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Behavioral impulsivity and risk-taking trajectories across early adolescence in youths with and without family histories of alcohol and other drug use disorders

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Abstract

Background—Youths with family histories of alcohol and other drug use disorders (FH+) are at increased susceptibility for developing substance use disorders relative to those without such histories (FH−). This vulnerability may be related to impaired adolescent development of impulse control and elevated risk-taking. However, no previous studies have prospectively examined impulse control and risk-taking in FH+ youth across adolescence.

Methods—A total of 386 pre-adolescents (305 FH+, 81 FH−; ages 10–12) with no histories of regular alcohol or other drug use were compared on behavioral measures of impulsivity including delay discounting, response initiation (Immediate Memory Task), response inhibition impulsivity (GoStop Impulsivity Paradigm), and risk-taking (Balloon Analogue Risk Task-Youth). Youths completed these laboratory tasks every 6 months, allowing for examination of 10–15 year olds. Hierarchical linear modeling was used to characterize the development of impulse control and risk-taking as shown in performance of these tasks throughout adolescence.

Results—We found that: (1) FH+ youths had increased levels of delay discounting and response inhibition impulsivity at study entry; (2) regardless of FH status, all youths had relatively stable delay discounting across time, improvements in response inhibition and response initiation impulsivity, and increased risk-taking; and (3) although FH+ youths had increased response inhibition impulsivity at pre-adolescence, these differences were negligible by mid-adolescence.

Conclusions—Heightened delay discounting in FH+ pre-adolescents coupled with normal adolescent increases in risk-taking may contribute to their increased susceptibility towards problem substance use in adolescence.

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Keywords

Family history; Substance use disorders; risk-taking; impulsivity; delay discounting; adolescent development

Introduction

Adolescence is marked by an increased risk for developing substance use disorders, at least partially driven by delayed maturation of forebrain circuits responsible for impulse control and regulation of risk-taking behaviors (Ernst and Fudge, 2009, Blakemore and Robbins, 2012). Throughout typical adolescent development, forebrain circuitry maturation occurs and impulse control increases (Liston et al., 2006, Christakou et al., 2011, Stevens et al., 2007). However, a “temporal gap” may occur between the full maturation of circuitry responsible for impulse control and the earlier-maturing affective system, which promotes reward-seeking and risk-taking (Ernst et al., 2006, Geier and Luna, 2009). This gap partially explains why impulse control improves throughout adolescence but reward-seeking behaviors (e.g., propensity to initiate drug use and subsequent vulnerability to develop substance use disorders) increase (Steinberg, 2010).

Adolescents with family histories of alcohol and other drug use disorders (FH+) are more likely to develop substance use disorders compared to peers without such family histories (McCaul et al., 1990, Cotton, 1979). This is likely due to high heritability and transmission of a “behavioral undercontrol” phenotype, i.e., elevated impulsive and risk-taking behaviors (Sher et al., 2005). Additionally, frontal white matter maturation may be impaired in FH+ youths (Acheson et al., 2014b, Acheson et al., 2014a), which may contribute to impaired impulse control and increased substance use disorder risk. It is clear that FH+ youth may have problems with impulse control and risk-taking related to their propensity to use substances, but it is unclear how these processes progress throughout early adolescence.

Impulsivity is a multifaceted construct assessed with either personality or behavioral measurements. Prospective studies using personality measures find impulsivity declines across adolescence into early adulthood (Shulman et al., 2014, Steinberg et al., 2008, Collado et al., 2014), and youths who declined more slowly in impulsivity across adolescences showed more rapid increases in alcohol, marijuana, and cigarette use (Quinn and Harden, 2013). Although personality measurements are associated with substance use vulnerability, they are subjective reports of comprehensive impulsive traits. Alternatively, behavioral approaches examine impulsive performances on tasks, and these measures typically index specific facets of impulsivity (Reynolds et al., 2006). At least three core components of impulsivity are indexed by behavioral measures: delay discounting, response initiation, and response inhibition impulsivity (Dougherty et al., 2005). Delay discounting is the preference for smaller-sooner rewards rather than larger-later rewards. Response initiation impulsivity is rapid responding that occurs before complete processing and evaluation of a stimulus. Response inhibition impulsivity is the failure to withhold an already-initiated response. FH+ adults without substance use disorders show increases in each facet of impulsivity compared to FH– adults including delay discounting (Acheson et

al., 2011d), response initiation and response inhibition impulsivity (Acheson et al., 2011a). Similarly, individuals with substance use disorders have been shown to have increased impulsivity compared to those without (de Wit, 2009) on all components: delay discounting (MacKillop, 2013), response initiation impulsivity (Verdejo-Garcia and Perez-Garcia, 2007), and response inhibition impulsivity (Li et al., 2009). Collectively, these results indicate that by adulthood, FH+ individuals perform more impulsively than FH– individuals, akin to individuals with substance use disorders versus those without. We demonstrated that FH+ pre-adolescents are more impulsive on delay discounting and response inhibition impulsivity than FH– youths (Dougherty et al., 2014). However, it is unclear how FH status affects development of impulse control across adolescence. This time period is particularly important because both delay discounting and response inhibition impulsivity in youths predict problem substance use later (Audrain-McGovern et al., 2009, Nigg et al., 2006).

Risk-taking (propensity to seek out novel, stimulating but potentially harmful experiences) and impulsivity are regulated by distinct mechanisms and appear to develop independently (Harden and Tucker-Drob, 2011). In normal development, risk-taking (as indexed by self-report, laboratory behavioral, and epidemiological measures) dramatically increases in early adolescence, peaks in mid-adolescence, and then decreases by early adulthood (Braams et al., 2015, Romer et al., 2014, Hale et al., 2014, Collado et al., 2014). These changes in risk taking across adolescence contrast with changes in impulsivity, which generally decreases across adolescence (Steinberg et al., 2008). Risk-taking is positively associated with substance use (Wills et al., 1994), but few studies have examined risk-taking and its development among FH+ populations. FH+ men (Lovallo et al., 2006) exhibit higher levels of risk-taking than FH– men, and both FH+ adolescents and adults have altered frontal activity when performing risk-taking tasks (Acheson et al., 2009, Cservenka and Nagel, 2012). What is still unknown is how risk-taking develops across early adolescence among FH+ youths relative to their peers; this is a process that may contribute to increased vulnerability for initiating and developing substance use problems.

This study is part of a larger prospective longitudinal study (Ryan et al., In Press) to identify how impulse control assessed during pre-adolescence and its development during the critical period of adolescence (ages 10–15) contributes to the susceptibility for substance use and developing disorders among FH+ and FH– youths. The current report focuses on characterizing: (a) differences in impulse control and risk-taking propensity among FH+ and FH– pre-adolescents; (b) developmental trajectories of behavioral impulsivity and risk-taking; and (c) differences in developmental trajectories among FH+ and FH– youths. We hypothesized that: (1) FH+ pre-adolescents would be more impulsive and have increased risk-taking behaviors relative to FH– pre-adolescents; (2) impulsivity would decrease as part of normal development, but that risk-taking would increase over time; and (3) both FH+ and FH– youths would show similar trends over time, but higher levels of impulsivity and risk-taking would occur in FH+ youths.

Methods

Participants

Participants were recruited for a prospective longitudinal study assessing how impulse control development relates to substance initiation and progression of use (Ryan et al., In Press). Families were recruited when youths were age 10–12 and followed for a maximum of 48 months (Median = 30 mo) prior to the current analyses. Overall, 386 youths participated, including 305 with a family history of substance use disorders (FH+) and 81 with no family history of substance use disorders in 1st or 2nd degree relatives (FH–). FH+ participants were deliberately oversampled to increase the likelihood of observing substance use initiation and problem use during our ongoing prospective monitoring of this cohort. All FH+ participants had at least a biological father with a past or present substance use disorder. Pre-adolescents and their parents were recruited from the San Antonio, Texas community through radio, internet, and television advertisements. Respondents completed an initial telephone interview; those who appeared to meet study criteria were invited to the laboratory to complete a comprehensive assessment (including physical and psychiatric health, substance use history, and cognitive ability).

At study entry, parents reported their pre-adolescent's age, sex, race, and ethnicity. Parents self-reported their education and employment on the Four Factor Index of Social Status (FFISS; Hollingshead, 1975), a measure of socioeconomic status that ranges from 8 (unskilled laborer) to 66 (business owner/professional). Both pre-adolescents and their parent/guardian were interviewed using the Kiddie-Schedule for Affective Disorders and Schizophrenia: Present and Lifetime Version (K-SADS-PL; Kaufman et al., 1997). The Wechsler Abbreviated Scale of Intelligence Full 4-Factor (WASI; Psychological Wechsler, 1999) was administered to pre-adolescents to estimate IQ. Adolescents also completed a Drug History Questionnaire (Sobell et al., 1995) to assess current and lifetime substance use and provided breath (AlcoTest® 7110 MKIII C, Dräger Safety Inc., Durgano, CO) and urine samples to screen for recent alcohol and drug use (THC, cocaine, benzodiazepines, opiates, and amphetamines; Panel/Dip Drugs of Abuse Testing Device, Redwood Biotech, Santa Rosa, CA). A physical examination was performed by a physician or physician's assistant. Lastly, family history status was classified using the Family History Assessment Module (Janca et al., 1992).

Exclusionary criteria included a physical or neurological condition that would interfere with study participation, regular substance use (defined as substance use at least once per month for 6 consecutive months; Clark et al., 2005), and Full Scale IQ < 70. Having any current or past DSM-IV Axis I psychiatric disorders was exclusionary for the FH– group, however Oppositional Defiant Disorder, Conduct Disorder, Attention Deficit Hyperactivity Disorder, Dysthymia or Anxiety Disorders were not exclusionary for the FH+ group because these disorders are commonly co-morbid with substance use involvement (Iacono et al., 2008). Written informed consent was obtained from pre-adolescents and their parent/guardian before study participation. The protocol was approved by the Institutional Review Board of The University of Texas Health Science Center at San Antonio.

Prospective procedure

Participants were assessed at study entry and at 6-month intervals (maximum 36 months). The prospective assessment included psychiatric diagnoses and measurement of substance use described above, along with the addition of measures of behavioral impulsivity and risk-taking conducted at each study visit. For each visit, adolescents and parents were compensated \$120 and \$75, respectively.

Impulsivity assessment

Because impulsivity is a multidimensional construct, we used different behavioral tasks to measure three facets. Tasks were counterbalanced among participants and completed in a sound-attenuated room equipped with a computer monitor and mouse.

Delay discounting—Delay discounting was assessed with a paper and pencil measure of choice behavior (Kirby et al., 1999). Participants completed 27 fixed-choice options between immediate, smaller and delayed, larger hypothetical amounts of money (e.g., “Would you prefer (a) \$54 today or (b) \$80 in 30 days?”). Delayed amounts of money ranged from small (\$25–\$35), medium (\$50–\$60), to large (\$75–\$85). Rates of delay discounting were characterized by calculating k values based on Mazur’s hyperbolic discounting function (Mazur, 1987) for choices in each of the three delayed monetary categories. For this study, k values were averaged across the three monetary categories and log transformed. Higher average k values indicated increased delay discounting.

Response inhibition—Response inhibition was assessed using the GoStop task (Dougherty et al., 2005), which measures the ability to withhold an already-initiated response when a stop cue is presented. Five-digit numbers are presented in rapid sequence (500 ms on, 1500 ms off), half of which are exact matches to the preceding stimulus. Matching numbers include “Go” trials, presented in black for the full 500 ms, and “Stop” trials, numbers that change from black to red at one of four predefined delays: 50, 150, 250, or 350 ms after stimulus onset. Participants are to respond to matching numbers, but inhibit responses if the number color changes from black (*Go*) to red. Of the four types of stop trials, only responses to the 150 ms signals trials were analyzed because they best discriminate between impulsive and control groups. Variables of interest are *go responses*, where the participant correctly responds to a number that matches the preceding one when it remained black; and *inhibition failure responses*, where the participant failed to inhibit responses to a matching number when a stop cue was delivered. The primary dependent measure for this task was the GoStop Ratio, or the proportion of inhibition failures relative to go responses, with higher ratios indicating more response inhibition impulsivity.

Response initiation—Response initiation impulsivity was measured by the Immediate Memory task (IMT; Dougherty et al., 2005). A series of randomly-generated 5-digit numbers appear on a screen for 500 ms at a rate of one per second during a 10-min session. Participants are instructed to only respond with a mouse button click when the number they see is identical to the preceding number. Variables of interest are *correct detections* --the number of times the participant correctly responds; and (2) *commission errors* --the number of times the participant responds incorrectly to a stimulus that differs from the previous

stimulus by one digit. These two variables were used to calculate the primary dependent measure for this task, the IMT Ratio (the proportion of commission errors to correct detections); higher ratios indicate more response initiation impulsivity.

Risk-taking assessment

Risk-taking was measured using the BART-Y (Lejuez et al., 2002, Lejuez et al., 2007), a computerized task where participants are required to “pump up” a series of 30 balloons on a computer screen to earn points towards prizes. As the balloon expands, and earnings accrue, participants can stop pumping at any time and save their accumulated points. However, if they continue to pump, the balloon occasionally “explodes” and points on that balloon trial are lost. Points accumulated for each trial, and cumulative points earned, are displayed on the screen during the testing session. After completing the session, participants were offered their choice of prizes (e.g., plastic sunglasses, a water bottle, etc.) regardless of task performance. The primary dependent measure is the average adjusted number of pumps on balloon trials without explosions, with more pumps indicating higher levels of risk-taking.

Data analyses

Participants’ characteristics were summarized using descriptive statistics and compared between FH+ and FH– using *t* tests or chi-squared tests for continuous and categorical variables, respectively. The associations between tasks (within group) were tested with Pearson's *r*. Hierarchical linear modeling (HLM; Bryk and Raudenbush, 1987, Bryk and Raudenbush, 1992) was used to characterize development of impulse control and risk-taking. HLM extends multiple linear regression modeling to repeated-measures data, provides a framework for analyzing individual change over time, and can accommodate time-invariant and time-varying predictors to determine whether individual characteristics are related to initial status or change over time. The presence of sex differences was evaluated using two additional sets of models. In the first set, sex was included as the predictor of initial status and change over time. No significant results were found. In the second set, controlling for sex in models with FH status as the predictor of initial status and change over time did produce different results than FH status alone. Accordingly, the simpler model using only FH status was retained. Because adolescents were assessed in 6-month intervals, results on the three impulse control measures and one risk-taking measure were modeled as functions of age in half-year increments from 10 to 15 years; FH status was then added as a predictor of initial status and change over time. All models were fit using a compound symmetry covariance structure for the repeated measures; SAS PROC MIXED was used to fit all models.

Results

Participant characteristics

Demographic characteristics, current DSM IV-TR diagnoses, and frequencies of participants’ history of non-regular substance use at study entry are summarized in Table 1. The groups had similar age and racial demographics, although the FH+ group had lower socioeconomic status and a slightly higher frequency of Hispanic participants. FH+ adolescents also had lower IQs, although the mean of both groups was in the average range

(i.e., 90–110). A minority of FH+ adolescents (34%) met criteria for one or more DSM IV-TR disorders. Study attrition during the prospective longitudinal assessment period was low (10.8% for FH+ and 7.4% for FH– youths) and was unrelated to study outcomes.

Behavioral task differences as a function of FH status at study entry

To characterize differences between FH+ and FH– pre-adolescents at study entry, we assessed delay discounting, response inhibition impulsivity (GoStop), response initiation impulsivity (IMT), and risk-taking (BART-Y). FH+ youths had higher log k values at study entry than FH– youths ($\beta = 0.24$, $SE = 0.09$, $p = 0.010$), indicating greater discounting of delayed rewards for FH+ youths (Figure 1a). FH+ pre-adolescents had more response inhibition impulsivity relative to FH– youths (GoStop $\beta = 12.1$, $SE = 4.05$, $p = 0.003$) (Figure 1b). However, there were no significant differences between FH+ and FH– pre-adolescents on response initiation impulsivity (IMT $\beta = 1.0$, $SE = 2.19$, $p = 0.639$) (Figure 1c). Lastly, there were no significant differences at study entry between FH+ and FH– youths on risk-taking (BART-Y $\beta = -1.4$, $SE = 2.36$, $p = 0.565$) (Figure 2). Actual means and model plots are presented in Figures 1 and 2. Finally, the association between task outcomes were tested by FH status (FH– below the diagonal, FH+ above; Table 2). There were significant associations between IMT and GoStop ratio scores for the FH+ group ($r = .36$). The magnitude of this effect was similar to previously reported correlations among adolescents with disruptive behavior disorders ($r = .39$; Dougherty et al., 2003). The FH– group had only a significant relationship between Delay Discounting k and BART Pumps ($r = .26$). None of the other correlations was significant.

Developmental trajectories of impulsivity and risk-taking

To characterize developmental trajectories of impulsivity and risk-taking across all youths, we assessed each behavioral task every six months for up to three years. Average log k values on the delay discounting measure indicated a slight increase across adolescence ($\beta = 0.02$, $SE = 0.01$, $p = 0.010$), indicating more delay discounting over time for both groups (Figure 1a). However, log k values only increased by about 10% from ages 10 to 15. Response inhibition and response initiation significantly decreased across adolescence (GoStop $\beta = -2.4$, $SE = 0.27$, $p < 0.001$; IMT $\beta = -3.1$, $SE = 0.14$, $p < 0.001$), indicating reduced impulsivity and thus greater impulse control over time (Figure 1b and 1c). Additionally, risk-taking significantly increased across adolescence (BART-Y $\beta = 1.89$, $SE = 0.16$, $p < 0.001$) (Figure 2).

Differences in developmental trajectories as a function of FH status

To characterize the differences in developmental trajectories among FH+ and FH– youths, we compared the trajectories between each group for each behavioral task (Figures 1 and 2). Both FH+ and FH– youths overall had similar delay discounting trajectories over time ($\beta = -0.02$, $SE = 0.02$, $p = 0.25$). FH+ and FH– youths appeared to converge on delay discounting at age 15, but this is likely due to limited number of subjects tested at this age ($n = 42$ FH+, 14 FH–). There were different trajectories between FH+ and FH– youths on the response inhibition task (GoStop $\beta = -1.7$, $SE = 0.65$, $p < 0.001$), demonstrating greater relative improvements over time for FH+ youths (Figure 1). However, both FH+ and FH– youths

had similar trajectories over time on the response initiation task (IMT $\beta = 0.19$, $SE = 0.34$, $p = 0.59$) and risk-taking task (BART-Y $\beta = -0.09$, $SE = 0.39$, $p = 0.809$) (Figure 2).

Similar trajectories between FH+ and FH– youths on both response initiation and risk-taking, coupled with similarities at study entry, indicate no FH-related differences on these two behavioral tasks from ages 10 to 15. In contrast, FH+ youths show greater response inhibition and delay discounting impulsivity in preadolescence. The difference in response inhibition impulsivity decreases over time, such that FH+ youths perform similarly to FH– youths on this measure by mid-adolescence. However, the difference for delay discounting persists across development (Figure 1a).

Controlling for substance use and DSM-IV disorder diagnoses

DSM-IV disorder diagnoses—When we replicated analyses including only participants who did not meet criteria for any DSM-IV disorder diagnosis ($n = 133$ removed), results about impulsivity development over time as well as the effects of FH status on preadolescent levels and developmental trajectories were the same as with the full sample. For example, FH+ and FH– youths had different trajectories over time for response inhibition (GoStop $\beta = -1.9$, $SE = 0.68$, $p = 0.005$), but had similar trajectories over time for response initiation (IMT $\beta = 0.11$, $SE = 0.37$, $p = 0.771$), delay discounting ($\beta = -0.02$, $SE = 0.02$, $p = 0.257$), and risk-taking (BART-Y $\beta = 0.01$, $SE = 0.41$, $p = 0.973$). Thus, the findings were not driven by youths with psychiatric disorders in our sample.

Substance use—To ensure outcomes were not driven by those using substances, analyses were repeated with subjects who reported no use. When analyzing the subsample of participants who reported no use at study entry ($n = 18$ removed), all tests of impulsivity development over time, and effects of FH status on preadolescent levels and trajectories over time, did not differ from the full sample. When analyzing only participants who reported no use during the study ($n = 74$ removed), the small increase in delay discounting was no longer significant ($\beta = 0.01$, $SE = 0.01$, $p = 0.059$). Additionally, FH+ youths no longer significantly discounted delayed rewards more than FH– youths at pre-adolescence ($\beta = 0.18$, $SE = 0.10$, $p = 0.072$); decreased significance levels are likely due to decreased statistical power. All other conclusions about impulsivity development over time and effects of FH status on preadolescent levels and trajectories over time were the same as with the full sample. All parameter estimates are available upon request.

Discussion

To our knowledge, this is the first study to examine laboratory measures of behavioral impulsivity and risk-taking propensity longitudinally in FH+ and FH– youths across early adolescence. Behavioral impulsivity measures assessed were delay discounting (preference for smaller, sooner rewards rather than larger, later rewards), response initiation impulsivity (rapid responding that occurs prior to complete processing and evaluation of a stimulus), and response inhibition impulsivity (failure to withhold an already-initiated response). Three main findings related directly to our hypotheses: (1) at pre-adolescence, FH+ youths had increased levels of delay discounting and response inhibition impulsivity; (2) regardless of FH status, all youths had relatively stable delay discounting across time, improvements in

response inhibition and response initiation impulsivity, and increased risk-taking; and although FH+ youths had increased response inhibition impulsivity at pre-adolescence (study entry), these differences were negligible by mid-adolescence. There were no other differences between FH+ and FH– groups.

Previously, we demonstrated delay discounting more robustly predicts FH+ status during pre-adolescence, prior to substance use initiation, than measures of response initiation and response inhibition impulsivity (Dougherty et al., 2014). The current study extends this work by showing that FH+ youths show increased delay discounting through mid-adolescence. While delay discounting trajectories were relatively flat across time, we would expect delay discounting to decrease as participants mature, and that FH+ individuals will also discount more as adults (Acheson et al., 2011d). Delay discounting is increased in adults with substance use disorders (MacKillop, 2013), and our findings provide additional evidence that the increased delay discounting in individuals with substance use disorders may occur before regular substance use in vulnerable individuals.

FH+ youths were also more impulsive at study entry on response inhibition but improved to levels that were similar to FH– by mid-adolescence. However, response initiation impulsivity did not differ as a function of FH status. These results contrast with previous findings that FH+ adolescents and adults had increased response inhibition impulsivity (Nigg et al., 2004, Acheson et al., 2011a) and FH+ adults had increased response initiation impulsivity (Acheson et al., 2011a, Saunders et al., 2008). Consequently, these tasks may reveal more robust differences in later adolescence, given that increased response inhibition in mid-adolescence predicts later substance problems (Nigg et al., 2006). Thus, FH+ individuals may show more relevant differences in performance in response initiation and inhibition impulsivity later as a function of developmental processes across adolescence or as a consequence of substance use.

Risk-taking propensity between FH+ and FH– groups, as measured by the BART-Y, did not differ, which is in contrast with a previous report of increased risk-taking among FH+ compared to FH– adults (Lovallo et al., 2006) on the Iowa Gambling Task. However, the Iowa Gambling Task is complex and involves a variety of behaviors and is difficult to use for repeated administrations (Stocco et al., 2009). We selected the BART-Y because it is a less complex task and increases observed in adolescents in longitudinal studies are thought to reflect increased risk-taking rather than simply learning effects (e.g.; MacPherson et al., 2010). We did observe a modest (27%) increase in points earned on this task, a measure of performance, from age 10 to age 15. This suggests that the increased responding on the task could at least partially reflect youths improvement on this measure over time. However, this increase in points earned is more modest than the increase in responding on the BART-Y (46%) across these same ages. This indicates that youths are responding more in general, i.e., engaging in more risk taking, but not necessarily learning to optimize their performance on the task. This finding is consistent with cross-sectional studies using other laboratory behavioral measures as well as studies using self-report and epidemiological measures indicate risk taking peaks in mid-adolescence as part of normal development (Braams et al., 2015, Romer et al., 2014, Hale et al., 2014, Collado et al., 2014, Burnett et al., 2010).

Importantly, we found no evidence for differences in risk taking on this measure in FH+ and FH– youths at any time point in the study.

Overall, regardless of family status, all youths improved their impulse control and exhibited more risk-taking across time. These trends are consistent with the idea that there is a temporal delay between full maturation of impulse control and the earlier development of risk-taking and reward seeking behaviors (Blakemore and Robbins, 2012, Chambers et al., 2003, Christakou et al., 2011, Liston et al., 2006, Madsen et al., 2010, Somerville and Casey, 2010, Steinberg et al., 2008). Our findings suggest that this relative imbalance between impulse control and risk-taking may contribute to FH+ individuals' propensity for developing substance use disorders. Specifically, increased delay discounting in FH+ youths coupled with typical adolescent increases in risk-taking and reward seeking tendencies may result in FH+ youths being more likely to engage in real world risky behaviors like using alcohol and other drugs because they may be more prone to discount potentially negative consequences of these actions.

A major strength of this study is that we examined youths both with and without family histories of substance use disorders, from pre-adolescence into mid-adolescence. These comparisons were conducted both for the full sample and then again, including only those who had not initiated substance use (either at study entry or during the prospective assessments). Thus, we can compare effects of family history and onset of substance use while measuring behavioral changes in multiple facets of impulsivity and risk-taking during a vulnerable time. Additionally, we did not exclude FH+ individuals with disorders common in families with substance use disorders, because these diagnoses are associated with increased vulnerability for developing problem substance use (Iacono et al., 2008, Tarter, 2002). However, our follow-up analyses indicated these disorders did not drive the group differences in behavioral impulsivity measures. Limitations include lacking substance use outcome data for participants beyond mid-adolescence. However, we continue to assess these individuals in our longitudinal study.

In conclusion, we measured FH+ and FH– adolescents on four separate behavioral measures across an important developmental period. Although this prospective longitudinal study sheds light on early adolescent development, changes in impulse control and risk-taking continue into adulthood. Future studies are needed to examine impulse control development and risk-taking behaviors into young adulthood, to further delineate their role in FH+ individuals' heightened vulnerability for substance use disorders. Our results indicate that FH+ individuals have deficits in impulse control which, simultaneous with the increased risk-taking typical in adolescents, may contribute to propensity for substance use involvement.

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Figure 1.

Table 1

Demographic Characteristics at Study Entry

	FH– <i>n</i> = 81		FH+ <i>n</i> = 305	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age	11.62	0.95	11.52	0.89
IQ Score	102.32	12.18	94.88*	11.18
Socioeconomic Status	43.45	10.80	32.71*	11.40
	<i>n</i>	%	<i>n</i>	%
Sex				
Male	35	43.2	152	49.7
Female	46	56.8	153	50.3
Race				
African-American	5	6.2	37	12.4
Caucasian	74	91.4	261	85.3
Other	2	2.5	7	2.3
Ethnicity				
Hispanic/Latino	57	70.4	246*	80.7
Not Hispanic/Latino	24	29.6	59	19.3
Externalizing Disorders				
ADHD	0	0	90	29.4
Conduct Disorder	0	0	2	0.7
Oppositional Defiant Disorder	0	0	30	9.8
Internalizing Disorders				
Generalized Anxiety Disorder	0	0	16	5.2
Separation Anxiety Disorder	0	0	21	6.9
Specific Phobia	0	0	12	3.1
Lifetime use (<i>n</i> , ever used)				
Alcohol	2	2.5	10	3.3
Marijuana	0	0	2	0.7
Cigarettes	1	1.2	5	1.6
Other	0	0	0	0

Note. Given that having a disorder was exclusionary for FH– youths, significance tests for the diagnostic criteria were not performed. WASI, Wechsler Abbreviated Scale of Intelligence; FFISS, Four Factor Index of Socioeconomic Status

*
p < .05

Table 2

Correlation between Task Performance by FH Status

	IMT Ratio	GoStop Ratio	Delay Discounting Average <i>k</i>	BART Adjusted Number of Pumps
IMT Ratio		.360 **	.119	-.111
GoStop Ratio	.196		.063	.020
Delay Discounting <i>k</i>	.118	-.056		-.002
BART Pumps	-.064	.156	-.261 *	

FH- below the diagonal, FH+ above.

*
 $p < .05$,**
 $p < .001$