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A Meta-Analytic Review of Sex Differences on Delay of Gratification and Temporal Discounting Tasks in ADHD and Typically Developing Samples

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Abstract

Objective: To examine whether males and females with ADHD differ in their preferences for delayed rewards, since there is some evidence that suggests a sex difference with typically developing (TD) samples. **Method:** We used meta-analyses to examine sex differences on delay of gratification and temporal discounting tasks in both TD and ADHD samples. We identified 28 papers with 52 effect sizes for children and adults, and calculated the average effect size for sex comparisons within TD and ADHD samples. **Results:** The estimated mean difference between TD males and TD females was negligible, but males with ADHD were more likely to choose the larger delayed rewards than females with ADHD. Meta-regressions indicated that task type, age, and reward type did not significantly predict sex differences. **Conclusion:** These findings suggest that females referred for ADHD may make less adaptive choices by preferring smaller immediate rewards over larger delayed rewards more often than males with ADHD. Implications of our findings are discussed. *(J. of Att. Dis. XXXX; XX[X] XX-XX)*

Keywords

ADHD, temporal discounting, sex differences, delay of gratification, reward, meta-analysis, choice impulsivity

Introduction

ADHD is a neurodevelopmental disorder relating to impulsivity, inattention, self-regulation, and executive functioning (Barkley & Murphy, 2010; Castellanos, Sonuga-Barke, Milham, & Tannock, 2006). ADHD is also one of the most commonly assessed neurodevelopmental disorders and the diagnosis rate has been increasing among children and adults (Polanczyk, Willcutt, Salum, Kieling, & Rohde, 2014; Visser et al., 2014). On tasks that involve choosing between a small immediate reward and a larger reward with a delay (often referred to as *choice–impulsivity* tasks), participants with ADHD tend to prefer an immediate smaller reward more often than do individuals without ADHD (Patros et al., 2016; Solanto et al., 2001). Although researchers in the ADHD field acknowledge that there are differences between ADHD and typically developing (TD) populations in terms of their preferences for delayed rewards, little attention has been paid to how males and females with ADHD differ in their preferences for delayed rewards or whether the sex differences are similar to those seen in TD individuals without ADHD.

Temporal discounting, also known as delay discounting, has become an index of self-control and willpower (Ainslie, 2003; Shamosh & Gray, 2008). It has been conceptualized as prudently discounting the future in models of rational thinking and decision making (Stanovich, 2009, 2011; Stanovich, West, & Toplak, 2011). In general, people's discounting curves tend to be more hyperbolic than exponential (Ainslie, 2003), suggesting that people tend to discount larger delayed rewards too quickly over smaller immediate rewards. Choosing the smaller reward is usually considered less optimal because this is often at the expense of a person's larger and more significant long-term goals (Metcalfe & Mischel, 1999; Shamosh & Gray, 2008). The inability to delay reward can have important consequences, and it has been shown that this tendency has correlated with degree of later life success in social interactions, the ability to cope with stress, and unhealthy body mass indices (Mischel, Shoda, & Peake, 1988; Mischel, Shoda, & Rodriguez, 1989; Schlam, Wilson, Shoda, Mischel, & Ayduk, 2013; Shoda, Mischel, & Peake, 1990). Also, the ability to delay gratification can predict future life success

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as early as the preschool years (Mischel et al., 1989; Shoda et al., 1990). Preference for choosing a smaller immediate reward is associated with more impulsive decision making (Reynolds, Ortengren, Richards, & de Wit, 2006; Richards, Zhang, Mitchell, & de Wit, 1999).

In laboratory settings, the preference for delayed rewards is associated with predispositions in natural settings such as achieving long-term goals and having better executive functioning and working memory (Basile & Toplak, 2015; Shamosh et al., 2008). It takes maturation to develop the ability to choose a delayed reward; for example, younger children choose immediate rewards more often than older children (Steinberg et al., 2009; Toplak, Hosseini, & Basile, 2016). But as we develop, the preference to delay a larger reward at some future date is also correlated with higher grades in college and with higher intelligence (Basile & Toplak, 2015; Kirby, Winston, & Santiesteban, 2005; Shamosh et al., 2008; Shamosh & Gray, 2008).

It has been reported that individuals with ADHD have been found to prefer smaller immediate rewards on experimental delayed reward tasks at even higher rates (Jackson & MacKillop, 2016; Patros et al., 2016). The preference for smaller immediate rewards in experimental settings also appears to be parallel to related findings in more naturalistic situations. Compared with TD controls, participants with ADHD engage in riskier impulsive decisions that are centered around short-term rewards in activities such as driving, sexual behavior, and gambling (Faregh & Derevensky, 2011; Flory, Molina, Pelham, Gnagy, & Smith, 2006; Thompson, Molina, Pelham, & Gnagy, 2007). In addition, ADHD is often comorbid with other disorders that are linked to riskier impulsive decisions such as conduct disorder (CD) and oppositional defiant disorder (ODD; Connor, Steeber, & McBurnett, 2010).

Delay of gratification tasks and temporal discounting tasks have been used to assess the preference for small immediate rewards over larger delayed rewards. Although these tasks broadly capture similar constructs that may be empirically inseparable (Shamosh & Gray, 2008), others distinguish these tasks as conceptually unique (Reynolds & Schiffbauer, 2005; Stanovich, 2011; Toplak et al., 2016). Delay of gratification tasks, commonly known as the "marshmallow test" (Mischel & Ebbesen, 1970; Mischel, Ebbesen, & Raskoff Zeiss, 1972), have been most well studied in child samples (Campbell, Spieker, Vandergrift, Belsky, & Burchinal, 2010; Hongwanishkul, Happaney, Lee, & Zelazo, 2005; Silverman, 2003). In this paradigm, children are presented with a choice of either a smaller immediate reward (such as a marshmallow) or a larger reward (such as two marshmallows) that they would receive at a later time. Actually waiting for the larger delayed reward is more difficult because the immediate smaller reward is directly available and in front of the participant, which makes the immediate reward conspicuous and tempting (Metcalfe & Mischel, 1999). The participant must, therefore, devote considerable willpower to sustain a choice to delay while waiting for the delayed reward (Metcalfe & Mischel, 1999; Reynolds & Schiffbauer, 2005; Shamosh & Gray, 2008).

In more recent research, these tasks have become more elaborate, including computerized games where the participants are given the same rewards and the same delay periods throughout the whole task (Patros et al., 2016). For example, the *choice delay task* is a delay of gratification task[1] in which participants play a computer task across numerous trials: Participants choose between a small reward presented as a green square labeled 1 point resulting in a 2-s reward delay, or a large reward shown as a blue square labeled 2 points with a 30-s delay (Lambek et al., 2010; Sonuga-Barke, Bitsakou, & Thompson, 2010; Sonuga-Barke, Taylor, Sembi, & Smith, 1992). The task score is the percentage of trials in which the larger, delayed reward is either selected or not selected. For other gratification paradigms, the amount of time a participant waits for the delayed reward is used to measure delay of gratification (Patros et al., 2016; Shamosh & Gray, 2008).

Another delay paradigm is temporal discounting tasks. Temporal discounting is the tendency to choose smaller rewards that are closer to the present time, and conversely, give less value, or discount, than larger delayed rewards in the future (Rachlin, Raineri, & Cross, 1991; Shamosh & Gray, 2008). For example, a participant might be offered US$2.00 today or US$4.00 in a month; many people would choose the option of US$2.00 today and discount the larger US$4.00 in a month because temporally it is too distant in the future.

On temporal discounting tasks, experimenters vary the amount of the delayed rewards between trials and the duration of the delays (Patros et al., 2016). For example, a temporal discounting task typically consists of more than 90 trials in which participants choose between small amounts of hypothetical money or a larger reward of US$10.00 after different delays ranging from 7, 30, 90, to 180 days (Costa Dias et al., 2013). Researchers then pinpoint when participants start to consistently switch their commitments from the immediate reward to the delayed reward across trials (Reynolds & Schiffbauer, 2005).

Although these two paradigms are slightly different, both have been used as measures of impulsivity (Patros et al., 2016), a key symptom domain of ADHD. Delay of gratification tasks are considered a measure of willpower and motivation because these tasks tend to offer participants fixed intervals of delays and rewards throughout the trials, during which the participants have to actually wait (Patros et al., 2016; Reynolds & Schiffbauer, 2005). In contrast, temporal discounting tasks are more measures of hypothetical choices where the amounts of rewards and delays in the future are constantly varied (Patros et al., 2016; Reynolds & Schiffbauer, 2005; Rubia, Halari, Christakou, & Taylor, 2009). Furthermore, the delay periods for delay of gratification tasks usually consist of seconds or minutes, but in temporal discounting, the delays can range from seconds and minutes to longer periods, such as days, weeks, months, and years.

Another key distinction between these tasks is that temporal discounting requires more complex calculations that take different delays and reward amounts into account to come up with a discount rate (Patros et al., 2016; Shamosh & Gray, 2008). Multiple scores can also be calculated from temporal discounting tasks. The area under the curve (AUC) score plots the participant's subjective value of a delayed reward against the duration of delay; a score closer to one indicates less discounting, whereas a score closer to zero means a person is more willing to choose the smaller immediate reward and discount the larger reward (Peper et al., 2013). The *k* value measures a person's sensitivity to delay (Myerson, Green, & Warusawitharana, 2001) and uses the indifference point, which is where the immediate reward has equal value to the long-term reward subjectively for the participant (Reynolds et al., 2006; Richards et al., 1999).

Studies on delayed reward tasks (including both temporal discounting and delay of gratification tasks) have reported mixed findings on sex differences in the broader population. In the TD population, some research suggests that females tend to delay gratification slightly longer than males on a variety of different delay of gratification tasks (Bembenutty, 2007; Mischel & Underwood, 1974; Silverman, 2003), whereas other studies have not found a sex difference (Funder & Block, 1989; Hongwanishkul et al., 2005; Mischel & Metzner, 1962). On temporal discounting tasks, some studies have suggested that females discount at a greater rate than males and, therefore, males have a slight advantage (Beck & Triplett, 2009; Reynolds et al., 2006; Weafer & de Wit, 2014), whereas other studies have found no sex difference on temporal discounting (Cross, Copping, & Campbell, 2011; Prencipe et al., 2011), or a female advantage (Dittrich & Leipold, 2014; Stanovich, West, & Toplak, 2016). Therefore, the findings across individual studies have been mixed regarding sex differences on delay paradigms in TD samples.

In addition to sex differences, it has been well documented that individuals with ADHD tend to prefer smaller immediate rewards compared with TD individuals (Jackson & MacKillop, 2016; Patros et al., 2016). However, sex differences are rarely viewed as a potential moderator of delayed reward preferences among individuals with ADHD, even though males and females appear differentially affected by ADHD.

In particular, boys with ADHD tend to receive higher ratings of inattention, impulsivity, and hyperactivity than girls with ADHD (Arnett, Pennington, Willcutt, DeFries, & Olson, 2015; Gaub & Carlson, 1997; Gershon, 2002). ADHD boys also score more impulsively on measures of executive functioning relating to inhibition (Newcorn et al., 2001). The increased presence of hyperactive/impulsivity symptoms in males may explain why teachers notice ADHD more often in males than females in class settings, because these are considered more disruptive than symptoms of inattention (Bruchmüller, Margraf, & Schneider, 2012; Derks, Hudziak, & Boomsma, 2007). This may also explain why males are diagnosed with ADHD at a much greater rate than females, ranging from a ratio of 2.28 males to every female to a ratio of nine males to every female (Gershon, 2002; Ramtekkar, Reiersen, Todorov, & Todd, 2010). Females also tend to be identified and diagnosed with ADHD later on in development (Abikoff et al., 2002). Finally, certain subcortical regions have been associated with ADHD symptom severity in ADHD preschool girls but not ADHD preschool boys (Rosch et al., 2018).

Differences between ADHD females and males manifest not only in different types of symptoms but also in other cognitive and emotional domains. From the ADHD literature, it is well known that girls with ADHD tend to have substantially greater problems in both externalizing and internalizing behaviors, as well as poorer social skills and lower feelings of self-worth, compared with TD girls (Cardoos & Hinshaw, 2011; Hinshaw, 2002; Hinshaw, Owens, Sami, & Fargeon, 2006; Hinshaw et al., 2012). Yet, in many domains of ADHD, females also are more impaired compared with ADHD males. Girls with ADHD have been reported to have higher rates of language and verbal difficulties compared with boys with ADHD (Berry, Shaywitz, & Shaywitz, 1985; Gershon, 2002). Females with ADHD appear to have greater rates of mood disorders such as major depression compared with males with ADHD (Gershon, 2002; Groß-Lesch et al., 2016). Furthermore, females with ADHD seem to have higher rates of anxiety compared with males with ADHD (Groß-Lesch et al., 2016; Skogli, Teicher, Andersen, Hovik, & Øie, 2013). Girls with ADHD have also been found to have lower IQs than boys with ADHD (Biederman et al., 2002; Gaub & Carlson, 1997; Gershon, 2002). Conversely, boys with ADHD have higher rates of ODD and CD compared with girls, and display greater motor function deficits (Biederman et al., 2002; Cole, Mostofsky, Larson, Denckla, & Mahone, 2008). Females with ADHD are reported to be more than twice as likely to be admitted into a psychiatric institution compared with males with ADHD (Dalsgaard, Mortensen, Frydenberg, & Thomsen, 2002). Females with ADHD have also been found to have poorer coping and social skills than males with ADHD (Rucklidge & Tannock, 2001). However, males with ADHD are more likely to use illegal substances and engage in criminal activity compared with females with ADHD (Groß-Lesch et al., 2016; Rasmussen & Levander, 2009).

Although researchers and clinicians are aware of the different diagnosis rates of ADHD between males and females, relatively less work has been done in evaluating how these differences in symptoms and cognitive domains manifest in delay task performance differences between males and females with ADHD, as well as in TD samples.

We conducted a meta-analysis to examine a direct sex comparison on choice impulsivity tasks for ADHD and TD populations. Our first aim was to use meta-analysis to characterize sex differences on delayed reward tasks in both ADHD and TD populations using both children and adult samples. We also conducted separate meta-analytic comparisons between TD females and TD males, and between ADHD males and ADHD females, which allowed us to measure whether the effect sizes were in the same direction and magnitude for both TD samples and ADHD samples. Our second aim was to use meta-regressions to examine moderators, such as delay paradigm type, reward type (hypothetical or real), and age, of these sex difference effect sizes.

Method

Inclusion and Exclusion Criteria

A systematic literature search was conducted using PubMed, Web of Science, and PsycINFO until July 14, 2016, as well as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009). PRISMA guidelines have been used for meta-analyses that examine ADHD and TD populations on decision-making tasks (Dekkers, Popma, van Rentergem, Bexkens, & Huizenga, 2016; Jackson & MacKillop, 2016). PRISMA guidelines also require documenting each stage of the search, including initial studies found, duplicates, number of eligible studies, and number of studies included in the meta-analysis; each of these stages is documented here.

The initial inclusion criteria for this meta-analytic review were any published study or dissertation in English that reported comparisons on delayed reward tasks of male and female participants meeting diagnostic criteria for ADHD or comparisons of TD males and females. Dissertations were included to potentially minimize publication bias. Studies had to have a minimum of 15 participants in total and at least five males and five females in each group.

For the ADHD samples, participants were required to have been diagnosed with ADHD. In addition, ADHD samples that had participants on medication were included along with nonmedicated ADHD samples; only those studies were included in which participants were asked to be off medication 24 hr prior to testing. The average age of participants in both TD and ADHD samples was restricted to a range from 6 years to 50 years. We also chose to use only children who were school age because temporal discounting tasks tend not to be applied with children who are in kindergarten or younger (e.g., Scheres, Tontsch, & Thoeny, 2013).

To minimize potential methodological variability, studies were also restricted to those using either temporal discounting tasks or delay of gratification tasks (including choice delay tasks). The types of rewards that were given in these tasks were also restricted to monetary rewards, nonedible prizes such as a toys or objects, and points from computer games. Studies that examined probabilistic discounting, social discounting, or academic delay of gratification were eliminated due to the variability of these task methods and dependent measures.

Studies that explicitly recruited smokers, overweight participants, or consumers of alcohol were excluded because these populations have been found to differ on delayed reward tasks (S. Mitchell, 1999; J. M. Mitchell, Fields, D'esposito, & Boettiger, 2005; Weller, Cook, Avsar, & Cox, 2008). Similarly, studies that recruited participants based on their ethnicity or certain income levels were excluded. Samples with psychiatric disorders such as schizophrenia, bipolar disorder, autism spectrum disorder, epilepsy, borderline disorder, and intellectual disabilities were also excluded.

Literature Search

Search terms included task descriptors (such as temporal discounting), which were paired either with the target population (such as ADHD) or with terms relating to sex differences.[2] A total of nine searches were conducted on each database. The specific terms entered were "delay of gratification & sex differences," "delay aversion & sex differences," "temporal discounting & sex differences," "delay aversion & ADHD," "delay of gratification & gender differences," "delay aversion & gender differences," "temporal discounting & gender differences," "delay of gratification & ADHD," and "temporal discounting & ADHD."

A single rater examined a total of 1,041 records, of which 301 were unique after eliminating duplicates from the three databases. The 301 abstracts were reviewed, of which 165 were deemed possibly relevant to inclusion criteria based on reading the abstracts. Then, full-text reviews were conducted on these 165 potential studies. Of these studies, six articles contained available information within the study to calculate sex difference effect sizes. Most studies tended to combine the delayed reward results of both sexes together and did not indicate how male and female results differed. Therefore, authors were contacted by email.[3] Using the previously mentioned criteria, 28 studies were included in the final meta-analysis with 52 distinct effect sizes (see Figure 1). Of these 28 studies, 14 studies contained both TD samples and ADHD samples and 14 studies contained only TD samples. Of these 52 effect sizes, 33 effect sizes were based on TD samples and 19 effect sizes were based on ADHD samples.

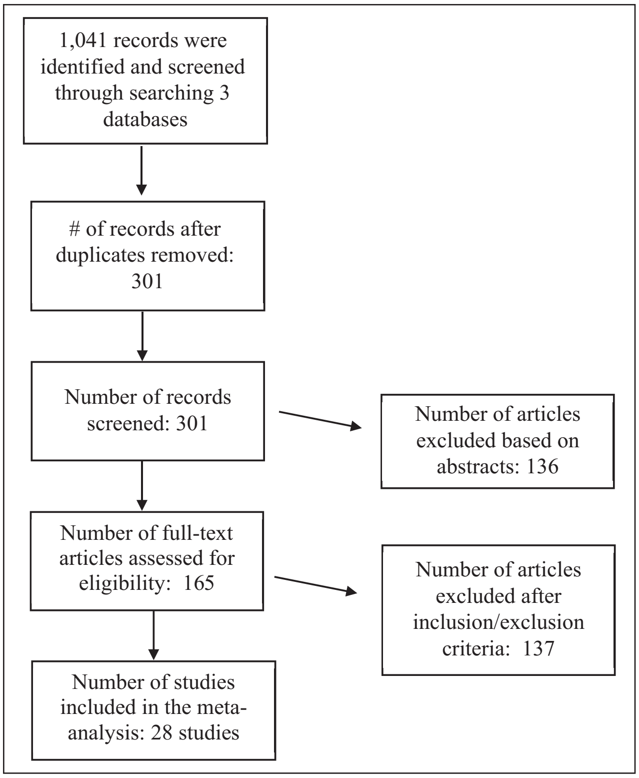

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses inclusion flow diagram.

Handling of Multiple Effect Sizes

Several studies contained multiple effect sizes, including the following: There were multiple measures for delay tasks, tasks were administered to multiple groups, or there were multiple time points. For one study that had multiple time points (e.g., Achterberg, Peper, van Duijvenvoorde, Mandl, & Crone, 2016), data from the first time point were used to reduce possible practice effects. Some studies did not provide an overall average preference for each task but gave average participant performance after a large reward and a small reward or with a large, medium, and small reward. We selected the mean for the larger reward because one study used only the large reward blocks in subsequent analyses (e.g., Mostert et al., 2015). Some studies offered two different choice impulsivity tasks for children (e.g., Rosch & Mostofsky, 2016). Not to double count studies, we opted to only use the task with shorter delays, where the children would actually be rewarded with whatever activity and choice they selected, because we thought this situation would better indicate the children's preferences.

Some studies provided multiple ADHD groups differing by subtype (e.g., Scheres et al., 2013; Solanto et al., 2007) or one group was only diagnosed with ADHD and the other group had a comorbid diagnosis of ADHD and ODD (e.g., Antonini, Becker, Tamm, & Epstein, 2015). In such situations, effect sizes were calculated separately for both groups. In studies that had multiple dependent measures for a task, the measure that was thought to provide the most optimal measurement of preference was chosen (e.g., Diller, Patros, & Prentice, 2011); for example, for delay discounting tasks, we chose the AUC-dependent measure as it is less likely to have a skewed distribution relative to k values (Myerson et al., 2001).

Sample Characteristics

Individual study task and sample characteristics are available in Appendices A and B. The total number of participants was N = 4,540 (n = 2,017 females and n = 2,523 males). The number of males with ADHD was n = 733; the number of females with ADHD was n = 322; the number of TD males was n = 1,790; and the number of TD females was n =1,695.

Statistical Analyses

Hedges' g was the effect size statistic used in the current analyses, calculated to represent the mean difference between males and females on the delayed reward tasks outcome measure divided by the pooled standard deviation and corrected for a positive bias (Hedges & Olkin, 1985). For the first meta-analysis comparing males and females, g was calculated so that positive values indicated that females were better able to choose the delayed rewards, whereas negative values indicated that males were better able to choose the delayed rewards; 95% confidence intervals (CIs) for each g were also calculated.

Random-effect models were used for this meta-analytic review because it is assumed that the true effect can vary from study to study (i.e., studies differ in ways other than random sampling of participants). Previous meta-analyses that compared ADHD and control samples on decision-making tasks also used random-effect models (Dekkers et al., 2016; Jackson & MacKillop, 2016; Mowinckel, Pedersen, Eilertsen, & Biele, 2015; Patros et al., 2016). The meta-analyses were conducted using the metafor package (Viechtbauer, 2010) in R (R Core Team, 2013).

Heterogeneity

Cochran's Q and I^2 were used to measure heterogeneity among effect sizes included in the meta-analyses. Cochran's Q reflects the sum of squared differences between each individual weighted effect size and the overall effect estimate (Higgins, Thompson, Deeks, & Altman, 2003). Significant Q tests indicate substantial differences in effect sizes among studies that cannot be explained by sampling error, suggesting systematic differences between studies (Huedo-Medina, Sánchez-Meca, Marín-Martínez, & Botella, 2006). I^2 reflects

Table 1. Summary of Statistics From Meta-Analyses of Males vs. Females.

Comparison	*G*	*SE*	95% CI	*z*	*Q*	I^2	*df*
Males vs. females	−0.08	0.05	[−0.17, 0.02]	−1.63	84.00*	40.82%	51
TD males vs. TD females	−0.01	0.06	[−0.13, 0.10]	−0.24	58.15*	48.27%	32
ADHD males vs. ADHD females	−0.23*	0.08	[−0.39, 0.07]	−2.80	18.43	15.76%	18

Note. Negative *g* indicates a male advantage in terms of choosing the delayed reward, whereas positive indicates a female advantage in terms of choosing the delayed reward. g = Hedge's g; CI = confidence interval; Q = heterogeneity test statistic; I^2 = total heterogeneity / total variability; TD = typically developing.
$^*p < .05$.

the percentage of total variation that is explained by the variation among studies and is used along with Q partly because I^2 is not influenced by the number of studies in the meta-analysis (Higgins et al., 2003). Values of I^2 less than 25% indicate low heterogeneity, values around 50% indicate moderate heterogeneity, and values of 75% or greater indicate high heterogeneity (Higgins et al., 2003).

Publication Bias

Publication bias (also known as the file-drawer effect) occurs when studies that have smaller samples are more likely to be published if they attain larger effect sizes that are statistically significant (Dickersin, 1990; Egger, Smith, Schneider, & Minder, 1997). There are many ways to measure publication bias; one method is Egger's test, which is a regression test of asymmetry where a greater y intercept indicates that a meta-regression model might be affected by publication bias (Egger et al., 1997). Funnel plots, in which effect sizes are plotted against their standard errors, are good visual indicators for possible publication bias as well as heterogeneity. Possible publication bias is indicated by asymmetry of the effect sizes from either side of the "funnel." For this study, funnel plot asymmetry was investigated with the trim and fill method (Duval, 2005; Duval & Tweedie, 2000), which is a nonparametric, rank-based procedure that is used to estimate the number of studies missing from a meta-analysis due to leaving out the most extreme effect sizes that would be on one side of the funnel plot. Finally, Kendall's tau is a nonparametric rank correlation statistic used to measure the correlation between effect size and the effect size's variance estimate (Jin, Zhou, & He, 2015). A large correlation indicates the set of studies might be affected by publication bias.

Meta-Regressions

Simple linear meta-regression was used to model moderator effects because effect sizes varied in their study characteristics (such as relating to task and reward characteristics); these study characteristics were used as effect size predictors (i.e., moderators) in the regression models. All studies included information about the sample age, the type of task, and whether there was some real reward given for participating in the task. Therefore, the moderator variables were task type (delay of gratification task or temporal discounting task), average age of the total combined male and female samples (below or above 18 years of age), and task reward (real money/prize or hypothetical money/prize).

Results

The overall weighted mean effect size, combining ADHD and TD studies, was very small, $g = -0.08$, $p = .10$, 95% CI = [−0.17, 0.02]. This result indicates that, overall, choosing a delayed reward does not differ substantially between males and females (see Table 1). There was moderate heterogeneity of effects among the studies ($Q = 84.00$, $p < .05$, $I^2 = 40.82\%$; see Table 1). Within TD participants, the weighted mean sex difference was $g = -0.01$, $p = .81$, 95% CI = [−0.13, 0.10], but variation among studies was again moderate (see Table 1). This result indicates that there is practically no overall difference between TD females and TD males on these delay tasks (see Figure 2), although the effects are quite variable across studies. Within ADHD participants, the weighted mean sex difference was small in the male direction, $g = -0.23$, $p < .05$, 95% CI = [−0.39, −0.07], suggesting that females with ADHD are more likely to choose smaller immediate rewards over delayed rewards relative to males with ADHD. This result indicates that, overall, there was a difference between ADHD females and ADHD males on these delay tasks (see Figure 3), and the heterogeneity across studies was low and not significant (see Table 1).

Robustness of the Overall Results

The robustness of the overall average effect was investigated in multiple ways. Egger's test (Egger et al., 1997) indicated no funnel plot asymmetry ($z = -0.54$, $p = .59$). Similarly, Kendall's tau did not indicate significant publication bias, $\tau = -0.05$, $p = .64$. Finally, the funnel plot with the trim and fill method also did not reveal publication bias (Figure 4).

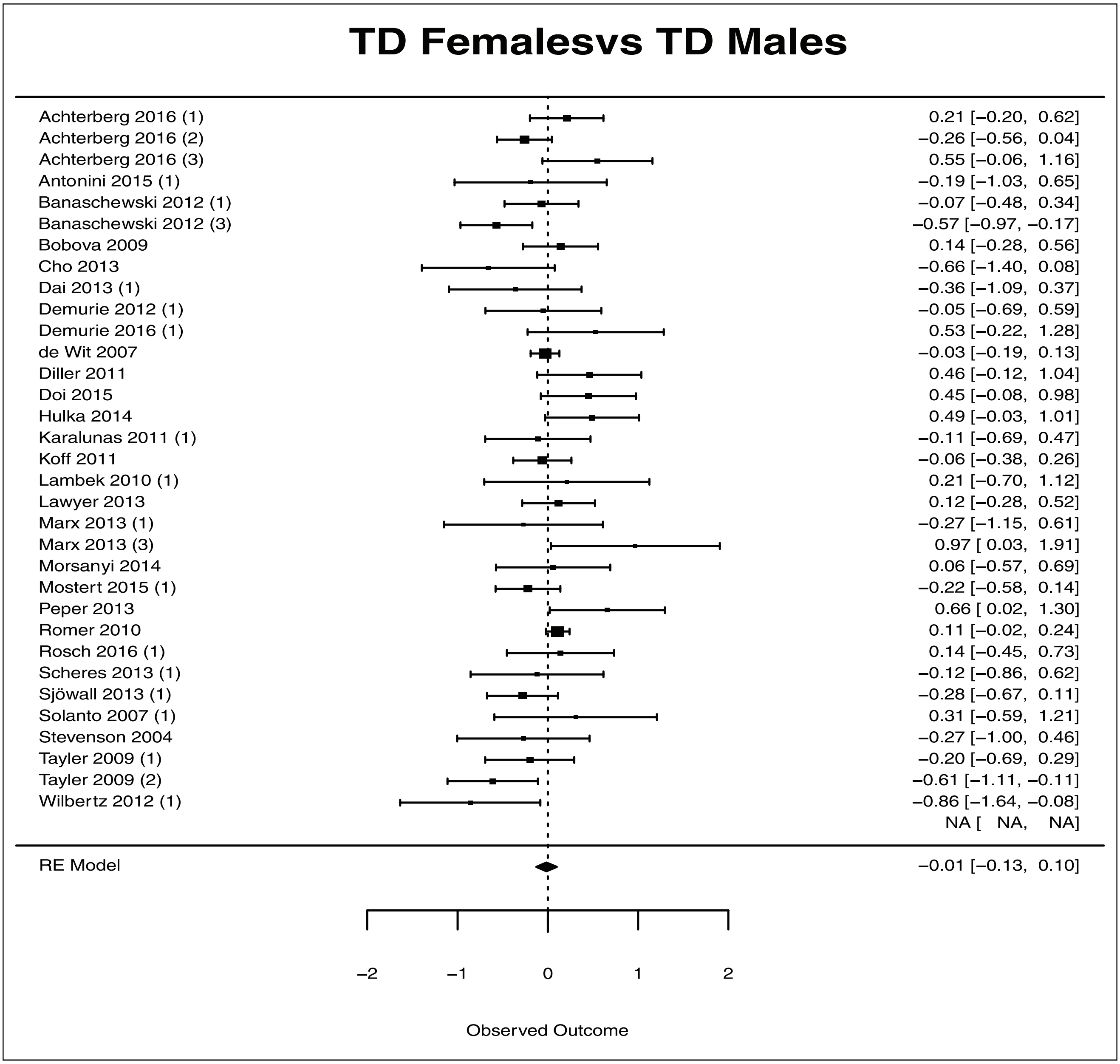

Figure 2. Forest plot providing effect sizes by study for comparisons of TD males and TD females.
Note. Multiple comparisons were conducted in some studies, which are denoted by citations with different numbers. Effects to the right of zero and positive reflect a female advantage in terms of choosing delayed rewards, whereas effects to the left of zero and negative reflect a male advantage in terms of choosing delayed rewards. TD = typically developing.

Meta-Regression Results for TD Samples: Task Type, Age, and Type of Reward

Task type did not significantly moderate sex differences in TD samples, $B = 0.17$, $p = .22$, 95% CI = [−0.10, 0.43]. Of the 33 effect sizes for TD samples, 24 contained temporal discounting measures and nine contained delay of gratification measures. Age did not significantly moderate sex differences in TD samples, $B = 0.08$, $p = .48$, 95% CI = [−0.15, 0.31]. Of the 33 effect sizes for TD samples, 16 contained effect sizes with an average age of below 18 years, and 17 contained effect sizes with the average age above 18 years. Whether there was a real reward or hypothetical reward did not significantly predict sex differences in TD samples, $B = 0.02$, $p = .88$, 95% CI = [−0.25, 0.29]. Of the 33 effect sizes for TD samples, 23 contained hypothetical rewards, whereas 10 contained real rewards.

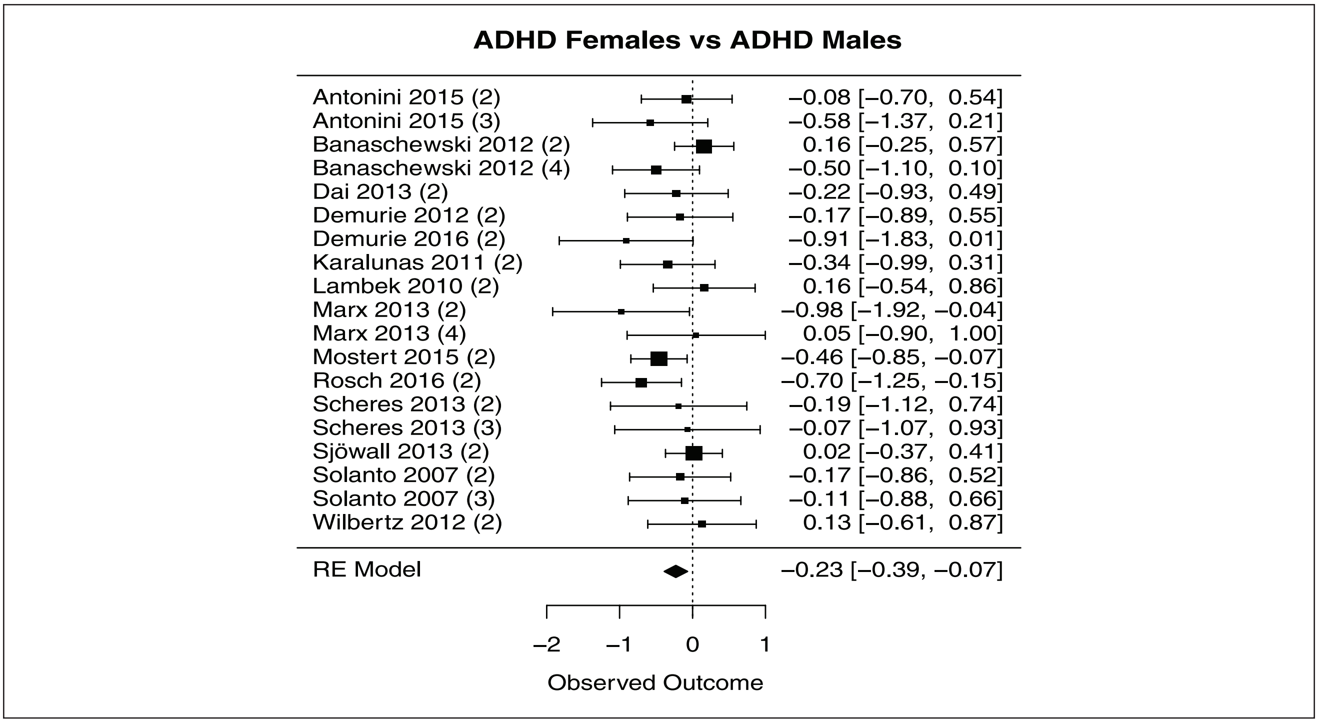

Figure 3. Forest plot providing effect sizes by study for comparisons of ADHD males and ADHD females.
Note. Multiple comparisons were conducted in some studies, which are denoted by citations with different numbers. Effects to the right of zero and positive reflect a female advantage in terms of choosing delayed rewards, whereas effects to the left of zero and negative reflect a male advantage in terms of choosing delayed rewards.

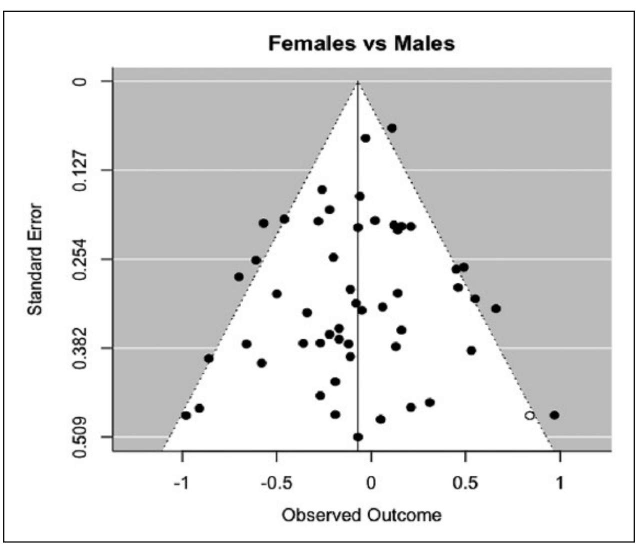

Figure 4. Funnel plot with the trim and fill method.
Note. Points indicate female–male effect sizes from all studies. Black points are original effect sizes, white points represent filled-in effects based on the trim and fill method.

Meta-Regression Results for ADHD Samples: Task Type, Age, and Type of Reward

Task type did not significantly moderate sex differences in ADHD samples, $B = -0.27$, $p = .06$, 95% CI = [−0.56, 0.01]. Of the 19 effect sizes for ADHD samples, 10 contained temporal discounting measures and nine contained delay of gratification measures. Age did not significantly moderate sex differences in ADHD samples, $B = -0.13$, $p = .48$, 95% CI = [−0.50, 0.23]. Of the 19 effect sizes, five contained effect sizes with an average age of below 18 years, and 14 contained effect sizes with the average age above 18 years. Whether there was a real reward or hypothetical reward did not significantly predict sex differences in ADHD samples, $B = -0.13$, $p = .46$, 95% CI = [−0.47, 0.21]. Of the 19 effect sizes, 11 contained hypothetical rewards, whereas eight contained real rewards

Discussion

The present meta-analyses were conducted to examine sex differences on delayed reward tasks in both TD and ADHD populations using 28 studies. Our findings revealed no differences for both the overall comparison between males and females (using both ADHD and TD samples together) and the separate comparison between TD males and TD females. However, there was a small significant effect ($g = -0.23$) comparing ADHD males with ADHD females on delay tasks, demonstrating that females with ADHD are more likely to prefer immediate smaller rewards than males with ADHD. Age, task type, and reward type did not significantly moderate any of the male–female comparisons.

The novel finding of this study was that there is a small sex difference in the ADHD samples, but not for the TD samples. This finding indicates that ADHD females prefer immediate rewards more than ADHD males on both temporal discounting tasks and delay of gratification tasks (given that task type did not significantly moderate the effect size). This finding was surprising, given that males often display greater impulsivity and hyperactivity than females (Gershon, 2002), characteristics usually associated with preference for immediate rewards (Reynolds et al., 2006; Richards et al., 1999). The findings might be explained if there were differences in ADHD symptom severity between females and males for the participants recruited for the studies, but we had no way to assess this hypothesis based on the studies included in this meta-analysis. The majority of studies included in the meta-analytic review did not have separate information for ADHD males and females regarding the severity of ADHD symptoms or symptom count. One paper reported no differences between ADHD boys and girls regarding inattention or hyperactivity ratings (Rosch & Mostofsky, 2016), but we cannot know whether symptom severity among males and females in these samples may have contributed to these findings. Clinical manifestation of ADHD symptoms in males and females has been identified as a critical issue, and it has been suggested that current diagnostic tools fail to adequately address female–male differences in ADHD (Bruchmüller et al., 2012; Hinshaw, 2002; Hinshaw et al., 2006; Hinshaw et al., 2012; Rucklidge, 2010). For example, if ADHD in females is underdiagnosed because these females display fewer symptoms of hyperactivity/impulsivity, females with ADHD may only be diagnosed when they have severe impairments and symptoms (Bruchmüller et al., 2012; Gershon, 2002; Quinn, 2005). Furthermore, if females with ADHD tend to be underdiagnosed, this will have implications for empirical studies investigating differences between males and females with ADHD.

In addition to referral bias, another potential explanation for our finding is that females with ADHD have been reported to have worse outcomes than males with ADHD in areas such as coping abilities, internalizing distress, difficulties with organization, speech and language, and social skills issues (Berry et al., 1985; Gershon, 2002). Furthermore, females with ADHD often have comorbid disorders such as anxiety, depression, and eating disorders at a greater rate than ADHD males (Groß-Lesch et al., 2016; Skogli et al., 2013). The presence of comorbid conditions may have an impact on ADHD females' delayed reward preferences. For example, studies have found that those with depression discount more than controls (Imhoff, Harris, Weiser, & Reynolds, 2014; Pulcu et al., 2014). This finding from the current study should be examined more systematically in an empirical investigation. If in fact there are differences in delay of gratification and temporal discounting, key indicators of self-control behaviors, this could have significant implications for differential treatment strategies for males and females with ADHD.

The current meta-analysis also obtained a near-zero difference between TD males and females. A review by Silverman (2003) on sex differences on delay of gratification tasks indicated that females performed slightly better than males. Notably, the reported effect was small. In addition, Silverman included studies that used food as a reward, such as candy, marshmallows, and candy bars (e.g., Moore, Clyburn, & Underwood, 1976), whereas the studies in the current meta-analyses involved monetary rewards, points, and nonedible prizes such as pens (e.g., Stevenson & Cate, 2004). The current meta-analysis also included several recent studies that would not have been in Silverman's (2003) review. Other studies have also reported no sex differences on delay paradigms (Funder & Block, 1989; Hongwanishkul et al., 2005; Mischel & Metzner, 1962), including a meta-analysis by Cross et al. (2011). Toplak et al. (2016) examined sex differences on a temporal discounting task in a TD sample and found that, compared with males, females displayed a greater tendency to prefer the larger delayed reward on the indifference point–dependent measure, but not on the AUC or k values, suggesting that the dependent measure affects findings. Overall, our results are generally consistent with other studies, which have reported no significant sex differences on delay paradigms in TD samples.

Task type was not a significant moderator in our study. Our results are consistent with Shamosh and Gray (2008), who found no differences between delay of gratification and temporal discounting studies in a meta-analysis they conducted on TD samples. Similarly, the Patros et al. (2016) meta-analytic comparison of TD and ADHD samples found no differences between delay of gratification and temporal discounting tasks. Although there may be conceptual differences in these paradigms (Reynolds & Schiffbauer, 2005; Stanovich, 2011; Toplak et al., 2016), empirically, it may be difficult to separate the differences between these tasks.

We also found that age was not a significant moderator in the analyses. Perhaps because we were only able to test a binary age effect of above age 18 versus below age 18, the grain size of our analysis may not have been sensitive enough to obtain any differences between childhood/adolescence to middle adulthood. However, our results are consistent with a meta-regression conducted by Jackson and MacKillop (2016), which reported no significant age effects in the comparison of ADHD and TD groups above and below 18 years of age. We also found that real versus hypothetical reward type was not a significant moderator, which is also consistent with other studies (Jackson & MacKillop, 2016; Johnson & Bickel, 2002).

One limitation of the current meta-analysis is that many of the studies found in the literature search did not report male and female means separately on delay tasks. Even if the number of males and females was reported, most of the data were not in the actual articles and needed to be requested through email, which meant that only some authors responded to our requests. In addition, many studies neither provided the number of males and females who had comorbid disorders, nor reported sex differences in symptoms such as impulsivity and hyperactivity.

Future research should examine both comorbidity and symptom severity as potential moderators, over and above ADHD diagnosis, of sex differences on delayed reward tasks. Further research should examine how ADHD female preferences on these delay tasks are related to other important areas where ADHD males and females differ, such as speech and language difficulty, and internalizing difficulties such as anxiety and depression (Gershon, 2002; Groß-Lesch et al., 2016). Other variables to examine should include age as a continuous moderator, medication status, intelligence, and measures of executive functioning such as working memory.

These findings have a number of potentially important implications. The finding that females with ADHD prefer immediate rewards more than males with ADHD may have clinical significance, as ADHD females may be at risk of making poorer life choices compared with ADHD males, because delayed reward tasks are significantly correlated with success in many life domains (Daugherty & Brase, 2010; Mischel et al., 1989; Petry, 2003; Shoda et al., 1990). The sex difference found in our study may highlight a further need to differentiate how ADHD is diagnosed and assessed across males and females. It has been reported that boys are 3 times as likely to get diagnosed with ADHD compared with girls, despite the fact that girls can have worse outcomes in many domains (Gershon, 2002; Rucklidge & Tannock, 2001; Vasiliadis et al., 2017). Females who are at risk of ADHD may in the future benefit from assessments that are more tailored to the symptoms and issues associated with ADHD females, and degree of discounting may provide a unique diagnostic domain for further investigation of their difficulties.

Temporal discounting and delay of gratification paradigms have been extensively studied in TD and ADHD samples, but relatively less attention has been given to sex differences. ADHD provides an interesting context for examining sex differences, given the referral rates of males and females who are diagnosed with ADHD. Our results suggested that females with ADHD make less adaptive choices on temporal discounting and delay of gratification tasks than males with ADHD, but we did not obtain differences in TD samples. Temporal discounting and delay of gratification choices may provide a novel direction for understanding how difficulties in girls with ADHD may be more severe or impaired than in boys with ADHD, but further investigation is needed.

Appendix A

Task Characteristics.

Study	Task type	Task description	Outcome measure	Reward type
Achterberg et al. (2016)[a]	Temporal discounting	A computerized version of a temporal discounting task based on the task in Richards, Zhang, Mitchell, and de Wit (1999). The task had four hypothetical delays: 2, 30, 180, or 365 days, and US$10 was the amount used as a delayed reward. If a participant chose the immediate reward, the amount of immediate reward was decreased on the next trial; whereas, if the delayed reward was chosen, the amount of immediate reward was increased on the next trial.	AUC discount rate	Hypothetical money
Antonini et al. (2015)	Temporal discounting	The temporal discounting task was a computerized task that was approximately 10 min in length. The immediate reward varied from US$0 to US$10.00 in US$0.50 increments, whereas the delayed reward was always US$10. There were four hypothetical delays: 7, 30, 90, or 180 days. The task involved 88 trials.	AUC discount rate	Hypothetical money
Banaschewski et al. (2012)	Delay of gratification	The MIDA was used in this study. In this task, the participant chose between getting 1 point with a 2-s delay or 2 points with a 30-s delay. Each participant was given two conditions—*no postreward condition*: choosing the smaller reward led to the immediate next trial, reducing the overall length of the task delay; *postreward delay condition*: choosing the smaller reward led to a 30-s delay.	Time preference for immediate reward[b]	Hypothetical points
Bobova, Finn, Rickert, and Lucas (2009)	Temporal discounting	The temporal discounting task consisted of 22 choices. The delayed amount was US$50, and the delay periods were 1 week, 2 weeks, 1 month, 3 months, 6 months, 1 year. On some trials, the immediate reward value began with US$0.05, followed by US$1.25 and was then increased from US$2.50 to US$50 in 20 increments of US$2.50. On other trials, the immediate reward was reduced from US$50 to US$2.50 in 20 reductions of US$2.50. Participants made choices on both increasing and decreasing immediate reward trials. At each delay, the increasing and decreasing of reward trials were administered in order, no matter the participant's choice.	*k*-value discount rate[c]	Two conditions 1. chance payoff 2. real money
Cho et al. (2013)	Temporal discounting	A computerized temporal discounting task based on the Kirby, Petry, and Bickel's (1999) delay task, which consisted of 27 trials with two options that did not change based on the participant's response. Delays ranged from 7 days to 186 days. The immediate reward ranged from US$11 to US$80, whereas the large reward ranged from US$25 to US$85.	*k*-value discount rate[d]	Hypothetical money
Dai, Harrow, Song, Rucklidge, & Grace (2013)	Temporal discounting	Participants completed a computer-based delay task. The immediate delay had two blocks of trials that started with either a US$50 or US$5,000 amount. The delays were 1 or 6 months, 1 or 3 years, or 5 or 10 years. The computer program would adjust the amounts in an attempt to get to the indifference point where the immediate reward would become of equal value to the delayed reward.	AUC discount rate	Hypothetical money

(continued)

Appendix A. (continued)

Study	Task type	Task description	Outcome measure	Reward type
Demurie, Roeyers, Baeyens, and Sonuga-Barke (2012)	Temporal discounting	The temporal discounting task consisted of 100 trials, and the choice between small rewards available immediately of €0, €5, €10, €20, and €30, or a large fixed delayed reward of €30. The delay periods were tomorrow, in 2 days, 1 week, and 2 weeks. The amounts were shown on the computer screen as euro notes. Each small immediate reward was paired with one of the four delay times of the large reward. All combinations of immediate reward and delay period were presented to participants in a pseudo-randomized order.	AUC discount rate	Hypothetical money
Demurie, Roeyers, Wiersema and Sonuga-Barke (2016)	Temporal discounting	The temporal discounting task consisted of 100 trials, and the choice between small rewards delivered immediately ranging from €0, €5, €10, €20, and €30 or a large constant reward of €30. The delay periods were now, tomorrow, 2 days, 1 week, and 2 weeks. Reward amounts were shown on the computer screen as euro notes. Each small immediate reward was paired with one of the four delay times of the large reward. All combinations of immediate reward and delay period were presented to participants in a pseudo-randomized order.	AUC discount rate	Hypothetical money
de Wit, Flory, Acheson, McCloskey, and Manuck (2007)	Temporal discounting	This task involved the same delay procedure that was used in Mitchell (1999). The immediate rewards ranged from US$0.10 to US$105 for the same day, or a delayed reward of US$100 after a delay of 0, 7, 30, 90, 180, 365 days or 5 years. All trials with different immediate rewards and delay periods were presented in a randomized order.	k-value discount rating[e]	Hypothetical money
Diller et al. (2011)	Temporal discounting	A computerized delay task was used. The delayed amount was US$1,000 delivered at one of seven delays ranging from 1 week to 25 years. The immediate reward was one of 27 amounts ranging from US$1 to US$1,000, which were presented first in descending order and then in ascending order for the seven delay periods.	AUC discount rate[f]	Hypothetical money
Doi, Nishitani, and Shinohara (2015)	Temporal discounting	A computerized delay task was used. The amount of delayed reward was unchanged throughout a block of either 1,000,000 yen or 100,000 yen. Seven levels of delays were 1, 4, 12, 36, 96, 240, and 480 days; each delay was used twice, producing a total of 70 trials for both the delayed reward blocks. If the participant chose the delayed reward over the immediate reward, then the amount of the immediate reward was increased on the next trial; but if the participant preferred the immediate reward, the amount of the immediate reward was decreased on the next trial. This ascending and/or descending was repeated until the participant had made his or her fifth choice.	k-value discount rate[g]	Hypothetical money
Hulka et al. (2014)	Temporal discounting	This was the same task that was used in Kirby et al. (1999). The task was composed of 27 trials based on two options that did not change based on the participant's response. Delays ranged from 7 days to 186 days. The immediate reward ranged from US$11 to US$80, whereas the large delayed reward ranged from US$25 to US$85.	k-value discount rate	Hypothetical money

(continued)

Appendix A. (continued)

Study	Task type	Task description	Outcome measure	Reward type
Karalunas and Huang-Pollock (2011)	Delay of gratification	In this computerized task, called the CDT, and based on Sonuga-Barke et al. (1992), children chose between two rewards each requiring a different waiting period. They would get a 1-point reward after 2 s, or a 2-point reward after 30 s. A new trial would start immediately after the reward was received from the previous trial. Children had 20 trials, as well five practice trials.	Time preference for the delayed reward	Points could be exchanged for a real prize
Koff and Lucas (2011)	Temporal discounting	This task involved the Monetary Choice Questionnaire, described by Kirby and Maraković (1996), where participants had 21 trials with the delay periods ranging from 10 days to 75 days. Each trial presented a choice between a smaller immediate reward and a larger delayed reward. Both the immediate reward and delayed reward amounts varied, whereas the different reward amounts and delay periods were presented in random order.	k-value discount rate[h]	Chance payoff
Lambek et al. (2010)	Delay of gratification	This computerized task, called CDT, was based on Sonuga-Barke et al. (1992). Participants chose between a green square, which was equivalent to 1 point with a 2-s delay, or a blue square equivalent to 2 points after 30 s. This task consisted of 20 trials.	Time preference for delayed reward	Points could be exchanged for real money
Lawyer and Schoepflin (2013)	Temporal discounting	A computerized task based on Richards et al. (1999). In this task, participants chose between an immediate smaller amount of money that was adjusted or delayed for an amount of US$10. There were five delays: 1 day, 1 week, 1 month, 6 months, 1 year. If the delayed amount was chosen, then on the next trial, the immediate amount would be decreased randomly from the pool of possible amounts of US$0.50. If the immediate reward was chosen, then for the next trial, the immediate amount would be increased randomly from the pool of possible amounts of US$0.50.	AUC discount rate	Hypothetical money
Marx, Höpcke, Berger, Wandschneider, and Herpertz (2013)	Delay of gratification	A computerized task based on Müller, Sonuga-Barke, Brandeis, and Steinhausen (2006), in which a donkey deposited gold into a basket. Participants were asked to collect as much gold as they could; the gold being delivered decreased over the trial and stopped after 60 s. Participants decided when to complete the trial and move on to the next trial. The whole task contained 22 trials, and after each trial, participants were informed of the number of trials left.	Mean trial duration	Two conditions 1. real money offered 2. no money offered
Morsanyi and Fogarasi (2014)	Temporal discounting	A computerized task based on Kirby and Maraković (1996), the task consisted of 18 trials between a smaller amount of money that would be available tomorrow, and a larger amount that would be available later ranging from 10 to 75 days. The value of the immediate reward ranged from US$1.50 to US$7.00, and the value of the delayed reward ranged from US$3.00 to US$8.00.	Time preference for delayed rewards[i]	Chance payoff
Mostert et al. (2015)	Temporal discounting	A computerized task based on Dom, D'haene, Hulstijn, and Sabbe (2006). Depending on the choices selected, the amount of immediate reward was adjusted across trials. For the task, five different delays were used within the range of 2, 30, 180, 365, to 730 days. For delay amounts, participants could choose between varying amounts of money: €10, €30, and €100, which became available after a delay. The number of trials was not mentioned but the Dom et al.'s (2006) paper consisted of more than 100 questions.	k-value discount rate[j]	Hypothetical money

(continued)

Appendix A. (continued)

Study	Task type	Task description	Outcome measure	Reward type
Peper et al. (2013)	Temporal discounting	A computerized task based on Richards et al. (1999). Participants had to make a choice between a small, immediately available amount of money and a delayed amount of €10 available after 2 days, 30 days, 180 days, or 365 days. When the participant chose the immediate reward, this amount was decreased on the next trial. But if the delayed money was preferred, the immediate reward was increased on the next trial.	AUC discount rate	Hypothetical money
Romer, Duckworth, Sznitman, and Park (2010)	Temporal discounting	This computerized delay task was a modification of Green, Fry, and Myerson (1994). Participants were first asked whether they would prefer US$500 immediately or US$1,000 in 6 months. Then, participants were asked to identify an amount of money if received now (range = US$100-US$900), which would be equal to receiving US$1,000, 6 months later. Immediate reward amounts were adjusted based on the participant's response. Those who accepted the US$500 were asked whether they would accept an amount lower than US$500 in US$100 amounts, whereas those who did not accept US$500 were asked whether they would accept an amount greater than US$500 in US$100 amounts.	The final dollar offer they would accept today in lieu of US$1,000 in 6 months.	Hypothetical money
Rosch and Mostofsky (2016)	Temporal discounting[k]	During this task, participants could make nine trials after deciding whether to play their choice of a game immediately for a period of 15, 30, or 45 s, or instead wait 25, 50, or 100 s to play the game for a fixed longer amount of time (60 s). Participants had several game options such as playing a video game, Legos, or coloring. The game of choice was placed in a clear box directly in front of participants when they made their decisions and whether they decided to wait for the larger reward. This task in total consisted of two practice trials, and nine real trials. The immediate rewards were given in ascending order for each delay, whereas the delays were counterbalanced between participants.	AUC discount rate	Nonmonetary reward
Scheres et al. (2013)	Temporal discounting	Three computerized temporal discounting tasks were used. Task 1 consisted of 80 trials; the small immediate reward was 2, 4, 6, or 8 cents, and the delayed reward was 10 cents with a delay of 5, 10, 20, 30, or 60 s. In Task 2, participants made 40 trials; the immediate reward was 2, 4, 6, or 8 cents, and the delayed reward was 10 cents with the same delay periods of Task 1. Task 3 consisted of 80 trials; the immediate reward was 1, 2, 3, or 4 cents, and the delayed reward was 5 cents with the same delay periods of the other tasks. Trials were administered in the same pseudo-random order for all participants.	AUC discount rate	Real money
Sjöwall, Roth, Lindqvist, and Thorell (2013)	Delay of gratification	Participants did the CDT based on Sonuga-Barke et al. (1992). In this task, participants chose between one option that offered 1 point after a 2-s delay, or a delayed option of 2 points after a 30-s delay.	Time preference for immediate rewards	Hypothetical points

(continued)

Appendix A. (continued)

Study	Task type	Task description	Outcome measure	Reward type
Solanto et al. (2007)	Delay of gratification	Same task as in Solanto et al. (2001), which was the CDT involving a computer game that took approximately 30 min to complete. Participants had to choose between collecting points from a green square representing 1 point with a 2-s delay, or a blue square representing 2 points after a 30-s delay.	Time preference for delayed rewards	Real money[l]
Stevenson and Cate (2004)	Delay of gratification	A computer game where the participant had to destroy an enemy spacecraft, similar to Kuntsi, Oosterlaan, and Stevenson (2001). For each of the 20 trials, the participant had to choose between a small immediate reward, which was equal to 1 point and a delayed reward equal to 3 points.	Researchers' ratings of the participant's behavior as they were waiting for the delayed reward	Real prize
Tayler, Arantes, and Grace (2009)	Temporal discounting	In Experiment 1, participants did a temporal discounting task similar to the task in Chapman (1996), which consisted of 16 trials. Participants were asked the amount of a delayed reward that would be equal to four immediate rewards of US$500, US$1,000, US$2,000, and US$4,000. There were four delays: 1, 3, 6, and 12 years. In Experiment 2, participants did a temporal discounting task, which consisted of 16 trials. Participants were asked the amount of a delayed reward that would be equal to four immediate rewards of US$500, US$1,000, US$2,000, and US$4,000. There were four delays: 3 months, 6 months, 1 year, and 2 years.	Annual discount rate	Hypothetical money
Wilbertz et al. (2012)	Temporal discounting	Computerized hypothetical temporal discounting task based on the experiment of Richards et al. (1999) that consisted of 42 trials. Participants chose between €200 that would be delayed or an immediate reward that was adjusted depending on the participant's response to obtain the subjective indifference point. For every trial, the delay time was changed from 1, 3, 9, 24, 60, 120, 240 months and the immediate amount option started at €100.	k-value discount rate[m]	Hypothetical money

Note. AUC = under the curve; MIDA = Maudsley Index of Childhood Delay Aversion; CDT = Choice Delay Task.
[a]This study had two time points. Only the first time point was used.
[b]Only the no postreward delay condition of the MIDA was used as the outcome measure.
[c]Log10 transformed k values were used.
[d]Natural logarithms of *k* were used.
[e]Natural logarithms of *k* were used.
[f]Multiple discount rates were presented in the study, but AUC was chosen as the discount rate because this was used in all other analyses in the article. (This would be Diller)
[g]Logarithms of *k* were used only for the larger reward blocks.
[h]Logarithms of *k* were used.
[i]Logarithms of *k* were only used for the larger reward blocks.
[j]Logarithms of *k* were only used for the larger reward blocks.
[k]In this study, children also engaged in another temporal discounting task that involved longer delays; the children only had the option of winning some of the rewards that were semirandomly selected. Not to double count studies, we opted to only use the task with shorter delays (described above) where the children would actually be rewarded with whatever activity and choice they selected, because we thought this would be a better indicator of the children's preferences.
[l]The study did not indicate reward type. But in an earlier study by Solanto et al. (2001), a real reward was given for the task.
[m]Natural logarithms of *k* were used.

Appendix B

Sample Characteristics Comparing TD or ADHD Males vs. Females on Delayed Reward Tasks.

Study	Sample type	Total combined samples	Percentage of females	Developmental period
Achterberg et al. 2016 (1)	TD sample below 12 years	94	54	Childhood
Achterberg et al. 2016 (2)	TD sample between 12 to 18 years	168	49	Adolescence
Achterberg et al. 2016 (3)	TD sample above 18 years	43	51	Adulthood
Antonini et al. 2015 (1)	TD	25	32	Childhood
Antonini et al. 2015 (2)	ADHD	55	24	Childhood
Antonini et al. 2015 (3)	ADHD and ODD	31	29	Childhood
Banaschewski et al. 2012 (1)	TD sample below 12 years	101	35	Childhood
Banaschewski et al. 2012 (2)	ADHD sample below 12 years	198	14	Childhood
Banaschewski et al. 2012 (3)	TD sample above 12 years	136	24	Adolescence
Banaschewski et al. 2012 (4)	ADHD sample above 12 years	134	9	Adolescence
Bobova, et al. 2009	TD	89	48	Adulthood
Cho et al. 2013	TD	34	32	Adulthood
Dai et al. 2013 (1)	TD	29	48	Adulthood
Dai et al. 2013 (2)	ADHD	31	55	Adulthood
Demurie et al. 2012 (1)	TD	46	28	Childhood and adolescence
Demurie et al. 2012 (2)	ADHD	38	26	Childhood and adolescence
Demurie et al. 2016 (1)	TD	39	23	Childhood and adolescence
Demurie et al. 2016 (2)	ADHD	32	19	Childhood and adolescence
de Wit et al. 2007	TD	606	50	Adulthood
Diller et al. 2011	TD	48	56	Adulthood
Doi et al. 2015	TD	57	53	Adulthood
Hulka et al. 2014	TD	68	31	Adulthood
Karalunas and Huang-Pollock 2011 (1)	TD	46	57	Childhood
Karalunas and Huang-Pollock 2011 (2)	ADHD	45	29	Childhood
Koff and Lucas 2011	TD	192	74	Adulthood
Lambek et al. 2010 (1)	TD	26	23	Childhood and adolescence
Lambek et al. 2010 (2)	ADHD	48	21	Childhood and adolescence
Lawyer and Schoepflin 2013	TD	103	64	Adulthood
Marx et al. 2013 (1)	TD real reward condition	20	50	Adulthood
Marx et al. 2013 (2)	ADHD real reward condition	20	45	Adulthood
Marx et al. 2013 (3)	TD nonreal reward condition	20	55	Adulthood
Marx et al. 2013 (4)	ADHD nonreal reward Condition	18	39	Adulthood
Morsanyi and Fogarasi 2014	TD	40	40	Adolescence
Mostert et al. 2015 (1)	TD	123	59	Adulthood
Mostert et al. 2015 (2)	ADHD	109	59	Adulthood
Peper et al. 2013	TD	40	50	Adulthood
Romer et al. 2010	TD	898	48	Adolescence and young adulthood
Rosch and Mostofsky 2016 (1)	TD	55	27	Childhood
Rosch and Mostofsky 2016 (2)	ADHD	65	29	Childhood
Scheres et al. 2013 (1)	TD	31	35	Children and adolescence
Scheres et al. 2013 (2)	ADHD-combined type and hyperactive/inattentive type	22	23	Children and adolescence
Scheres et al. 2013 (3)	ADHD-inattentive type	19	37	Children and adolescence
Sjöwall et al. 2013 (1)	TD	102	55	Children and adolescence
Sjöwall et al. 2013 (2)	ADHD	102	55	Children and adolescence
Solanto et al. 2007 (1)	TD	20	60	Childhood
Solanto et al. 2007 (2)	ADHD-combined type	34	38	Childhood
Solanto et al. 2007 (3)	ADHD-inattentive type	26	46	Childhood
Stevenson and Cate 2004	TD	30	60	Childhood
Tayler et al. 2009 (1)	TD experiment 1	64	55	Adulthood
Tayler et al. 2009 (2)	TD experiment 2	64	50	Adulthood
Wilbertz et al. 2012 (1)	TD	28	50	Adulthood
Wilbertz et al. 2012 (2)	ADHD	28	46	Adulthood

Note. A number in parentheses refers to a study with multiple samples, groups, or conditions within the study.

Author Contributions

Joshua Doidge, David Flora, and Maggie Toplak, all contributed significantly to the manuscript. Joshua Doidge conducted the literature review, summarized the findings and wrote the article. David Flora and Joshua Doidge conducted the analyses. David Flora and Maggie Toplak provided important intellectual contributions to the study's conceptualization, as well as critical revisions of the article for intellectual content.

Declaration of Conflicting Interests

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Notes

1. The Maudsley Index of Delay Aversion (MIDA) Task, which is comprised of different conditions, has a condition that is the same as the Choice Delay Task known as the *no postreward delay* condition (Banaschewski et al., 2012; Paloyelis, Asherson, & Kuntsi, 2009). For the MIDA, only the *no postreward delay* condition is considered a delay of gratification task (Patros et al., 2016).
2. Because differences between male and females are also often referred to both as "gender differences" and "sex differences" depending on the meta-analytic study (e.g., Dekkers, Popma, van Rentergem, Bexkens, & Huizenga, 2016; Patros et al., 2016; Silverman, 2003), both terms were included in searches so as to not miss studies.
3. In their emailed responses, some authors clarified whether multiple published studies contained overlapping samples. If the authors indicated that their multiple papers contained overlapping samples, the sample in the later paper was excluded. If studies had multiple developmental periods, authors were emailed to request separate data on children, teenagers, and adults for the purpose of moderator analyses.

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