TEMPORAL DISCOUNTING AND COGNITIVE ABILITIES IN A DEVELOPMENTAL SAMPLE

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Abstract

Temporal discounting (TD) is the tendency to choose smaller, immediate rewards over larger, later rewards. Temporal discounting choices were studied in relation to cognitive abilities and self-control rating measures in a sample of children and adolescents aged 8 to14 years. First, we evaluated TD choices using measures typically used in the literature (indifference point, area under the curve, and *k*-value), and explored their association with developmental level, cognitive abilities (comprised of IQ and executive function) and self-control ratings by parents. Second, we developed a novel way to study TD choices: categorization of choices into Now (consistent preference for immediate rewards), Switcher (switching from immediate to later rewards), Later (consistent preference for later rewards) and Random (random selection of immediate and later rewards) groups. The Now and Switcher choosers were the most frequent, and these groups were compared on cognitive abilities and the self-control ratings. Results indicated that the indifference point, area under the curve, and *k*-value were not associated with developmental level, cognitive abilities, or self-control ratings. The Now and Switcher groups had significant relationships with developmental level, cognitive ability measures and self-control ratings. These findings suggest that, at this period of development many children may not recognize the competing choices in this task. The implications of assessing TD in developmental samples is discussed, including a comparison between TD and delay of gratification paradigms.

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Introduction

Temporal Discounting and Cognitive Abilities in a Developmental Sample

Temporal discounting (TD) refers to the tendency to choose smaller, immediate rewards over larger, later rewards (Critchfield & Kollins, 2001). For instance, when offered a choice between $20 now or $40 in a month, some people may prefer $20 now, even though waiting for an additional month would increase the rate of return by 100%. This preference reflects the idea that time delay may lead one to discount the value of a reward (choose sooner, smaller rewards over larger, later rewards). Although the TD measure is task specific (delay is measured on a specific condition), this paradigm has been studied as an index of self-control and impulsive behaviors (Metcalfe & Mischel, 1999; Mischel, Shoda & Rodrigues, 1989; Shamosh & Grey, 2008). TD has also been related to age and intelligence (Scheres et al., 2006; Steinberg et al., 2009) as well as real world outcomes such as physical well-being, personal finances, and criminal offending (Bickel, Odum & Madden, 1999; Mofitt et al., 2011).

In community samples, ratings of impulsivity have been associated with choosing smaller, sooner rewards on TD tasks (Scheres & Sumiya, 2008). Temporal discounting is also significantly associated with intellectual abilities (Shamosh & Gray, 2008). It has been found that higher scores on tests of cognitive abilities, as encompassing measures of executive functioning (EF) and IQ in this study, are associated with greater willingness to wait for larger, later rewards (Shamosh & Grey, 2008). Scores on tests of intellectual abilities also tend to increase developmentally (Salthouse & Davis, 2006). Similarly, ratings of self-control may provide another converging index of TD, as older children have been rated as displaying more self-control than younger children (Moffitt et al., 2011).

Relatively less work has been done to examine TD in children and adolescents, in particular, associations between TD, cognitive abilities, and parent ratings of self-control. The purpose of the current study was to explore the relationship between TD, cognitive abilities and ratings of self-control in a developmental sample. Furthermore, sex differences in TD choices were examined. This study has implications for understanding variables in self-control and developmental differences in TD decision making task in children and adolescents.

Defining Temporal Discounting

Temporal discounting tasks generally require participants to make choices between a small variable reward and a larger constant reward available after a variable delay (Rachlin, Raineri, & Cross, 1991; Scheres et al., 2006). This task can be referred to as a "commitment-choice" procedure because it requires the individual to commit to an immediate or delayed reward (Reynolds & Schiffbauer, 2005). For the purpose of this study, the term "higher discounting" refers to the preference for a smaller, immediate reward over larger, later reward and "lower discounting" refers to the tendency to wait for larger, later reward over smaller, immediate reward. There are many reasons why people choose Now or Later options (Frederick, 2006), but the focus of this study was on understanding individual differences (based on cognitive abilities) in those who choose immediate versus larger delayed rewards.

The TD task is different from delay of gratification tasks (DoG), because DoG tasks require participants to wait for a reward during a delay period while a smaller reward is constantly available (Shamosh & Gray, 2008). Delays of gratification tasks are considered "sustained-choice" procedures because the choice between the immediate and delayed reward is available for the duration of the delay period (Reynolds & Schiffbauer, 2005).

While several studies have found age differences on DoG tasks (Hongwanishkul et. al., 2005; Johnson & Paulsen, 1980; Mischel & Metzner, 1962), studies on TD have not found similar results (Duckworth & Seligman, 2005; Scheres et. al., 2006). In a meta-analysis, Shamosh and Gray (2008) reported no differences between TD and DoG tasks in strength of association between discounting and intelligence. These findings may suggest that the paradigms of TD and DoG may be different to some extent (Reynolds & Schiffbauer, 2005) and may be tapping into separable constructs developmentally. However, for the present study, both TD and DoG tasks were considered, given the fact that these tasks are often discussed together and are conceptually related in terms of assessing the choice between small immediate rewards versus larger delayed rewards.

In TD tasks, there is an *indifference point*, where the participant will switch from preferring the immediate reward to the delayed reward. The indifference point represents the subjective value of the reward for the participant because it is the amount preferred (which will vary by participant) and is usually less than the face value of the larger delayed reward (Critchfield & Kollins, 2001). Steinberg and colleagues (2009) determined that the indifference point declines as the delay interval increases. Therefore, the longer one has to wait for a reward, the less value it holds in comparison to the sooner, immediate reward being offered. As such, the length of delay has been identified as an important variable in TD.

Other TD variables can be described using a mathematical equation known as the hyperbolic function. Data in figure 1 is represented by the hyperbolic function (Mazur, 1987; Myerson & Green, 1995):

$$V = \frac{A}{1+kD}$$

Where the A and V are the amount of delayed reward and discounted value of the delayed reward, respectively, and D is the delay. Another important dependent measure of TD is the *k*-value. The *k*-value is the sensitivity to delay or an individual's rate of discounting (Green et al., 1996). A large *k*-value means a preference for smaller, immediate reward or higher discounting while a small *k*-value represents a preference for a larger, delayed reward or lower discounting. The preference for a reward depends on the magnitude of the reward. Lastly, area under the curve (AUC) is also calculated using the formula above. Figure 1 illustrates how changes in the preference for delayed rewards, affect the AUC (Critchfield & Kollins, 2011). The relationship between AUC and *k*-value is such that a large *k*-value will result in smaller AUC while a small *k*-value form a larger AUC. These three dependent variables have been examined in the developmental literature (Reed & Martens, 2011; Steinberg et al., 2009) and were also examined in the present study to assess TD.

Temporal Discounting and Developmental Differences

Although the literature in the area of TD and development is mixed, the suggestion that older children choose larger later rewards over smaller, immediate ones is supported across some studies (see Table 1 for a sample of such studies). In an early study of the phenomenon, Lessing (1969) reported no significant age differences between Grade 5, 8, and 11 in DoG tasks. In contrast, Paulsen and Johnson (1980), found delayed response on DoG tasks to increase with age, in a sample of children with age mean of 4.56 years, and the most marked change was between ages 8 and11. Similarly, Green (1986) found significant age-related decreases in discounting among children (M=12.1 years) and young adults (M=20.3 years) respectively, when using the DoG measures. This is the typical finding with DoG paradigm and may reflect the strengthening of cognitive ability mechanisms that allow for better decision-making, reasoning, and the ability to exert self-control in delaying immediate rewards.

Only a handful of more recent studies have examined age differences in TD during childhood and adolescence (Green et al., 1996; Scheres et al., 2006; Steinberg et al., 2009). Cohen and colleagues (2011) showed an age effect on TD tasks, with lower discounting in 15-year-olds than 8- to 9-year-olds. In support of these results, in the Scheres et al. (2006) study, children aged 6 to 11 years showed higher discounting than adolescents ages 12 to 17 years. This study used a TD task in which the large reward (10 cents) was delayed by between 0 and 30 seconds, and the immediate reward varied in magnitude (0–10 cents). Similarly, Green and colleagues (1994), reported developmental differences between three groups of 6th graders, young adults (M=20.3 years) and older adults (M=67.9 years), with the younger groups having more sensitivity to delay than older groups. Finally, an important study by Steinberg at al. (2009) recruited a sample of 935 participants, and found that younger adolescents consistently demonstrated a greater willingness to accept smaller immediate rewards than individuals 16 and older. This study adapted a TD task where the amount of the delayed reward was held constant at $1,000 with six varied delayed blocks (1 day, 1 week, 1 month, 3 months, 6 months, and 1 year), presented in a random order. The respondents were asked to choose between an immediate reward of a given amount and a delayed reward of $1,000. Together these studies suggest that developmental differences in TD become more apparent in late childhood, but further research is needed in order to understand the nature of tasks and developmental patterns associated with them. One additional way to understand the development of TD is to examine whether it covaries with developmental differences in cognitive abilities.

What are Cognitive Abilities?

Research has emphasized differences in cognitive abilities throughout development (Cattell, 1971; Flavell, 1982; Horn, 1968). The increase of specialized thinking mechanisms and knowledge from childhood to adulthood reflects developmental differences in cognitive abilities (e.g., Carroll, 1993). For instance, in a lifespan study, Li et al. (2004) examined correlations among a variety of basic processes including psychometric intelligence (i.e., fluid and crystallized intelligence) in a sample aged 6 to 89 years. Their results support the longstanding theoretical assumption (Baltes et al., 1980) that intellectual abilities and cognitive processes are more homogenous in childhood, and gradually become more specialized in adolescence and young adulthood. This finding was also consistent with better performance on intellectual abilities and EF measures in older children than younger children (Salthouse & Davis, 2006).

Further evidence for developmental changes in cognitive ability are the differentiation of functions, mainly developed in prefrontal cortex (PFC), referred to as , a family of top-down mental processes needed for goal directed behavior (Diamond, 2013). EF skills are essential in reasoning, problem solving and decision-making (Collins & Koechlin, 2012; Lunt et al., 2012). They include inhibition, set-shifting and working memory (WM). Inhibition refers to controlling one's attention, behavior and thoughts to override distracting external stimuli utilizing self-control, selective attention and cognitive inhibition (Diamond, 2013). Research has established the improvements in inhibition with age (Anderson, Anderson & Lajoie, 1996; Moffitt et al., 2011). Development of inhibition throughout childhood plays a critical role in self-regulatory behavior, reasoning, and decision-making. For instance, younger children show less inhibition on timed tasks than older children (Diamond, 2013). Similarly, developmental improvements in set-shifting (the capacity to switch rapidly between tasks), and WM (the ability to mentally manipulate and hold information in mind) have been reported in the literature (Anderson, 2002; Cowan, Saults, & Elliot, 2002; Cowan et al., 2011; Crone et al., 2006; Espy, 1997; Luciana et al., 2005).

Many studies that have adopted the differentiation of EF in children have found similar patterns of findings (Espy et al., 2011; Hughes, Ensor, Wilson, & Graham, 2010). For example, Lee and colleagues (2013) used cohort-sequential design to examine developmental changes in 6 to 15 year olds and found differences in the structure of EF, and higher EF abilities among 15 year olds than 8 and 11 year olds. Moreover, there was a strong correlation between the three above-mentioned domains, and children with higher WM, exhibited faster reaction time in inhibition and set-shifting tasks. The development of EF with age may account for planful, anticipatory decision-making in older children than younger children. In support of this difference, Salthouse and Davis (2006) reported age effects on EF measures in children ages 5 to 17 years, with a significant increase in performance of older children than younger children. Understanding the development of EF paradigms is critical in studying TD, as well as its relationship with cognitive abilities in this population. Thus, based on this existing literature, it was predicted that older children would display higher intellectual and EF abilities than younger children.

Temporal Discounting, Intelligence and Executive Functions

The association between IQ, EF and TD has been examined empirically. Studying this association is important, as cognitive abilities and development are both indicators of the capacity for more complex thinking and competencies. Shamosh and Gray (2008) conducted a meta-analysis of the relationship between TD paradigms and intelligence. These authors found that people with higher intelligence (i.e., IQ) were more willing to wait for larger, later rewards.

Therefore, it would be expected that people with higher intelligence scores, would also demonstrate increased ability to delay rewards.

Steinberg and colleagues (2009) also found that indifference points were positively related to IQ in a sample of people aged 10 to 30 years old. In other words, the higher the IQ, the higher the indifference point (amount at which the subjective value of an immediate reward is equivalent to the value of a delayed reward). This implies that people with higher IQs are more willing to wait for larger, later rewards because they do not devalue these rewards as quickly as those with lower IQs. This study included an examination of whether these associations are stronger in older children than younger children as TD/cognitive ability paradigms are expected to develop with increasing age.

Executive functions are another domain of cognitive abilities that are associated with TD although the results across the literature are somewhat discrepant. For instance, inhibition has been examined in relation to delay discounting and no association was found (Lamm, Zelazo, & Lewis, 2006), however, this finding has not been replicated. Similarly, Cuskelly and colleagues (2003) found no significant developmental effect between TD and EF measures, yet they reported ratings of self-control to be significantly associated with TD tasks. This may suggest a relationship between TD and self-control. Other studies have reported associations of TD and set shifting (Hongwanishkul, Happaney, Lee, & Zelazo, 2005), and TD and inhibition (Shoda, Mischel, & Peake, 1990). Examining the association between TD and the cognitive abilities of IQ and EF informs us whether TD is associated with cognitive abilities and self-control ratings developmentally.

Sex Differences in Temporal Discounting

The TD literature on sex differences is somewhat mixed. The majority of studies that have examined TD in boys and girls have not found significant differences between the sexes. For instance, out of the 16 TD and DoG studies reviewed in the literature, five of the studies did not study sex differences while ten did not find differences between the sexes (see Table 1). One study that did find gender differences in TD, utilized a unitary self-discipline composite by combining parent, teacher, self-control ratings and TD questionnaires (Duckworth & Saligman, 2006). Girls were found to be more self-disciplined than boys as determined by their overall GPA, and performance on achievement tests. Moreover, girls were more likely to wait for delayed rewards compared to boys. More research is needed in order to understand self-control differences between boys and girls as measured by TD tasks.

Summary

Temporal discounting is the tendency to prefer smaller, immediate rewards to larger, later rewards. Temporal discounting has been studied as an important indicator of self-control. The limited research has shown some support for the idea that the willingness to wait for larger, later reward on temporal discounting tasks is associated with developmental stage, as are EF, intelligence, and self-control. More specifically, EF and cognitive flexibility have shown a longer developmental progression in adolescence and early adulthood than childhood. Temporal discounting has not been looked at specifically in relation to the cognitive abilities and self-control ratings and therefore this study examined these associations in a developmental sample. Sex differences in TD were also explored. There were 5 specific hypotheses for this study:

Hypothesis 1

Children in Grades 6 to 9 will discount less (show increased preference for larger, later rewards) than children in Grades 2 to 5. There will be developmental differences in Indifference Point, Area Under the Curve and the *k*-value between the two groups.

Hypothesis 2

There will be developmental differences in performance on EF, and intelligence measures with older children performing better on cognitive ability measures than younger children.

Hypothesis 3

IQ and executive functioning, as measures of cognitive ability are associated with TD, and ratings of self-control. There will be a higher association of the above-mentioned variables in older children than younger children.

Hypothesis 4

Older children will receive higher parent ratings of self-control than younger children. More specifically, children who discount less (show preference for delayed rewards) will receive higher parent ratings of self-control.

Hypothesis 5

In support of previous literature, this study hypothesizes no significant sex differences in TD task.

Method

Participants

A developmental sample of 252 8 to 14-year-old participants (130 males and 122 females) was recruited from the Greater Toronto Area. The communities fro mwhich the participants were recruited from were middle to upper income, with families mainly from European descent. Assent was obtained from the child and consent from his/her parent before proceeding with the study. Participants were recruited through posters in the community and local school boards. The participants were divided into two groups: Grade 2 to 5 (*n*=134) and Grades 6 to 9 (n=118). As inclusion criteria, participants must have been between 8 and 15 years of age (Grades 2-5, 6-9). One participant was eliminated from the original sample due to not meeting the inclusion criterion in the study (age criterion). There were no exclusion criteria in this study.

The mean age of the sample was 10.65 years (*SD* = 1.88). The Grade 2 to 5 group comprised 53.2% of the sample, and 46.8.0% of the participants were in Grades 6 to 9 (see Table 2).

Measures

Temporal Discounting

A temporal discounting task modeled on the hypothetical money choice task used by Rachlin et al. (1991) was used in this study. This task required individuals to make a choice between a small, immediate reward or a fixed larger, delayed reward. The Appendix displays all of the trials for this task. The hypothetical rewards task was used since no differences between real and hypothetical versions of the task have been found in the literature (Johnson & Bickel, 2002; Locey, Jones, & Rachlin, 2011). There were five blocks of delay periods (one day, two days, 30 days, 180 days, and 365 days) in conjunction with one delayed reward of $10. The immediate variable reward changed in a sequential manner by factors of 1. The typical administration of this task involved administering each reward magnitude at each delay first in ascending then in descending order. For example, the immediate reward began by $1 increments in a descending manner ($10, $9, $8, $7, $6, $5, $4, $3, $2, and $1) and was followed by an ascending sequence of ($1, $2, $3, $4, $5, $6, $7, $8, $9, $10). Each participant made a total of 100 choices (5 delay periods x 10 trials). The dependent measures in the temporal discounting task were the Indifference Point (IP), Area Under the Curve (AUC), and the *k*-value.

The Now, Switcher, Later and Random Categories

A novel way of examining the data was to look at temporal discounting in a categorical form, which became apparent after data analysis began. This was organized such that the sample was categorized into four groups of Now choosers (consistently choosing immediate rewards over later rewards), Later choosers (consistently choosing later rewards over immediate rewards), Switchers (switching between immediate to later rewards), and Random choosers (switching back and forth between now and later rewards).

Cognitive Ability

Wechsler Abbreviated Scales of Intelligence (WASI) – Vocabulary and Matrices Subtest. The Vocabulary and Matrix Reasoning subtests of the WASI were used as a measure of cognitive ability using an estimated IQ score (WASI; Wechsler, 1999). The Vocabulary subtest involved participants providing verbal definitions of increasingly difficult words. The Matrix Reasoning subtest required the participant to determine which of five options best completes a pattern in a series of pictures, with each item becoming increasingly more difficult. The raw scores on these subtests were converted into *z*-scores and summed to create a composite measure of intellectual ability for use in the analyses (*M*= -.05; *SD*= 1.79, range= 10). Higher composite scores indicated higher intellectual abilities.

Sentence Span Task. The Sentence Span task was used to measure working memory (originally developed by Daneman and Carpenter [1980] Working memory is the ability to hold information in mind while manipulating it when necessary (Miyake, Friedman, Emreson, Witzki, & Howerter, 2000). This study used the adapted version of sentence span by Gottardo, Stanovich, and Siegel (1996). The task is a simple word span task, with the added component of the comprehension of sentences. Participants listened to sets of two to five statements and indicated whether each statement was true or false. After responding to each of the sentences in a set, the child was asked to recall the final word of each sentence in the set. Recall accuracy was the dependent measure (*M*=20.10; *SD*= 3.12; range= 25). Higher scores on this task were indicative of better working memory abilities.

Stroop Test. The Stroop test (1935) was used in this study as a measure of inference control, a type of inhibition (Cohen & Servan-Schreiber, 1992; Strauss, Sherman & Spreen, 2006). Interference control refers to the ability to filter out irrelevant information and to select relevant information. The task included three different conditions: a naming of coloured rectangles condition, a naming of coloured words condition, and an interference condition. In the coloured rectangles condition, participants were presented with a chart of 24 coloured rectangles presented in four columns and six rows array. Participants were asked to name the colour of each rectangle as quickly as possible without making any errors and were timed on this task. In the second condition, the participant was presented with a series of coloured words printed in different ink presented in an array of four by six matrix. The participants were asked to state the colour of ink of each word as quickly as possible without making any errors. In the interference condition, participants were presented with a chart of 24 words presented in a matrix of 4 columns and 6 rows. In this condition, the colour naming words (red, green, blue, and yellow) appeared in a different coloured ink (red, green, blue or yellow) than the colour to be named. For example the word 'red' appeared in the colour yellow. Participants were asked to name the colour of ink as quickly as possible without making any errors. The interference condition was the most difficult of the three conditions because the participants needed to inhibit a response from the competing modality that is, naming the words. Time to complete each trial, the number of errors, and the number of self-corrections were scored for each trial (*M*=1.50; *SD*= .17; range=. 96). An interference score was calculated by subtracting the time to complete the interference condition minus the time taken to complete the colour naming condition (Macleod, 1991; Strauss, et al., 2006), with a higher score indicative of greater inhibitory problems.

The Trailmaking Test (TMT; Reitan, 1958). The TMT was used as a measure of set-shifting. Set-shifting is a cognitive task that requires one to display flexibility when there are changing rules/schedules of reinforcement in the environment (Barkley, 1998; Strauss et al., 2006). The TMT consists of two parts, Part A and Part B. Participants completed practice items for both parts. Part A required the participant to connect with a pencil line 25 numbered circles, in numerical order without lifting the pencil off the paper. Part B consisted of 13 numbered and 12 lettered circles, and the participant was instructed to alternate between numeric and alphabetic order, going from 1 to A to 2 to B to 3 to C, etc., until they had exhausted all of the circled numbers and letters. The dependent measure of interest in this task was total completion time on part B minus total time on Part A, as this discrepancy represents the total additional time required for the participants to 'shift set' between numbers and letters (*M*= 1.98; *SD*= .18; range=1.04) A higher score indicated lower set-shifting.

Parent Rating of Self-Control

The Strengths and Weaknesses of ADHD-symptoms and Normal Behaviour Scale (SWAN; Swanson et al., 2009) assesses inattention and hyperactive and impulsive behaviours. This scale was used to assess self-control in the current study, as similar scales have been used to assess self-control in other studies (Moffit et al., 2011). The SWAN Scale included the 18 diagnostic criteria for ADHD based on the DSM-IV-TR (APA, 2000). The SWAN differs from most behavior rating scales used for assessing developmental psychopathology in that the symptoms of ADHD are reworded using a strength-based rather than a weakness-based formulation as in the DSM-IV. For instance, the DSM-IV symptom "Often avoids, dislikes, or reluctantly engages in tasks requiring sustained mental effort" is reworded as "Engage in tasks that require sustained mental effort" and "Often fidgets with hands or feet or squirms in seat" is rephrased as "Sit still (control movement of hands/ feet or control squirming)". The informant was asked to rate the child's behavior for each of the 18 items using a 7-point scale ranging from " far below average" to "far above average", relative to other children of the same age over the past month. The SWAN has been shown to have strong cohesiveness among items rating inattention (mean inter-item correlation = .64) and hyperactivity/impulsivity (mean inter-item correlation of .66; Young et al., 2009). Higher scores on this scale indicated greater self-control.

Procedure

Three trained examiners tested participants. At the beginning of each testing session, participants were informed that they could have the questionnaires read to them by the examiner. In total, six participants opted to have some, if not all, of the measures read to them. The order of measures administered were as follows: Child Assent, WASI Vocabulary and Matrices, Stroop, Trailmaking, Sentence Span, and Temporal Discounting Task.

Results

Statistical Analyses

A one-way ANOVA was conducted in order to examine developmental differences in TD; the relationship between age (as separated by two Grades of 2-5 and 6-9) and dependent variables of TD task (*k*-value, AUC, IP) was analyzed. Correlation analyses were conducted to determine the associations between intellectual ability measures, EF and TD dependent measures within each Grade group and in the full sample. An independent *t*-test was used to analyze associations between cognitive abilities and TD at each delay period (one day, two days, 30 days, 180 days and 365 days). Furthermore, *t*-tests were used to measure significant differences between the Now and Switcher groups at each of the five delays, between all the measures (cognitive ability and self-control rating). Using chi-square analyses, significant proportional differences between the Now choosers and Switchers at each delay (five delay periods) was measured. Lastly, sex differences were explored by conducting *t*-tests to measure any significant differences between boys and girls. For the current study, an alpha level of $p = .05$ was used to indicate significance.

Developmental Differences on Temporal Discounting, Executive Functions, Cognitive Abilities, and Self-control Ratings

The dependent measures related to the temporal discounting task are displayed in Table 3. Independent *t*-tests were conducted to compare developmental differences on intellectual abilities, EF and self-control ratings. The participants in Grades 6-9 showed higher intellectual abilities and EF than the participants in Grades 2-5. There were no significant differences between Groups on self-control ratings. The mean indifference point, AUC and the *k*-value did not differ significantly between the two grades (see Table 3).

Correlations Between TD, Cognitive Abilities, and Self-Control Ratings

Pearson Correlations between cognitive abilities, TD and self-control ratings were examined (see Table 4). Intellectual ability (IQ) was significantly correlated with EF and self-control rating scale. The EF variables were correlated with one another and the self-control rating scale, but not with any of the TD variables. Self-control ratings were also significantly correlated with IQ, stroop, trailmaking, but a significant relationship with TD variables was not found. Although all the TD variables were significantly associated with one another, the only variable that was significantly correlated with self-control ratings was the indifference point. Therefore, none of the TD variables were associated with EF and IQ.

Frequency Distribution of Now Choosers, Later Choosers, Switchers and Random Choosers on Temporal Discounting

A novel coding scheme was developed to assess TD choices that became apparent after the data had been collected. In particular, it was discovered that there were different profiles in how the participants responded on the TD task. Only part of the sample actually switched to making a choice for the larger delayed reward (Switchers), and a large proportion of the sample consistently chose the smaller immediate choice (Now Choosers). Then, a minority of the sample consistently chose the larger delayed reward (Later choosers) or displayed random responding (Random group). Additional analyses were conducted based on these categories that had been coded. The frequency of Now choosers, Later choosers, Switchers, and Random choosers were examined on the temporal discounting task (See Table 5). The frequency of the groups shows that the Now choosers comprised of the 2.1-67.9%, of the sample and the Switchers comprised of 29.3-87.3% of the sample. On the other hand, the Late choosers (2.4-8.1%) and the Random group (0.4-2.5%) comprised of a lower frequency in the sample. The focus on the relationship of Now choosers and Switchers is important as there was higher frequency of these two categories in the sample. There were higher numbers of Now choosers as delay increased and fewer numbers of Switchers at larger delays. The mean percentage of the Now group was 2.1% at the 1-day delay, 34.2% at the 30-day delay and increased to 67.9% at the 365 days delay period. That is, the size of the Now group increased as the delay time got larger. The mean percentage of the Switchers was 87.3% at the one day delay, 63.3% at the 30 days delay and decreased to 29.3% at the 365 days delay period. Therefore, although the tendency of both groups' was to wait for the larger reward decreased at the 365 days delay, the Switcher group tended to wait longer for delayed rewards than the Now group. Thus, given the higher frequency of Now and Switcher groups, these two groups were used for further analyses of developmental differences and associations with cognitive ability.

The Relationship between Cognitive Abilities, Executive Functions and Self-Control Ratings among Now and Switcher Groups

The Now and Switcher groups were compared on overall intellectual ability and the executive functioning composites and self-control rating as presented in Table 7. One- and two-day delay periods were not included in the analyses as frequency in these groups was too low for statistical comparison.

Independent *t*-tests were conducted to examine the relationship among cognitive variables, EF and self-control ratings between the two categorical groups: Now and Switchers. There was an overall significant mean difference in the mentioned measures between both groups during the 30 days, 180 days and 365 days delay times. That is, the higher the intellectual ability and the EF composite scores, the amount of discounting (preference for immediate rewards) decreased. The relationship between self-control ratings and delay intervals was positive and reflects the same pattern. There was a significant relationship among 30 days, 180 days, and 365 days delay period and self-control ratings, indicating that parent ratings of self-control between both groups are associated with longer delay periods.

There was no significant difference between cognitive abilities and EF at the one-day and two-day delay periods. It is important to note that the groups were very unbalanced for these two comparisons. For the one day delay period, the proportion of Switchers (*n*=206) and the Now group (*n*=5) were unbalanced and similar numbers were observed at the two-day delay with Switchers (*n*=205) exhibiting higher numbers than the Now group (*n*=19).

Frequency of Now and Switcher Groups in the Developmental Sample Using Chi-Square Analyses

Separate chi-square analyses were conducted between groups of (Now x Switcher) on five categories of TD delay periods (see Table 5). Five analyses were conducted to compare the Now and Switchers at each of the delay periods. Results indicated significant differences in three delay periods between these two categories. Results indicated no significant difference among one day ($\chi^2(1) = .09$, *ns*), and two days ($\chi^2(1) = 2.18$, *ns*) delay. Chi-square post-hoc analyses revealed the proportion of children in Grades 2-5 and Grades 6-9 to be significantly different at the 30 days, 180 days and 365 days. At the 30 day-delay period, the proportion of the Now group was higher in Grades 2-5 than Grades 6-9 while the Switcher's category was higher in Grades 6-9 than Grades 2-5. The same relationships were observed in the 180 days and 365 days delay intervals. There were more participants in Grades 6-9 in the Switcher group than the Now group. Thus, there were more Switchers in the older grade groups while there are more exclusively now choosers in the younger grade groups. Post-hoc comparisons confirmed these patterns, indicating that the proportion of Now choosers and Switchers in Grade 2-5 were significant at intervals of 30 days, 180 days and 365 days. Similarly, the proportion of Now choosers and Switchers in Grade 6-9 was significant at the 30 days, 180 days and 365 days.

Sex Differences

Independent *t*-tests were conducted to examine sex differences in TD, cognitive abilities, and self-control ratings. As predicted, there was an overall significant mean difference in boys and girls in self-control rating measure with girls rated higher on parent self-control measures than boys. Higher scores represent better self-control. Although girls showed higher mean scores than boys on all EF, intelligence abilities and TD variables, only indifference point at the 30- day interval and AUC were significant. Similarly, an independent *t*-test was conducted and there was a significant relationship between sex, category of Now choosers and Switchers at the two-day delay period. Thus, there was a higher proportion of girls in the Switcher category that preferred waiting for a larger, later reward than boys. Other delay periods were not significantly associated.

Discussion

Summary of Findings

The present findings demonstrated developmental differences in cognitive ability (IQ and EF) but no developmental differences were found on temporal discounting variables as measured by the AUC, *k*-value, and indifference point dependent variables. Participants in Grades 6-9 had higher scores on cognitive ability, EF and self-control ratings compared to children in Grades 2-5. Using a novel scoring scheme the sample was categorized into four groups of Now choosers (consistently choosing the immediate rewards), Later Choosers (consistently choosing the delayed reward), Switchers (switching from the immediate to the delayed reward), and the Random Group (random selection of immediate and delayed rewards). Independent *t*-tests revealed significant mean differences between the Now choosers and Switchers on cognitive ability, EF and self-control ratings at the three delay periods of 30 days, 180 days and 365 days. When examining the proportion of Now choosers and Switchers, the latter tended to wait longer for larger, delayed rewards while the former preferred the immediate, smaller reward. Chi-square analyses revealed significant developmental differences at the 30-day, 180-day and 365-day intervals in Now and Switcher choosers. This indicates a higher number of Switchers among older children preferring delayed TD choices and a higher proportion of Now choosers among younger children. The results point to the importance of considering Now and Switcher categorical forms in understanding TD in developmental samples. These categories are an informative method of measuring and conceptualizing temporal discounting in a developmental sample. Further research is needed to replicate these results as this is the first study to explore TD using categorical analysis.

Developmental Differences in TD, Cognitive Abilities, and Self-Control

One of the important findings in the current study was the lack of developmental differences in TD variables (IP, AUC and *k*-value). This is generally consistent with previous literature that has examined developmental effects in TD tasks (Johnson & Paulsen, 1980; Lessing, 1969; Tweedie, 1966), with the exception of a couple of studies. Scheres and colleagues (2006) reported significant associations between age and AUC in a sample of 6 to 11-year-olds and 12 to 17 year-olds in ADHD and control groups. In this study, participants received real money before starting the task, which may have increased the salience of the reward in younger children. Scheres and colleagues (2006) used a clinical sample, which contributed to variability in their sample as well as extreme scores. Also, an increased sensitivity to cash beforehand may have led to increased motivation to wait longer for later rewards. One comprehensive study conducted by Steinberg and colleagues (2009) that employed the same TD task as the present study, reported developmental differences between children and youth below 16 years and youth above 16 years of age. This finding may support the lack of capturing developmental differences among children aged 8 to14 years in the current study. It may be the lack of sampling above 16 years of age that accounts for no significant findings in this study. Moreover, delayed rewards may be more difficult to foresee for younger children when the reward is hypothetical. Our findings are consistent with Steinberg's theory that younger children are less future oriented as they have more difficulty thinking ahead and considering the future than older children (Steinberg et al., 2009).

Although the literature is mixed in reporting developmental differences in TD variables, most studies that report developmental differences used DoG tasks that are different in nature from TD tasks. An interesting difference between TD and DoG is the developmental onset differences and cognitive capacity these tasks capture (Reynolds & Schiffbauer, 2005). While children in studies that have used DoG tasks to predict long-term developmental outcomes are able to perform these procedures as early as 3 to 4 years of age (Mischel, Ebbensen & Zeiss, 1972; Mischel et al., 1989), children younger than ages 8 to 9 have not been able to perform on TD tasks in a way that demonstrates their sensitivity to delay (Reynolds, Schiffbauer, Swenson & Karraker, 2001; Steinberg et al., 2009). With such age differences in sensitivity to delay, it is possible that DoG and TD tasks measure somewhat different processes, with TD tasks assessing a more mature cognitive process, thus tapping into distinct developmental abilities.

The second important finding in the present study is developmental differences in cognitive ability and EF measures but not self-control ratings. As predicted, this study confirmed previous findings on the positive relationship between age and cognitive abilities (Anderson, 2002; Diamond, 1995, 1996, 2013; Zelazo, Lamm & Lewis, 2006). This study found no developmental significance in self-control ratings. This may be because of less variability in a nonclinical sample; the self-control rating measure (SWAN) was originally designed for clinical samples, suggesting it may be less sensitive to normal variation in self-control. However, the mean averages of self-control ratings indicate a trend in the predicted direction, with children in Grades 6-9, receiving higher self-control ratings than children in Grades 2-5. In support of this finding, a study reported no age differences in parent/teacher SWAN ratings in a community sample of 1025 students. Sex differences were reported with higher ratings of self-control for girls than boys (Murray et al., 2008). In contrast, studies with clinical samples have reported age effects in parent/teacher ratings of inattention (Connors, 2007; Murray et al., 2009). It seems that the SWAN is more sensitive to capturing impulsivity in clinical samples due to more variance of symptoms than is present in community samples.

Temporal Discounting, Now and Switcher Choosers

A novel contribution of this study was to categorize choices into Now, Switcher, Random and Later categories on the TD task. The focus was on the relationship between the Now choosers (always preferring immediate rewards over delayed rewards) and the Switcher group (switching from the immediate to the delayed rewards) as the majority of the sample choices comprised these two groups.

It is important to note that the discrepancies in frequency of the Now and Switcher groups is task dependent. For some of the choice items, most participants (younger children) are more likely to prefer the now option while for other items, participants (older children) are likely to switch and choose a delayed option. This pattern is likely because of the nature of the items on the TD task. While the frequencies are not statistically conclusive, they reflect on developmental differences in preference for now and delayed choices.

Results indicated significant age differences in cognitive abilities and self-control ratings between Now and Switchers at the larger delay periods. More specifically, these developmental differences between the Now and Switchers were present for the 30-day, 180-day and 365-day delay intervals. The proportion of older children clustered in the Switcher groups and the younger children clustered in the Now group was significant. The Switchers may have been more likely to recognize the choice between a smaller reward now and a larger reward later, and those children that made any shift to later at any time during the task had higher cognitive abilities. The Now group may have more difficulty with recognizing the gains of later rewards and what they would do with that gain in the extended future. This is supported in findings of cognitive ability, where significant cognitive ability differences are reported between these two groups. Even developmentally, children in the older grades clustered in the Switcher category tended to exhibit higher cognitive abilities, EF and self-control ratings than children in the younger grades.

The differences between the Now choosers and Switchers compliment the two-process theory of individual differences in decision-making. According to the two-system theory modeled by Stanovich and West (2000), there is a heterogeneous set of systems involved in decision making: System 1 is a heuristic response that can be characterized as default, automatic and requires less mental effort. System 2 requires decontextualization, as it requires overriding heuristic responses to arrive at a decision. According to Stanovich and West (2008), it is in the cases where the analytic response has to override automatic responses where we observe individual differences in problem solving (see Figure 2). Arriving at a System 2 response requires the individual to be available to carry out an override, detect the need to override, sustain inhibition to carry the override and lastly the cognitive ability to sustain an override. As elaborated by Stanovich, West, and Toplak (2011), it is critical to understand that System 2 processing does not always equate to correct responding and System 1 does not equate with normatively incorrect processing. However, what is evident is the difference in cognitive processes of a System 1 and System 2 responders.

With respect to the findings of this study, the Late choosers can be conceptualized as showing a System 2 response at all times. This study's findings suggest that the Switchers are perhaps showing the override and thus generate a System 2 response, while Now choosers are System 1 responders, generating a heuristic, effortless response. The developmental consequences of the two-system theory are integrated with the concept of mental conflict in TD tasks. It is possible that the Now choosers and younger children do not undergo the same mental conflict (steps required to override an automatic response). The developmental associations with cognitive ability are valid indicators in supporting the idea that the nature of TD task may be different for younger children than it is for older children.

Developmental predictions are complex when examining reasoning in children. Temporal discounting tasks are capturing something different in younger children compared to older children and the notion of multiple minds and systems to recognize conflict may be present in Switchers but absent in the Now group. Therefore, examining the data in such a way allows for a broader perspective in understanding decision making in children and adolescents. From the present study, it became apparent that certain predictions about self-control in children emerges by the categorization of Now and Switcher groups that otherwise would be lost using the traditional TD dependent variables.

Temporal discounting findings in this study based on the Now versus Switcher analyses are aligned with the literature on cognitive ability and developmental effects. Consistent with previous literature (Cohen et al., 2011; Hongwanishkul et al., 2005; Lessing, 1969; Mischel & Metzner, 1962; Steinberg et al., 2009), there is a positive association between cognitive abilities, TD and age. This indicates that participants who recognized the conflict in the choices (Switchers) were children who have better developed cognitive abilities. Both intelligence and EF had a significantly positive relationship with TD performance, with higher EF scores associated with more Switcher than Now chooser responses. Similar parallels were found in the current study as the Switcher group, significantly comprised of older children, tended to delay reward while the Now choosers, mainly comprised of younger children, preferred immediate rewards. The developmental relationship between Now choosers and Switchers is an important finding as it conceptualizes the difference in self-control and possible nature of TD tasks in younger children versus older children.

Sex Differences

One of the exploratory questions of this study was whether there are any sex differences in TD choices. As predicted, girls received higher parent self-control ratings on the SWAN measure, consistent with previous literature (Duckworth & Saligman, 2011; Murray et al., 2009). One would expect higher self-control ratings to be associated with lower discounting in girls but the results did not show any significant differences, except at a 30-day interval for the IP dependent variable. This result is expected, as most studies in the literature have not reported any TD differences. Although girls exhibit higher cognitive ability and EF means (but not significantly different), that can be associated with higher self-control ratings, this developmental stage may not be capturing such differences.

Limitations of the Current Study and Future Directions

The first limitation was the type of sample used. Since the sample was from a mostly middle class sample, with children showing average to above average intelligence, there was not much variance, which may have produced higher effects in TD statistical analyses. Since this sample was normative, there were lower levels of self-control in parent rating measure as well. If there had been more variance, it may have produced significant developmental effects in self-control ratings in the statistical analyses. In the future, clinical and community samples should be used to confirm the current results.

In order to further examine the Now versus Switcher groups, it would be useful to ask further exploratory questions from participants to determine whether or not they displayed conflict in each judgment. When the participant reached their indifference point (the subjective value when the immediate and delayed reward are equal), she/he could be asked why such choice was made. Future research should also include a measureable way to assess whether a participant experiences conflict in making a choice between an immediate or delayed reward. It helps to understand what group of children recognize to override heuristic, automatic responses for a delayed choice and what group of children do not acknowledge any mental effort/conflict in making choices. This element is important as it helps to explain how TD choices are different across age, and the processes involved in making such choices.

Implications of the Current Findings

The findings in the current study as well as the novel method of assessing self-control in development contribute to the literature of TD in several important ways. Temporal discounting has been studied through different lenses in order to gain greater perspective on the concept of self-control across development and in relations to intellectual abilities. On one hand there is the classical study of delay of gratification and the Marshmallow Task that seems diagnostic (Mischel & Metzner, 1962), and on the other hand there is the most current and comprehensive study by Steinberg and colleagues (2009) that does not find TD differences in younger children. The current study adds insight to the literature by recognizing TD differences in children aged 8 to 14 years and developing new methods to evaluate and assess such differences. It is important to reconsider the nature of this task and how it can explain self-control in unique ways through the span of development. This study also highlights the need for understanding processes involved in reasoning and decision making in children and the importance of developmental sensitivity.

Conclusion

The current study replicated findings that demonstrated cognitive abilities increase with age. An important finding was lack of significant developmental effects in TD variables. Developmental differences in TD task choices were examined through a novel method of categorizing the data into Now, Switcher, Random and Later choosers. The temporal discounting variables were all highly related and showed a consistent relationship at intervals of 30 day, 180 day, and 365 day between Now and Switcher choosers. This finding indicated that there are significant differences between the two groups with the Now choosers' preference for immediate rewards and the Switcher group's preference for delayed rewards. Moreover, the proportion of children in Grades 6 to 9 was higher in the Switchers group while the proportion of children in Grades 2 to 5 was higher in the Now group. Taken together, these findings present the idea that effortful processing in TD tasks may be applicable to older children while younger children may be processing this task differently. This expands how we conceptualize TD from a developmental perspective.

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Appendix I

<u>Temporal Discounting Curve Task Instructions</u>

Examiner to present stimulus cards with amounts of money.

"Now I am going to ask you to make some choices. Let's pretend that you can choose between the following amounts of money."

For each item, give a further prompt for the time delay so that the length of time is made more salient (do separately for each):

-1 day is tomorrow. Today is ______, so it would mean waiting till tomorrow, which is _____.
-For two days, today is _______, and two days from now would be waiting till ______.
-For 30 days: 30 days is one month away. So it would mean waiting a month. Now it's the beginning/middle/end of _____, so it would mean waiting till the beginning/middle/end of ______.
- For 180 days: 180 days is six months away. So it would mean waiting 6 months. Now it's the beginning/middle/end of _____, so it would mean waiting till (naming months in between) the beginning/middle/end of ______.
-For 365 days, 365 days is one year away. So it would mean waiting 1 year. Now it's the beginning/middle/end of _____, so it would mean waiting till (naming months in between) the beginning/middle/end of ______.

Temporal Discounting Curve Task

1. Descending

$ Now	OR	$Later
$10 now ______	OR	$10 in 1 day ______
$9 now _____	OR	$10 in 1 day ______
$8 now _____	OR	$10 in 1 day ______
$7 now _____	OR	$10 in 1 day ______
$6 now _____	OR	$10 in 1 day ______
$5 now _____	OR	$10 in 1 day ______
$4 now _____	OR	$10 in 1 day ______
$3 now _____	OR	$10 in 1 day ______
$2 now _____	OR	$10 in 1 day ______
$1 now_____	OR	$10 in 1 day ______

1. Ascending

$ Now	OR	$Later
$1 now ______	OR	$10 in 1 day ______
$2 now _____	OR	$10 in 1 day ______
$3 now _____	OR	$10 in 1 day ______
$4 now _____	OR	$10 in 1 day ______
$5 now _____	OR	$10 in 1 day ______
$6 now _____	OR	$10 in 1 day ______
$7 now _____	OR	$10 in 1 day ______
$8 now _____	OR	$10 in 1 day ______
$9 now _____	OR	$10 in 1 day ______
$10 now_____	OR	$10 in 1 day ______

2. Descending

$ Now	OR	$Later
$10 now ______	OR	$10 in 2 days ______
$9 now _____	OR	$10 in 2 days ______
$8 now _____	OR	$10 in 2 days ______
$7 now _____	OR	$10 in 2 days ______
$6 now _____	OR	$10 in 2 days ______
$5 now _____	OR	$10 in 2 days ______
$4 now _____	OR	$10 in 2 days ______
$3 now _____	OR	$10 in 2 days ______
$2 now _____	OR	$10 in 2 days ______
$1 now_____	OR	$10 in 2 days ______

2. Ascending

$ Now	OR	$Later
$1 now ______	OR	$10 in 2 days ______
$2 now _____	OR	$10 in 2 days ______
$3 now _____	OR	$10 in 2 days ______
$4 now _____	OR	$10 in 2 days ______
$5 now _____	OR	$10 in 2 days ______
$6 now _____	OR	$10 in 2 days ______
$7 now _____	OR	$10 in 2 days ______
$8 now _____	OR	$10 in 2 days ______
$9 now _____	OR	$10 in 2 days ______
$10 now_____	OR	$10 in 2 days ______

3.Descending

$ Now	OR	$Later
$10 now ______	OR	$10 in 30 days ______
$9 now _____	OR	$10 in 30 days ______
$8 now _____	OR	$10 in 30 days ______
$7 now _____	OR	$10 in 30 days ______
$6 now _____	OR	$10 in 30 days ______
$5 now _____	OR	$10 in 30 days ______
$4 now _____	OR	$10 in 30 days ______
$3 now _____	OR	$10 in 30 days ______
$2 now _____	OR	$10 in 30 days ______
$1 now_____	OR	$10 in 30 days ______

3.Ascaneding

$ Now	OR	$Later
$1 now ______	OR	$10 in 30 days ______
$2 now _____	OR	$10 in 30 days ______
$3 now _____	OR	$10 in 30 days ______
$4 now _____	OR	$10 in 30 days ______
$5 now _____	OR	$10 in 30 days ______
$6 now _____	OR	$10 in 30 days ______
$7 now _____	OR	$10 in 30 days ______
$8 now _____	OR	$10 in 30 days ______
$9 now _____	OR	$10 in 30 days ______
$10 now _____	OR	$10 in 30 days ______

4. Descending

$ Now	OR	$Later
$10 now _______	OR	$10 in 180 days _______
$9 now ______	OR	$10 in 180 days _______
$8 now ______	OR	$10 in 180 days _______
$7 now ______	OR	$10 in 180 days _______
$6 now ______	OR	$10 in 180 days _______
$5 now ______	OR	$10 in 180 days _______
$4 now ______	OR	$10 in 180 days _______
$3 now ______	OR	$10 in 180 days _______
$2 now ______	OR	$10 in 180 days _______
$1 now______	OR	$10 in 180 days _______

4. Ascending

$ Now	OR	$Later
$1 now _______	OR	$10 in 180 days _______
$2 now ______	OR	$10 in 180 days _______
$3 now ______	OR	$10 in 180 days _______
$4 now ______	OR	$10 in 180 days _______
$5 now ______	OR	$10 in 180 days _______
$6 now ______	OR	$10 in 180 days _______
$7 now ______	OR	$10 in 180 days _______
$8 now ______	OR	$10 in 180 days _______
$9 now ______	OR	$10 in 180 days _______
$10 now ______	OR	$10 in 180 days _______

5. Descending

$ Now	OR	$Later
$10 now _______	OR	$10 in 365 days _______
$9 now ______	OR	$10 in 365 days _______
$8 now ______	OR	$10 in 365 days _______
$7 now ______	OR	$10 in 365 days _______
$6 now ______	OR	$10 in 365 days _______
$5 now ______	OR	$10 in 365 days _______
$4 now ______	OR	$10 in 365 days _______
$3 now ______	OR	$10 in 365 days _______
$2 now ______	OR	$10 in 365 days _______
$1 now______	OR	$10 in 365 days _______

5. Ascending

$ Now	OR	$Later
$1 now _______	OR	$10 in 365 days _______
$2 now ______	OR	$10 in 365 days _______
$3 now ______	OR	$10 in 365 days _______

$4 now ______	OR	$10 in 365 days _______
$5 now ______	OR	$10 in 365 days _______
$6 now ______	OR	$10 in 365 days _______
$7 now ______	OR	$10 in 365 days _______
$8 now ______	OR	$10 in 365 days _______
$9 now ______	OR	$10 in 365 days _______
$10 now ______	OR	$10 in 365 days _______

Table 1

Temporal Discounting, Intelligence, Executive Functioning and Sex Differences in Developmental Samples

Study	Sample Size	Age Range		Results
Ainslie, Balkan, Barke, Castellanos, Djikstra, Reynolds, Sonuga & Scheres (2006)	N=56 ADHD (n=22) Control (n=24) Males (n=34) Females (n=22)	6-11 years 12-17 years	Temporal Discounting Task(TD) Probabilistic Temporal Discounting Task (PD)	Developmental Differences: ADHD group did not differ in rate of discounting than control group for either of the TD tasks. F (1,42) = .69, *n.s.;* $\eta 2 = .02$ Younger participants discounted delayed rewards significantly more strongly than adolescents on both versions of the TD task F (1,42) = 4.3; $p < .05$; $\eta 2 = .09$ Relationship between Temporal Discounting and EF/IQ: PD was correlated significantly and positively with TD in the ADHD , r=.51 , p<.05 but not in the control group, r=.21, *ns* Sex Differences: Not Studied
Banich , Cauffman, Graham, O'Brien, Steinberg & Woolard (2009)	N= 929 Malesv(n=455) Females (n= 474)	10 –11(N 116), 12 –13 (N137), 14 –15(N128), 16 –17(N 141), 18 –21(N 148), 22-25 (N 136), 26 –30 (N 23)	Wechsler Abbreviated Scale of Intelligence (WASI) Full-Scale IQ Two-Subtest	Developmental Differences: A decline in planning ahead between ages 10 and 15 (r=-.12, $p < .05$), but an increase in planning from age 15 on (r=.21, p<.001) Significant effect of age on discount rates, F (6, 832)= 6.62, $p < .001$, $n^2 = .05$, between individuals aged 13 and

			Future Orientation Self Report Measure Delay Discounting Task	Individuals ages 14-15 fell in between Relationship between Temporal Discounting and EF/IQ: Temporal discounting and future orientation are predictive of an individual's indifference point but planning ahead subscale are not (β =.126, t= 3.39, p <001; β=.161, t= 4.03, *p*< .001; and β=.059, *t*= 1.49, *ns* , respectively) Relationship between IQ and Individual's discount rate is *r*=-.27 The relationship between delay discounting and motor impulsivity were *r*=.36 The relationship between delay discounting and EF batteries were *r*=.10 Sex Differences: Discount rate is unrelated to sex
Block, J., & Funder, D. C. (1989)	N=104 Males (n=50) Females (n=54)	14 years	Delay Gratification (DoG) WISC WAIS-R	Developmental Differences: N/A Relationship between DoG and EF/IQ: Correlation between DoG and IQ: *r*=. 35* (higher IQ scores are related to more delay) Sex Differences: The mean delay score for female subjects was 4.57 (SD=1.04) and for male subjects were 4.38 (SD=1.33). The sex difference did not approach significance, *t* (102)= .84, *ns*

Braswell, Kendall & Zupan (1981)	N=98 Males (n= 45) Females (n=53)	Grades 2-5 9.4 years	Delay Gratification (DoG) Teachers Self-Control Rating Scale (SCRS) PPVT IQ	<u>Developmental Differences:</u> N/A <u>Relationship between DoG and EF/IQ;</u> Intercorrelations of DoG and PPVT IQ: *ns* <u>Sex Differences:</u> Boys and girls differed significantly on the SCRS, F (1,96) = 15.60, $p < .001$, with boys rated as having less self-control than girls
Cohen, Kesek, Lamm, Lewis, Principe & Zelazo (2011)	N=102 Males (n=50) Females (n=52)	8-15 years	Iowa Gambling Task Color Word Stroop Temporal Discounting Digit Span	<u>Developmental Differences:</u> Main effect of age group F (3, 94) = 3.00, $p < .05$, $\eta 2$ = .09 revealed that 8-9 years old group revealed higher *k*-values than 14-15 years old group <u>Relationship between Temporal Discounting and EF/IQ:</u> Delay Discounting and Iowa Gambling task were not significantly correlated r=-.19 Delay discounting and Digit Span were correlated at a trend level r=-.15 Delay Discounting and Stroop did not approach significant correlation, r=.09 <u>Sex Differences:</u> Sex comparisons were not significant
Cuskelly, Hayes & Zhang (2003)	Group 1(Down syndrome): N=25	Group 1: 6.25-14.25 years with mental age of 4	Self-imposed Delay of Gratification	<u>Developmental Differences:</u> Not Studied <u>Relationship between DoG and EF/IQ:</u>

	Group 2 (Control): N=32	Group 2: 3.9 years with mental age of 30- 60 months	Stanford-Binet Intelligence Scale -IV	Significant difference between waiting times for the two groups on the self-imposed delay task Group 2 waited longer 11.26 min (*SD*=6.1) than group 1 3.8 min (*SD*=5.9) <u>Sex Differences:</u> Not studied
Duckworth & Seligman (2005)	N=140 Male (n=62) Female (n=78)	Grade 8 13.4 years	Kirby Delay-Discounting Rate Monetary Choice Questionnaire Self-Control Rating Scale Questionaire Standardized Achievement Test Scores	<u>Developmental Differences:</u> N/A <u>Relationship between Temporal Discounting and EF/IQ:</u> Not Studied <u>Sex Differences:</u> Gender differences were greatest on delay discounting task (d= .08), with females more self-disciplined than males Females were more self-disciplined than males on all measures t (138) = 4.12, p = .001, d =.71
Green, Fry & Myerson (1994)	N=36 Group 1: 12 Group 2: 12 Group 3: 12 Sex proportion not reported	Group 1: 12.1 years Group2: 20.3 years Group 3: 67.9 years	Delay Discounting Task	<u>Developmental Differences:</u> 6th Graders discounted $1,000 more steeply than did young adults, t (12) = 4.424, p < .001 and young adults discounted more steeply than did older adults, t (12) = 4.852, p < ,001 S parameter (sensitivity to delay) for the children and young adults differed significantly, t (12) = 4.281, p < .01, but not for young adults and older adults, t (12) = 1.206 The value of S increased substantially across the life span (from 0.37 to 0.72 to 5.0)

				<u>Relationship between DoG and EF/IQ:</u> N/A <u>Sex Differences:</u> N/A
Gray & Shamosh, (2008)	Meta analysis 24 Studies	Meta analysis	Delay Discounting Intelligence (several measures were included)	<u>Developmental Effects:</u> N/A <u>Relationship between Temporal Discounting and EF/IQ:</u> Association between IQ and Delay discounting was negative in direction, small to moderate range <u>Sex Differences:</u> Not Studied
Hongwanishkul, Happaney, Lee & Zelazo (2005)	N=98 Males (n= 40) Females (n= 48)	3.0 - 5.9 years	Delay of Gratification Task (DoG) Children's Gambling Task Dimensional Change Card Sort (DCCS)	<u>Developmental Differences:</u> 3-year-olds chose to delay on DoG task less often than 4 and 5year olds <u>Relationship between DoG and EF/IQ</u>: DoG and Children's Gambling Task: *r*=.24* DoG and DCCS: *r*=.21* <u>Sex Differences</u>: No significant gender effects $F(2, 92) = .28$, *ns*, $\eta^2 =$ p=006
Johnson & Paulsen (1980)	N=55 Males (n=27)	38- 72 months	Delay Gratification	<u>Developmental Differences:</u> Delayed response (delaying larger rewards) increases with

	Females (n=28)		(DoG) Peabody Picture Vocabulary Test (PPVT) Teacher Rating of Impulsivity IQ score (Not Specified)	age with the most marked change happening between Grade 3 and 4, *r*= .65 1st to 3rd Grade showed no significance chi square for linear regression of 0.23 while chi-square linear regression was significant X^2=7.08, *df*=1, *p*<. 01 for Grade 4 to 6 <u>Relationship between DoG and EF/IQ:</u> Delay Gratification measure was significantly correlated with (TR), *r*=.28 but not with other measures <u>Sex Differences:</u> The one-way MANOVA for the age-sex interaction was significant, Wilk's *F*=3.05, *df*=8, 92, *p*=. 004 with less errors in MFFT task in girls than boys ages 5, 4 and 3 respectively
Lessing (1969)	N=558 5th, 8th, 11th Grade Males (n=201) Females (n=357)	Not Reported	Delay Gratification (DoG) IQ (type not specified)	<u>Developmental Differences:</u> The difference between grades on DoG (*F*= .62, *p*>.05), *ns* Higher means for 11th than 8th Graders on SCS *F*=7.47 *p*<.01) <u>Relationship between DoG and EF/IQ</u> Correlation between DoG and IQ was *r*=. 23 DoG was significantly and positively related to GPA only in grade 8. *F*= 7.18, *p*<. 01 <u>Sex Differences:</u> No sex differences among 8th and 11th Graders
Lindqvist, Roth, Sjowall & Thorell, (2013)	N=102(ADHD) N=102 (Control)	7-13 years	Size Ordering Task Digit Span	<u>Developmental Differences:</u> Not Studied When studying group differences, the children with ADHD performed more poorly than controls with regard to all

	Males (n=97) Females (n=56)		Go/No-Go Task Choice Delay Task	neuropsychological functions except delay Aversion <u>Relationship between Temporal Discounting and EF/IQ:</u> No significant relationship between TD and other measures <u>Sex Differences:</u> No main effects of sex and no interaction effects of group and sex were found
Metzner & Mischel (1962)	N= 162 Males (n=68) Females n=58)	7.5 years	Delay Gratification (DoG) IQ scores Pintner General Ability test Verbal Series Forms A or B (no references given)	<u>Developmental Differences:</u> Delayed response (delaying larger rewards) increases with age with the most marked change happening between Grade 3 and 4, $r=.65$, $p<.05$ 1st to 3rd Grade showed no significance chi square for linear regression of 0.23 while chi-square linear regression was significant $X^2=7.08$, $df=1$, $p<.01$ for Grade 4 to 6 <u>Relationship between DoG and EF/IQ:</u> N/A <u>Sex Differences:</u> Gender differences were not significant $X^2=2.306$, $df=1$, $p>.10$
Mischel, Peake & Shoda (1990)	N=185 Males (n=82) Females (n=103)	4-18 years	SAT Verbal and Quantitative Scores	<u>Developmental Differences:</u> N/A <u>Relationship between DoG and EF/IQ:</u>

			California Child Q-Set Delay Gratification (DoG)	DoG was correlated with verbal intellectual ability r=.39, delay rule knowledge r=.52 and attention deployment r=.51 <u>Sex Differences:</u> Not Reported
Tweedie (1966)	N=36 Males (n=30) Females (n=16)	8-10 years	Delay Gratification (DoG) Teacher Ratings of Self-control	<u>Developmental Differences:</u> The younger girls (8 to 9.5) were compared with the older girls (9.5 to 11 years) and no significant difference was found in their number of delayed responses. There was also no differences found between the younger and older boys, t=. 482, $p < 0.4$ <u>Relationship between DoG and EF/IQ:</u> There was no significant relationship between ratings of restlessness and ratings of delay, X^2= .0462, *ns* p<. 05 <u>Sex Differences:</u> The girls that displayed higher DoG did not differ in teacher ratings than girls who displayed lower DoG t=1.485, p< 0.1 The boys that displayed higher DoG did not differ in teacher ratings than boys who displayed lower DoG t=. 710, p< 0.25

Table 2

Demographic Characteristics of Sample

Variable		M (SD)	*n*
	Female	----	122
	Male		130
Age (years)	8-12	10.00 (1.45)	203
	13-15	13.36 (0.56)	49
Grade	2-5		134
	6-9		118
Total			252

Table 3

Means and Independent t-test for Temporal Discounting, Executive Functions, Self-Control Ratings Among Two Grade Samples

Measures	Grades 2-5 M (SD)	Grades 6-9 M (SD)	*t*
Cognitive Abilities			
Intellectual ability composite	-.82 (1.63)	.82 (1.55)	-8.13 ***
Executive functions (EF)			
Stroop	1.60 (.14)	1.40 (.16)	8.20***
Trail making	2.07 (.16)	1.90 (.16)	8.45***
Sentence span	19.30 (3.10)	21.00 (2.92)	-4.31***
Self-control rating	85.00 (17)	87.40 (17)	-1.04
Temporal discounting			
Indifference point (IP)			
1day	8.40 (2.30)	8.15 (2.20)	.84
2days	6.70 (2.90)	6.63 (2.90)	.98
30days	4.52 (3.32)	4.30 (3.20)	.60
180days	2.84 (2.70)	3.00 (3.01)	-.45
365days	2.45 (2.52)	2.43 (2.73)	.06
Area under the curve	-.58 (.30)	-.60 (.31)	.34

k-value	-1.20 (1.00)	-1.11 (1.04)	-.70

Note.*p<.05, **p<.01, ***p<.001

Table 4

Intercorrelations between Cognitive Ability Measures, Executive Functions and Temporal Discounting Measures

	1.	2.	3.	4.	5.	6.	7.	8.
IQ								
1. Intellectual Ability	1							
EF								
2.Stroop	-.467**	1						
3.Trailmaking	-.551**	.505**	1					
4.Sentence span	.461**	-.356**	-.485**	1				
Temporal Discounting								
5.AUC	-.072	-.011	-.022	-.055	1			
6.Indifference point	-.055	.007	-.038	.002	.870**	1		
7.*k*-value	.077	-.012	-.005	-.011	-.893**	-.799**	1	
Self-control								
8. SWAN	.214**	-.200**	.258**	.127	-.127	-.183**	.107	1

*p<.05, **p<.01, Note. Area Under the Curve (AUC), The Strengths and Weaknesses of ADHD-symptoms and Normal Behaviour Scale (SWAN)

Table 5

Frequency Distribution of the Now, Switchers, Later and Random Group Categories in Each Temporal Discounting Delay Period

	Category				
Delay	Now *n* (%)	Switcher *n* (%)	Later *n* (%)	Random *n* (%)	N
1day	5 (2.1)	206 (87.3)	19 (8.1)	6 (2.5)	236
2days	19(8.1)	205 (87.2)	7 (3.0)	4 (1.7)	235
30days	81(34.2)	150 (63.3)	5 (2.1)	1 (.4)	237
180days	140(57.6)	96 (39.5)	5 (2.1)	2 (.8)	243
365days	167(67.9)	72 (29.3)	6 (2.4)	1 (.4)	246

Table 6

Frequency of Now and Switcher Categories Based on Developmental Groups

Delay periods (days)		Now n (%)	Switchers n (%)	Chi-square
1day	Grades 2-5	3 (2.68%)	109 (97.32%)	--
	Grades 6-9	2 (2.20%)	97 (97.98%)	
2 days	Grades 2-5	13 (11.11%)	104 (88.89%)	--
	Grades 6-9	6 (5.61%)	101 (94.39%)	
30 days	Grades 2-5	59 (49.17%)	61 (50.83%)	12.81***
	Grades 6-9	22 (19.82%)	89 (80.18%)	
180 days	Grades 2-5	85 (58.55%)	39 (41.45%)	9.12**
	Grades 6-9	55 (49.11%)	57 (50.89%)	
365 days	Grades 2-5	98 (79.03%)	26 (20.97%)	10.26**
	Grades 6-9	69 (60.00%)	46 (40.00%)	

Note. p<.01**, p<.001***, [The one day and two days delay intervals were not examined for significance due to small group sizes]

Table 7

Average of Cognitive Abilities Variables and Self-Control Ratings in Five Delay Periods between the Now and Switcher Groups

Measures	Now Group *M* (*SD*)	*n*	Switcher Group *M* (*SD*)	*n*	*t (df)*	Effect Size Cohen's d
WASI composite						
30days	-.69(1.80)	81	.39(1.69)	150	-4.58***	-.62
180days	-.38(1.70)	140	.50(1.70)	96	-3.94***	-.51
365days	-.28 (1.72)	167	.72 (1.65)	72	-4.20***	-.59
Stroop						
30days	1.56 (.16)	81	1.46 (.17)	150	4.30***	.60
180days	1.52 (.17)	140	1.46 (.17)	96	2.90**	.33
365days	1.52 (.17)	167	1.43 (.18)	72	3.87***	.07
Trailmaking						
2days	2.08 (.22)	19	2.00 (.18)	205	2.48*	.81
30days	2.07 (.19)	81	1.93 (.17)	150	5.41***	.77
180days	2.02 (.19)	140	1.93 (.15)	96	3.62***	.52
365days	2.01 (.18)	167	1.92 (.16)	72	3.52***	.52
Sentence span						
30days	19.48 (3.05)	81	20.58 (3.09)	150	-2.58**	-.35
180days	19.66 (3.18)	140	20.87 (2.90)	96	-2.30**	-.39
365days	19.89 (3.04)	167	20.80 (3.30)	72	-2.07*	-.28

Self-control rating						
30days	81.75(16.16)	77	89.29 (16.95)	131	-3.14**	-.45
180days	82.39 (15.88)	130	91.97 (16.85)	83	-4.19***	-.58
365days	84.54 (16.23)	156	90.48 (18.15)	60	-2.32*	-.34

Note. p<.05*, p<.01**, p<.001***

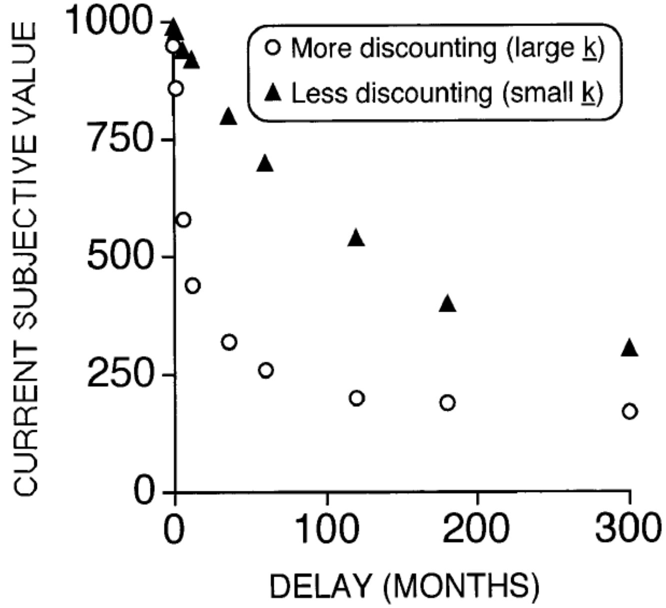

Figure 1: Critchfield & Kollins' Graphical Display of the Temporal Discounting Data (2001)

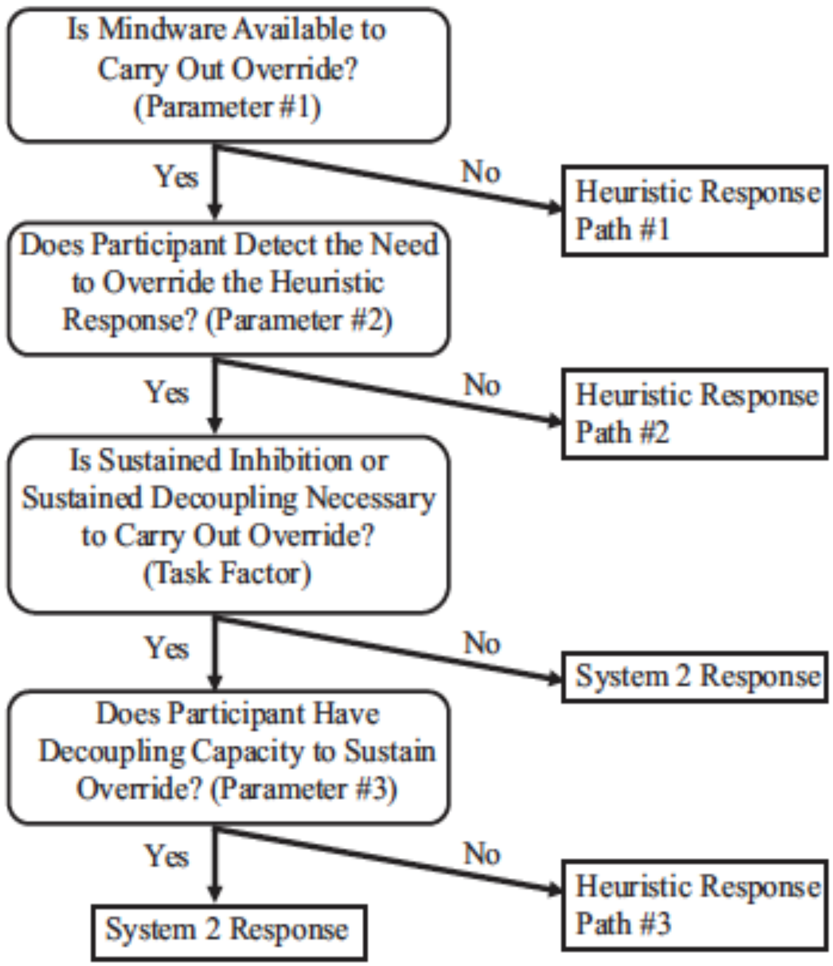

Figure 2: Stanovich & West's Framework for Differences in Decision Making (2008)