GRCS</td>
<td>0.12</td>
<td>-.22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.04</td>
<td>-0.28</td>
<td>-0.30*</td>
</tr>
<tr>
<td>GE</td>
<td>0.10</td>
<td>0.00</td>
<td>.85**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.27*</td>
<td>-0.18</td>
<td>-0.30*</td>
</tr>
<tr>
<td>IC</td>
<td>0.01</td>
<td>-0.25</td>
<td>.76**</td>
<td>.57**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.17</td>
<td>-0.25</td>
<td>-0.30*</td>
</tr>
<tr>
<td>PC</td>
<td>0.04</td>
<td>-0.28</td>
<td>.82**</td>
<td>.59**</td>
<td>.71**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.11</td>
<td>-0.21</td>
<td>-0.30*</td>
</tr>
<tr>
<td>ISG</td>
<td>0.27*</td>
<td>-0.18</td>
<td>.66**</td>
<td>.60**</td>
<td>.27*</td>
<td>.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.17</td>
<td>-0.25</td>
<td>-0.30*</td>
</tr>
<tr>
<td>IB</td>
<td>0.01</td>
<td>-0.21</td>
<td>.87**</td>
<td>.64**</td>
<td>.70**</td>
<td>.80**</td>
<td>.43**</td>
<td></td>
<td></td>
<td></td>
<td>0.17</td>
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<td>-0.30*</td>
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<tr>
<td>SOGS</td>
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<td></td>
<td>.21</td>
<td>.13</td>
<td>.13</td>
<td>.19</td>
<td>.13</td>
<td>.19</td>
<td>.22</td>
<td>-0.21</td>
<td>0.04</td>
<td>-0.01</td>
<td>-0.29*</td>
</tr>
<tr>
<td>AUC_DD</td>
<td>-0.21</td>
<td></td>
<td>-0.06</td>
<td>-0.10</td>
<td>.04</td>
<td>-0.16</td>
<td>.07</td>
<td>-0.16</td>
<td>.29*</td>
<td>0.19</td>
<td>-0.14</td>
<td>-0.36**</td>
<td>-0.20</td>
</tr>
<tr>
<td>AUC_PD</td>
<td>-0.30*</td>
<td></td>
<td>-0.10</td>
<td>-0.13</td>
<td>-0.10</td>
<td>-0.15</td>
<td>-0.07</td>
<td>-0.34**</td>
<td>-0.11</td>
<td>-0.32*</td>
<td>0.11</td>
<td>-0.20</td>
<td>-0.32*</td>
</tr>
<tr>
<td>AUC_DD–AUC_PD</td>
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<td></td>
<td>-0.10</td>
<td>-0.13</td>
<td>-0.10</td>
<td>-0.15</td>
<td>-0.07</td>
<td>-0.34**</td>
<td>-0.11</td>
<td>-0.32*</td>
<td>0.11</td>
<td>-0.20</td>
<td>-0.32*</td>
</tr>
<tr>
<td>CAARS</td>
<td>.57***</td>
<td>-.31*</td>
<td>.31*</td>
<td>.15</td>
<td>.32*</td>
<td>.22</td>
<td>.45***</td>
<td>.15</td>
<td>.30*</td>
<td>.27*</td>
<td>-0.29*</td>
<td>0.08</td>
<td>-0.31*</td>
</tr>
</tbody>
</table>

Note. CPT = The hypothetical money balance when quitting the Card Playing Task; GRCS = Gambling-Related Cognitions Scale, with subscales; GE = Gambling Expectancies; IC = Illusion of Control; PC = Predictive Control; ISG = Inability to Stop Gambling; IB = Interpretive Bias; SOGS = South Oaks Gambling Screen; AUC_DD = average of the delay discounting rates (measured as area under the curve) for $50 and $5,000; AUC_PD = Average of probability discounting rates (measured as area under the curve) for $50 and $5,000; AUC_DD–AUC_PD = difference between average delay and probability discounting rates (composite measure of impulsivity); CAARS = CAARS-Observer.

* p < .05, ** p < .01, *** p < .001.
However, prior studies on pathological gambling and ADHD had not relied on a clinical diagnosis of ADHD in adulthood, as we did, but asked whether ADHD symptoms had been experienced in childhood, which can present in a variety of other psychiatric and medical conditions. The current study thus provides stronger evidence of an association between ADHD symptoms experienced in adulthood and problem gambling.

The ADHD group also reported higher rates of problems with gambling at some point in life (46.2%), which is somewhat greater than other research that has found that 19% of young adults with ADHD meet criteria for possible problem gambling (Breyer et al., 2009). The increased rates of some problems with gambling in our sample could be due to examining gambling behavior within a broader age range (17.3-64.3), broader criteria (SOGS = 1-3), and within a lifetime as compared with a 12-month period.

It is important to acknowledge some limitations of our study. The sample size was relatively small, which limits generalizability and statistical power. Although many effect sizes were large enough to reach significance, we did not have sufficient power to test for more subtle questions, such as whether deficits in DD or PD might mediate the relationship between ADHD and gambling. This issue might be addressed in future research with a larger sample. Another limitation was that our discounting tasks only used hypothetical outcomes. Although there is good evidence that normative populations discount hypothetical and real outcomes similarly (e.g., Johnson & Bickel, 2002), this assumption may not necessarily be valid for clinical populations such as adults with ADHD. However, it is worth noting that the correlations between CAARS-observer scores and gambling and discounting variables were typically stronger than correlations with ADHD diagnosis (i.e., control/ADHD; see Table 4). This supports the validity of our results and suggests that a dimensional approach in which ADHD is measured as a continuous rather than binary variable may be more efficient in terms of detecting relationships with other variables.

There may be some clinical implications of the findings. This initial exploration into the possible mechanisms mediating gambling risk alerts clinicians to screen for problem gambling in adults with ADHD. The results of this study suggest that those with ADHD may be more prone in a lifetime to seek out gambling activities and endorse greater levels of problematic behavior and problem gambling compared with controls. Given that gambling may not always be assessed within the context of a clinical interview, this research, alongside others, highlights the need to ask adults with ADHD about gambling behaviors, particularly if they affect financial strains and relationships.

These results add to growing evidence that ADHD is associated with differences in processing of delayed and probabilistic rewards and is a risk factor for problem gambling. Previous studies of adults with ADHD have only examined performance on DD tasks (Hurst et al., 2011; Plichta et al., 2009), whereas we found that a composite measure, the difference between DD and PD rates, provided a more sensitive index of impulsivity and more clearly differentiated the ADHD group from the controls. Our results also support previous studies that have found that lower rates of PD are correlated with gambling prevalence (Holt et al., 2003; Madden et al., 2009) but, in addition, that PD rates were associated with gambling-related behavior and cognitions after controlling for ADHD symptoms. This result is interesting because it suggests that risk proneness, as measured by relatively low rates of PD, may be an additional risk factor for problem gambling for adults with ADHD.

Declaration of Conflicting Interests

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