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Genetic risk of AUDs and childhood impulsivity: Examining the role of parenting and family environment

Jinni Su[1], Angel Trevino[1], Belal Jamil[1] and Fazil Aliev[2]

[1]Department of Psychology, Arizona State University, Tempe, AZ, USA and [2]Department of Psychiatry, Rutgers University, Newark, NJ, USA

Abstract

This study examined the independent and interactive effects of genetic risk for alcohol use disorder (AUD), parenting behaviors, and family environment on childhood impulsivity. Data were drawn from White ($n = 5{,}991$), Black/African American ($n = 1{,}693$), and Hispanic/Latino ($n = 2{,}118$) youth who completed the baseline assessment (age 9–10) and had genotypic data available from the Adolescent Brain Cognitive Development Study. Participants completed questionnaires and provided saliva or blood samples for genotyping. Results indicated no significant main effects of AUD genome-wide polygenic scores (AUD-PRS) on childhood impulsivity as measured by the UPPS-P scale across racial/ethnic groups. In general, parental monitoring and parental acceptance were associated with lower impulsivity; family conflict was associated with higher impulsivity. There was an interaction effect between AUD-PRS and family conflict, such that family conflict exacerbated the association between AUD-PRS and positive urgency, only among Black/African American youth. This was the only significant interaction effect detected from a total of 45 tests (five impulsivity dimensions, three subsamples, and three family factors), and thus may be a false positive and needs to be replicated. These findings highlight the important role of parenting behaviors and family conflict in relation to impulsivity among children.

Keywords: alcohol; family conflict; impulsivity; parenting; polygenic score

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AUDs are prevalent (SAMHSA, 2019), affecting about 30% of individuals aged 18 or older in the United States (Grant et al., 2015) and associated with significant personal, interpersonal, and societal costs (Sacks et al., 2015). Initiation of alcohol use typically occurs in adolescence, and early onset alcohol use (age 14 or younger), in particular, has been associated with prolonged negative outcomes including increased risk for AUD (Gruber et al., 1996; Hingson et al., 2006; Hingson & Zha, 2009), in part due to influences on the developing brain (Spear, 2018; Squeglia et al., 2014). Thus, understanding the etiology of adolescent alcohol use is important to inform early prevention and intervention. There is strong evidence that both genetic predispositions and social environments contribute to alcohol use problems, and that genetic influences vary as a function of environmental experiences (i.e., gene–environment interaction; G×E), and vice versa (Dick & Kendler, 2012; Enoch, 2012). However, prior genetically informative research has primarily focused on alcohol use outcomes among adolescents and adults who have already initiated alcohol use or developed AUD, limiting our understanding about how genetic risk for AUD unfolds across development. In the present study, we took a developmental approach to examine how genetic risk of AUD influences early precursors of alcohol use (i.e., childhood impulsivity) and how familial contextual factors (i.e., parenting and family conflict) moderate genetic risk. By shifting the focus from problematic alcohol use to childhood precursors or intermediate phenotypes that underlie alcohol use and AUD, such as impulsivity, we can better understand how genetic risk of AUD manifests earlier in development (Dick et al., 2018), which can inform early prevention and intervention before alcohol use even begins.

Corresponding author: Jinni Su, email: jinnisu1@asu.edu

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Genetic risk of AUD and childhood impulsivity

Alcohol use and AUD are complex behavioral outcomes best understood from a developmental perspective (Trucco & Hartmann, 2021). Developmental cascade models depict adolescent alcohol and substance use as a result of a sequential progression from temperamental differences in childhood (e.g., impulsivity, behavioral control) to problem behaviors in early adolescence to riskier behaviors, such as alcohol and drug use during mid/late-adolescence, with this cascade sequence thought to be initiated by genetic and biologically based differences (Dodge et al., 2009). Accordingly, temperament traits such as childhood impulsivity are considered important early precursors of alcohol use and AUD.

We focus on examining the influence of genetic risk for AUD on childhood impulsivity as an early precursor and prime intermediate phenotype for AUD for several reasons. First, impulsivity is a robust predictor of alcohol use outcomes, with extensive literature linking impulsivity to alcohol use and problems in human studies and animal models (Coskunpinar et al., 2013; Dick et al., 2010). Prospective studies show that impulsivity in childhood predicts alcohol use in adolescence and adulthood (Elam et al., 2016; Pedersen et al., 2012) and the development of AUD (Clark et al., 2002; Dawes et al., 1997). Second,

impulsivity shares genetic etiology with alcohol phenotypes. Twin studies indicate that a variety of different disorders that are characterized by impulsive behavior, including alcohol and drug dependence, childhood conduct disorder, and adult antisocial behavior, overlap largely due to an underlying shared genetic liability (Kendler et al., 2003). Personality traits related to impulsivity also load on this latent genetic factor (Krueger et al., 2002; Young et al., 2000), which has been referred to interchangeably as behavioral disinhibition, behavioral undercontrol, or impulsivity. A recent study with a sample of college students showed that impulsivity dimensions, as measured by the UPPS-P scale (Cyders et al., 2007), mediate the relation between alcohol use genome-wide polygenic scores (PRS) and alcohol consumption (Ksinan et al., 2019), suggesting that impulsivity may be a manifestation of a genetic risk for alcohol use problems. Furthermore, prior research suggests that impulsivity and related traits are modifiable by interventions (Hentges et al., 2020), making them promising targets for early interventions aimed at reducing long-term risk of AUD.

Impulsivity is a multidimensional construct that has been conceptualized and measured in various ways, including the use of questionnaires and laboratory tasks (Dick et al., 2010). In an effort to address the lack of consensus in the literature and integrate different approaches to impulsivity, researchers developed the UPPS-P model, which operationalizes impulsivity as five related but distinct dimensions, including negative urgency (i.e., tendency to act rashly when experiencing negative emotions or affect), positive urgency (i.e., tendency to act rashly as a result of positive affect), lack of premeditation (i.e., lack of careful thinking and planning before action), lack of perseverance (i.e., inability to remain with a task or see it finished), and sensation seeking (i.e., the tendency to seek out excitement and adventure) (Cyders et al., 2007; Whiteside & Lynam, 2001). Each dimension has been related to alcohol use outcomes and other forms of externalizing behavior (e.g., aggression) (Berg et al., 2015). Some of the dimensions, most strongly negative urgency, have also been associated with depression and anxiety (Berg et al., 2015). Thus, differences in aspects of impulsivity may represent core underlying processes contributing to both the externalizing and internalizing pathways that have consistently been associated with the development of alcohol problems in the literature (Hussong et al., 2011; Zucker et al., 2008). Therefore, characterizing genetic and environmental processes in relation to impulsivity is critical to inform prevention and intervention efforts aimed at reducing alcohol problems.

G×E: The role of parenting and family environment

Bronfenbrenner's bioecological model (Bronfenbrenner & Morris, 2007) emphasizes the importance of the interactions between person-level characteristics (e.g., genetics) and social contexts in shaping human development. Family is one of the most important microsystems or immediate social environments that influences child development. Indeed, numerous studies have linked specific parenting behaviors, as well as the overall family environment, to child outcomes. For example, parenting behaviors such as parental monitoring and acceptance have been associated with lower levels of alcohol use among adolescents (Nash et al., 2005; Webb et al., 2002). Parental monitoring may lead parents to be more aware if their child begins engaging in or socializing with peers who engage in alcohol use (Branstetter & Furman, 2013; Soenens et al., 2006). Parents with greater knowledge of their child's lives may be more successful in influencing their adolescent's friend group and restricting access to alcohol (Bountress et al., 2017). Parental acceptance has been associated with less drinking, decreased stress, and fewer alcohol-related problems in adolescence (Nash et al., 2005). Similarly, parenting behaviors characterized by high warmth and acceptance have been linked to higher self-control and lower impulsivity among children and adolescents (Brody et al., 2005; Conway, 2020; Eisenberg et al., 2005). The emotional climate in the family environment, such as family conflict, has also been associated with alcohol use and related outcomes (Baer et al., 1987; Bray et al., 2001). Family conflict may contribute to both internalizing and externalizing problems among adolescents, which in turn can increase risk for problematic alcohol use (Chan et al., 2013; Timmons & Margolin, 2015). Previous studies and meta-analysis demonstrate that family conflict predicts lower self-control among adolescents (Willems et al., 2018, 2020), which has been linked to increased risk for alcohol misuse (Rømer Thomsen et al., 2018; Stautz & Cooper, 2013). These findings suggest that parenting behaviors, such as monitoring and acceptance, and family conflict may influence alcohol use and impulsivity among children and adolescents through multiple direct and indirect pathways.

Parenting and the family environment can also play an important role in moderating genetic influences. Different hypotheses regarding the role of social context in moderating genetic influences have been proposed by researchers (Shanahan & Hofer, 2005). The social context as compensation hypothesis of G×E posits that positive and enriched environments (e.g., parental acceptance) can prevent the expression of a genetic diathesis. Similarly, the social context as social control hypothesis of G×E proposes that environments that offer strong social control (e.g., parental monitoring) can suppress or attenuate genetic risk. Prior research using different genetically informed designs has provided evidence supporting these hypotheses. Twin studies and research using PRS approaches have been used to assess how parenting behaviors may moderate genetic risk for impulsivity and alcohol use. These studies found that high levels of parental monitoring attenuated genetic influences for alcohol-related problems (Cooke et al., 2015; Salvatore et al., 2015). The contextual triggering or diathesis-stress hypothesis of G×E posits that social context can act as a stressor that triggers or activates a genetic diathesis (Shanahan & Hofer, 2005). Accordingly, stressors in the family environment, such as family conflict, may exacerbate genetic risk of AUD. We note that research has yet to incorporate PRS to examine the role of family conflict in moderating genetic influences on alcohol use and related impulsive traits. Collectively, these studies demonstrate the potential role of both specific parenting behaviors (e.g., parental monitoring and acceptance) and the family environment (e.g., family conflict) in modifying genetic risk for alcohol use and related outcomes. Notably, prior research suggests that environmental factors, including parenting and family conflict, are in part influenced by genetic factors (i.e., gene-environment correlation or rGE; Elam et al., 2017; Kendler & Baker, 2007). Thus, it is important to account for rGE when examining G×E effects.

Studying G×E in diverse populations

The majority of genetically-informative research has been conducted with populations of European ancestry (EA) (Dick et al., 2017; Popejoy & Fullerton, 2016). The underrepresentation of racial/ethnic minority populations in genetic research is problematic, which may exacerbate existing health disparities among racial/

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ethnic minorities (Martin et al., 2019). Discoveries in genetic research are beginning to be used to inform personalized diagnosis and treatment for biomedical conditions (e.g., diabetes); yet precision medicine is primarily benefiting EAs (Grubb et al., 2019; Patel et al., 2016; Udler et al., 2019). Using genetically informed designs to understand pathways of risk for alcohol problems in diverse populations is critical to better understand and reduce racial/ethnic disparities in alcohol related outcomes and to ensure all of us equally benefit from health advances related to genetic discoveries. Racial/ethnic minorities, such as Black/African Americans (AA) and Hispanics/Latino (LA), on average consume less alcohol but experience similar or more negative social and health consequences related to alcohol use compared to EAs (Caetano et al., 2014; Chartier & Caetano, 2010; Mulia et al., 2009). In addition, there are differences in the environmental conditions and stressors experienced by racial/ethnic minorities compared to EAs, such as lower SES and experiences of racial discrimination (Wallace & Muroff, 2002; Williams et al., 2010), which may trigger alcohol use and exacerbate genetic risk. Moreover, cultural factors such as ethnic-racial identity (Walker et al., 2020) and cultural values (e.g., familism) also affect alcohol use (Shih et al., 2012; Zemore, 2007), and may attenuate genetic risk due to stronger social control. Finally, there are important differences in genetic diversity, allele frequencies, and linkage disequilibrium patterns across populations, implying potential differences in the effects of genetic factors on alcohol use and related phenotypes (Campbell & Tishkoff, 2008; Gelernter et al., 2014). Together, these differences in environmental, cultural, and genetic factors suggest that G×E processes related to alcohol use and related outcomes may vary across racial/ethnic groups, highlighting the importance of studying G×E among racially/ethnically diverse populations.

The present study

The goals of this study were two-fold. First, we examined the influence of genetic risk of AUD on childhood impulsivity, a robust early precursor and intermediate phenotype of alcohol use and AUD. Second, we examined the role of parenting behaviors (i.e., parental monitoring and acceptance) and family environment (i.e., family conflict) in moderating genetic risk in racially and ethnically diverse youth. Moving beyond the candidate-gene approach, which does not capture the fact that complex traits and behaviors like impulsivity and alcohol use are polygenic (i.e., influenced by many genes of small effect sizes; Plomin et al., 2009), we characterized individuals' genetic risk of AUD by using the PRS approach. This approach constructs weighted sums of risk allele counts of SNPs associated with a phenotype (i.e., AUD) based on published results from GWASs and captures the polygenic nature of complex behavioral outcomes (Bogdan et al., 2018). We hypothesized that higher AUD polygenic risk scores (AUD-PRS) would be associated with higher levels of impulsivity. We further hypothesized that parenting behaviors and family environment would moderate genetic influences, such that the association between AUD-PRS and impulsivity would be attenuated by high levels of parental monitoring and acceptance and exacerbated by high levels of family conflict.

Method

Sample

Data for the present study were drawn from the Adolescent Brain Cognitive Development (ABCD) Study (Volkow et al., 2018). The ABCD Study is an ongoing study aimed at understanding brain and behavioral development, which examines youth from ages 9–10 for approximately 10 years into young adulthood. Started in 2016, the ABCD study has completed recruitment for the baseline study sample ($N = 11,875$; youth = 9–10 years old at baseline; 47.8% female; 52.1% non-Hispanic White, 15.0% non-Hispanic Black, 20.3% Hispanic/Latino, 2.1% Asian, and 10.5% other [e.g., biracial]) that reflects the sociodemographic variation of the U.S. population (Karcher & Barch, 2021). A national, multi-stage probability sampling strategy was used to recruit eligible youth through schools across 21 sites in the U.S., with some participants (<10%) recruited via other means such as community events, non-targeted schools, and referral systems (Garavan et al., 2018). The ABCD study collects rich data on neurocognitive, biospecimen, behavioral, and environmental measures from participants, which is shared with the research community through annual data releases via the NIMH Data Archive. For the purpose of the present study, we used data from the baseline assessment included in the ABCD data release 3.0. We focused on youth who had genomic data available and were identified as non-Hispanic White ($n = 5,911$, 53% male), non-Hispanic Black/African American ($n = 1693$, 50% male), or Hispanic/Latino ($n = 2,118$, 53.4% male) by parent report, the largest three groups within the ABCD sample for which there are sufficient sample sizes for within-group analyses.

Measures

Impulsivity

Participants completed a 20-item youth short-version of the UPPS-P at baseline. This version was developed for the ABCD study and maintained the response format of the original child version (Zapolski et al., 2010) of the UPPS-P, which has been validated across populations (Magid & Colder, 2007; Smith et al., 2007). This measure included five subscales (four items each, responses ranged from 1 = *not at all like me* to 4 = *very much like me*): negative urgency (e.g., "when I am upset I often act without thinking"), positive urgency (e.g., "when I am in a great mood, I tend to do things that can cause me problems"), lack of perseverance (e.g., "I almost always finish projects that I start"), lack of premeditation/planning (e.g., "I tend to stop and think before doing things"), and sensation seeking (e.g., "I like new, thrilling things, even if they are a little scary"). Scores were coded and averaged across items within each subscale, such that higher scores indicate higher levels of impulsivity. Confirmatory factor analyses indicated that a one-factor latent factor model of the UPPS-P dimensions of impulsivity did not yield good model fit, with some dimensions having very small factor loadings (Supplemental Figure 1). Thus, the five UPPS-P dimensions of impulsivity were examined separately as outcome variables in subsequent analysis.

Parental monitoring

Participants completed the Parental Monitoring Scale which assessed parents' monitoring and knowledge of their children's whereabouts and who their children were spending time with (Gonzalez et al., 2021). The scale consists of a total of five items (e.g., "how often do your parents/guardians know where you are?" and "how often do your parents know who you are with when you are not at school and away from home?"). The participants were asked to indicate the extent to which they agreed with each item based on a scale ranging from 1 (*not at all)* to 5 (*very often)*.

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Total scores were calculated by averaging the individual's responses across all five items.

Parental acceptance

Participants were asked to complete a subscale of the Child Report of Behavior Inventory (CRPBI; Schaefer, 1965) that measured their perceptions of their caregiver's warmth, acceptance, and responsiveness (e.g., "my caregiver makes me feel better after talking over my worries with him/her" and "my caregiver smiles at me often"). The ABCD study's acceptance subscale utilizes five of the original scale's ten items with the highest factor loadings (Gonzalez et al., 2021). The participants were asked to respond to items related to the perceived acceptance levels of their two primary caregivers. The participants reported the extent to which they agreed with each item based on a scale ranging from 1 (*not at all*) to 3 (*very much*). A total parental acceptance score was calculated by averaging the scores on the five items across the two caregivers.

Family conflict

Participants completed nine items from the Family Conflict subscale of the Moos Family Environment Scale (FES), which assessed the amount of openly expressed conflict among family members (Moos & Moos, 1976). Participants were asked to indicate whether statements about conflict in the family were true or false in their home environment (e.g., "we fight a lot in our family" and "family members sometimes get so angry they throw things"). Items were scored either 1 or 0 (i.e., true or false) with appropriate reverse coding for certain items (e.g., "family members hardly ever lose their temper"). Raw scores were calculated by adding up all the individual items (with appropriate reverse coding). Prorated scores were calculated by multiplying the raw scores by the total number of items and dividing by the number of items completed by the participant. If a participant answered less than five items, their scores were not counted and coded as missing. Higher scores indicate more conflict within the family environment.

Genotyping and AUD genome-wide polygenic scores

Saliva samples were collected at the baseline visit and shipped from the collection site to Rutgers University Cell and DNA Repository (RUCDR) for genotyping. The Smokescreen Genotyping Array (Baurley et al., 2016) was used for genotyping. RUCDR performed DNA quality controls based on calling signals and variant call rates, and the quality-controlled (QCed) genotyping data contains 11,099 unique individuals with 516,598 genetic variants in the ABCD study. Imputation was performed via the TOPMed imputation server using mixed ancestry and Engle v2.4 phasing. SNPs with a genotyping rate <0.95 or that violated Hardy–Weinberg equilibrium ($p < 10^{-6}$) or with minor allele frequency <0.01 were excluded from analysis.

The predictive power and accuracy of PRS depends largely on the sample size and statistical power of the discovery GWAS (Dudbridge, 2013) and the genetic ancestral similarities between the discovery and target samples (Duncan et al., 2019; Martin et al., 2019). Thus, we used results from GWAS of AUD with the Million Veteran Program (MVP) sample (Kranzler et al., 2019), the largest published GWAS of alcohol phenotypes with a multi-ancestry sample, to calculate AUD-PRS in the ABCD sample. The MVP sample includes 209,020 individuals of European Ancestry (EA), 57,340 of African Ancestry (AA), 14,425 of Latinos/Latin Ancestry (LA), 1410 of East Asian Ancestry, and 196 of South Asian Ancestry. GWAS was conducted separately in each group and then meta-analyzed using a sample-size-weighted scheme; PRS derived from this GWAS study were associated with alcohol-related disorders in two independent samples of European and African ancestry (Kranzler et al., 2019). We used the EA GWAS results to calculate AUD-PRS for non-Hispanic Whites in the ABCD sample, using the PRS-CS method, a Bayesian regression and continuous shrinkage prior method shown to improve predictive power above traditional methods of PRS construction (Ge et al., 2019). An extension of this method (PRS-CSx) has recently been developed to improve polygenic prediction in non-EA populations by integrating GWAS summary statistics from multiple populations and leveraging linkage disequilibrium diversity across discovery samples (Ruan et al., 2021). We used PRS-CSx to calculate AUD-PRS for the non-Hispanic Black/African American and Hispanic/Latino subsamples in our study. Specifically, summary statistics from the MVP EA and AA GWAS were used to calculate AUD-PRS for Black/African Americans, and summary statistics from the MVP EA and LA GWAS were used to calculate AUD-PRS for Hispanic/Latinos. AUD-PRS were standardized to aid in interpretation of results.

Covariates

We included participants' age and sex as control variables given prior evidence that impulsivity, parenting, and family factors may differ between males and females and across age (Cross et al., 2011; Webb et al., 2002). Because socioeconomic status is associated with impulsivity, parenting, and family environment (Assari et al., 2018; Farley & Kim-Spoon, 2017), we also included parental education and family income as covariates. Parents answered the question "What is the highest grade or level of school you have completed or the highest degree you have received?". Response options ranged from 1 (*never attended school or Kindergarten only)* to 21 (*doctoral degree*). For those who indicated that they had a partner, they also answered the same question about their partner's education. Scores across the two questions were averaged, and higher scores indicate higher levels of parental education. Parents also reported their total combined family income for the past 12 months, with responses ranging from 1 = less than $5,000 to 10 = $200,000 or greater. Finally, we also included the first ten genetic ancestry principal components (PC1-PC10) as covariates to account for potential population stratification in genetic analyses (Hellwege et al., 2018).

Analytic strategy

We first conducted preliminary analyses to examine descriptive statistics and correlations between study variables using SPSS 25.0. All analyses were conducted separately for White, Black/African American, and Hispanic/Latino youth. To test our hypotheses, we conducted a series of hierarchical linear regression analyses using *Mplus* version 8.3. We included participants' age, sex, parental education, family income, and PC1-PC3 as covariates in all analyses. We first examined the main effects of AUD-PRS on impulsivity (Step 1). UPPS-P dimensions of impulsivity (i.e., negative urgency, sensation seeking, lack of premeditation, lack of perseverance, and positive urgency) were examined as separate outcome variables in parallel analyses. Next, we added parental monitoring, parental acceptance, and family conflict as additional predictors to the regression model to examine main effects of parenting and family conflict (Step 2). To examine interaction effects between AUD-PRS and family environmental factors, we created product terms of AUD-PRS and mean-centered parental monitoring, parental acceptance, and family conflict and added them as additional predictors to the regression model (Step 3).

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We also examined potential rGE by testing correlations between AUD-PRS and parenting and family conflict. Significant rGE were accounted for in our models testing G×E effects, by specifying AUD-PRS and parenting/family conflict to be correlated using the "WITH" command in Mplus. Missing data were accounted for using the full information maximum likelihood estimation method. Complex sampling (e.g., sibling and twin pairs) and recruitment procedures (e.g., across different study sites) for the ABCD Study were accounted for using cluster correction (Cluster = family ID) and stratification sampling (Stratification = study site) procedures in Mplus. In order to account for multiple testing (five impulsivity outcomes), we used a Bonferroni-corrected p value ($p < .01$) to evaluate statistical significance of coefficients in each of our analytic subsamples.

Results

Preliminary analysis

Descriptive statistics and correlations between variables are presented in Table 1. AUD-PRS was not significantly correlated with impulsivity, parenting, and family conflict among White, Black/African American, and Hispanic/Latino youth. Across racial/ethnic groups, there were significant negative correlations between parental monitoring/acceptance and dimensions of impulsivity, except that parental acceptance was positively correlated with sensation seeking for White and Hispanic/Latino youth; family conflict was positively correlated with dimensions of impulsivity, with the correlation coefficients varying to some extent across different dimensions of impulsivity.

Predicting childhood impulsivity from AUD-PRS, parenting, and family conflict

White youth

Results from hierarchical multiple regression models predicting impulsivity among White youth are presented in Table 2. Contrary to our hypothesis, there was no significant main effect of AUD-PRS on any of the UPPS-P impulsivity dimensions (Step 1). Consistent with expectation, higher parental monitoring was significantly associated with lower levels of impulsivity across all UPPS-P dimensions above and beyond the effects of age, sex, parental education, and family income, except that it was not associated with sensation seeking. Higher parental acceptance was associated higher sensation seeking, lower lack of premeditation, and lower lack of perseverance, but was not significantly associated with positive and negative urgency. Higher family conflict was associated with higher levels of impulsivity across all UPPS-P dimensions, except for sensation seeking (Step 2). There were two nominally significant interaction effects: the interaction between AUD-PRS and parental acceptance in relation to negative urgency ($\beta = .04$, $p = .02$), and the interaction between AUD-PRS and family conflict in relation to positive urgency ($\beta = .03$, $p = .04$) (Step 3). We conducted post hoc follow-up analysis to further evaluate these two interaction effects, by including AUD-PRS by covariate (age, sex, parental education, family income, PC1-PC10) and family factor (parental acceptance or family conflict) by covariate interaction terms in the regression model to further account for potential confounding effects (Keller, 2014; see Supplemental Tables 1 and 2). Neither of these interaction effects were statistically significant at $p < .01$ in the robustness analysis. Thus, we did not further probe or discuss these interaction effects.

Black/African American youth

Results from hierarchical multiple regression models predicting impulsivity among Black/African American youth are presented in Table 3. Consistent with findings for White youth, there was no significant main effect of AUD-PRS on impulsivity (Step 1). The patterns of associations between parental monitoring, parental acceptance, family conflict, and impulsivity dimensions were largely the same as those observed for White youth, except for the associations with sensation seeking. Specifically, higher parental monitoring was associated with lower levels of impulsivity across all UPPS-P dimensions above and beyond the effects of covariates, except for sensation seeking. Higher parental acceptance was associated with lower lack of premeditation and lower lack of perseverance, but was not significantly associated with negative urgency, sensation seeking, and positive urgency. Family conflict was associated with higher levels of impulsivity across all UPPS-P dimensions (Step 2). Finally, there was suggestive evidence of interaction between AUD-PRS and family conflict in relation to positive urgency ($B = .024$, $SE = .011$, 95% CI = [.006, .042], $\beta = .059$, $p = .032$) (Step 3). Follow-up analysis indicated that this interaction effect became statistically significant in follow up analysis where AUD-PRS by covariate (age, sex, parental education, family income, PC1-PC10) and family conflict by covariate interaction terms were included in the regression model ($B = .026$, $SE = .010$, 95% CI = [.010, .042], $\beta = .065$, $p = .007$, see Supplemental Table 1), suggesting robustness of the interaction effect. As illustrated in Figure 1, simple slope analysis indicated that AUD-PRS was significantly associated with higher positive urgency when family conflict was high (+1 SD; $B = .07$, 95% CI = [.03, .11], $\beta = .08$, $p = .005$) but not when family conflict was low (−1 SD; $B = -.03$, 95% CI = [−.08, .01], $\beta = -.04$, $p = .283$). We note that the follow-up analysis was post hoc and should be considered preliminary and interpreted with caution.

Hispanic/Latino youth

Results from hierarchical multiple regression models predicting impulsivity among Hispanic/Latino youth are presented in Table 4. Consistent with findings for White and Black/African American youth, there were no significant main effects of AUD-PRS on dimensions of impulsivity (Step 1). The patterns of associations between parental monitoring, parental acceptance, family conflict, and impulsivity dimensions were largely the same as those observed for White youth (see above), except that the association between family conflict and lack of perseverance was not statistically significant after adjusting for multiple testing ($p = .04$) for Hispanic/Latino youth. There were no significant interactions between AUD-PRS and parental monitoring, parental acceptance, and family conflict in relation to dimensions of impulsivity (Step 3).

Discussion

In this study, we examined the independent and interactive effects of genetic risk for AUD, indexed by AUD-PRS, parenting behaviors (i.e., parental monitoring and acceptance), and family environment (i.e., family conflict) on childhood impulsivity among White, Black/African American, and Hispanic/Latino youth in the ABCD study. We found that AUD-PRS was not significantly associated with childhood impulsivity as measured by the UPPS-P scale across racial/ethnic groups. In general, parental monitoring and acceptance were associated with lower levels of impulsivity, whereas family conflict was associated with higher

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Table 1. Descriptive statistics and bivariate correlations among key study variables

White Youth	1	2	3	4	5	6	7	8	9	10	11	12	13
1.Age[a]	–												
2.Sex[b]	.03	–											
3.Parental education	−.01	−.02	–										
4.Family income	.03	−.02	**.51**	–									
5.AUD-PRS	−.01	−.01	−.00	**.04**	–								
6.Parental monitoring	**.11**	**−.18**	**.10**	**.14**	.01	–							
7.Parental acceptance	.03	**−.06**	**.08**	**.09**	.02	**.38**	–						
8.Family conflict	**−.05**	**.06**	**−.11**	**−.13**	−.01	**−.26**	**−.34**	–					
9.Negative urgency	−.02	**.08**	−.03	**−.04**	−.01	**−.16**	**−.14**	**.26**	–				
10.Sensation seeking	**.04**	**.12**	**.06**	**.04**	.01	.02	**.04**	.00	**.12**	–			
11.Lack of premeditation	.00	**.13**	.00	−.02	−.00	**−.24**	**−.27**	**.21**	**.19**	**.10**	–		
12.Lack of perseverance	**−.06**	**.07**	**−.07**	**−.12**	−.02	**−.28**	**−.25**	**.19**	**.17**	**−.07**	**.43**	–	
13.Positive urgency	**−.05**	**.08**	**−.13**	**−.10**	−.01	**−.18**	**−.13**	**.23**	**.47**	**.17**	**.24**	**.22**	–
N	5911	5911	5910	5630	5911	5906	5902	5903	5905	5905	5905	5905	5905
Mean	119.13	.53	17.38	8.17	0	4.42	2.74	1.95	2.10	2.49	1.97	1.76	1.92
SD	7.49	–	1.9	1.68	1.00	.47	.29	1.96	.64	.65	.58	.55	.70
α	–	–	–	–	–	.44	.80	.69	.65	.51	.76	.73	.79
Black/African American Youth	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1.Age[a]	–												
2.Sex[b]	.02	–											
3.Parental education	.05	.02	–										
4.Family income	.04	−.01	**.58**	–									
5.AUD-PRS	.01	.02	.01	−.01	–								
6.Parental monitoring	.06	**−.16**	−.01	−.01	−.04	–							
7.Parental acceptance	−.04	**−.06**	−.04	−.03	−.01	**.37**	–						
8.Family conflict	**−.07**	**.08**	**−.09**	**−.09**	.01	**−.20**	**−.23**	–					
9.Negative urgency	−.01	**.08**	−.05	−.05	−.02	**−.11**	**−.08**	**.20**	–				
10.Sensation seeking	−.01	**.14**	.00	.00	.01	.01	.02	.06	**.21**	–			
11.Lack of premeditation	.04	**.15**	.05	.05	−.04	**−.25**	**−.28**	**.23**	**.13**	−.03	–		
12.Lack of perseverance	.04	.05	.01	.04	−02	**−.21**	**−.25**	**.16**	**.08**	**−.15**	**.53**	–	
13.Positive urgency	−.02	.06	**−.07**	**−.09**	.02	**−.12**	−.06	**.24**	**.48**	**.27**	**.21**	**.10**	–
N	1693	1692	1688	1436	1693	1691	1692	1692	1690	1689	1690	1689	1689
Mean	118.87	.50	14.96	5.00	0	4.31	2.74	2.46	2.20	2.39	1.87	1.74	2.18
SD	7.26	–	2.37	2.64	1.00	.59	.30	2.03	.71	.71	.65	.58	.80
α	–	–	–	–	–	.49	.77	.65	.59	.45	.69	.62	.73
Hispanic/Latino Youth	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1.Age[a]	–												
2.Sex[b]	.01	–											
3.Parental education	−.02	.01	–										
4.Family income	.03	−.00	**.55**	–									
5.AUD-PRS	−.01	.01	.05	.01	–								
6.Parental monitoring	**.09**	**−.20**	**.10**	**.10**	−.02	–							
7.Parental acceptance	.04	−.06	.05	.03	.00	**.38**	–						
8.Family conflict	−.05	.05	**−.08**	**−.09**	−.04	**−.22**	**−.29**	–					
9.Negative urgency	−.04	**.07**	−.01	.02	−.02	**−.15**	**−.12**	**.23**	–				

(*Continued*)

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Table 1. (*Continued*)

Hispanic/Latino Youth	1	2	3	4	5	6	7	8	9	10	11	12	13
10.Sensation seeking	.02	**.11**	**.07**	**.06**	.03	−.00	**.06**	.03	**.13**	–			
11.Lack of premeditation	−.04	**.10**	.05	.04	.01	**−.29**	**−.28**	**.20**	**.15**	.02	–		
12.Lack of perseverance	−.04	**.07**	−.02	.03	.01	**−.25**	**−.27**	**.14**	**.12**	**−.12**	**.46**	–	
13.Positive urgency	−.05	**.06**	−.06	−.02	−.01	**−.18**	**−.12**	**.21**	**.52**	**.23**	**.18**	**.13**	–
N	2118	2117	2114	1866	2118	2113	2110	2113	2112	2112	2112	2112	2112
Mean	118.55	.53	14.83	6.28	0	4.36	2.74	2.02	2.10	2.39	1.90	1.77	2.03
SD	7.54	–	3.21	2.40	1.00	.54	.29	1.88	.68	.68	.60	.59	.77
α	–	–	–	–	–	.46	.78	.65	.61	.48	.70	.69	.77

Note. AUD-PRS = alcohol use disorder genome-wide polygenic score. Coefficients with $p < .01$ were bolded. α = Cronbach's alpha. [a]age was coded in months. [b]sex was coded 1 = male, 0 = female.

Table 2. Predicting childhood impulsivity from alcohol use disorder polygenic scores, parenting, and family conflict among White/European American youth

	Negative urgency			Sensation seeking			Lack of premeditation			Lack of perseverance			Positive urgency		
	β	CI	*p*	*β*	CI	*p*	*β*	CI	*p*	*β*	CI	*p*	*β*	CI	*p*
Step 1															
Age	−0.02	−.04, .02	.19	**0.04**	**.01, .06**	**.00**	−0.00	−.00, .00	.96	**−0.06**	**−.09, −.03**	**<.001**	**−0.06**	**−.08, −.03**	**<.001**
Sex	**0.08**	**.05, .10**	**<.001**	**0.12**	**.10, .15**	**<.001**	**0.13**	**.12, .18**	**<.001**	**0.07**	**.04, .10**	**<.001**	**0.08**	**.06, .11**	**<.001**
Par Edu	−0.02	−.05, .02	.36	**0.06**	**.02, .09**	**.00**	0.02	−.00, .02	.25	−0.01	−.04, .02	.59	**−0.10**	**−.14, −.07**	**<.001**
Fam income	−0.03	−.07, .00	.08	0.02	−.02, .05	.31	−0.03	−.02, .00	.08	**−0.12**	**−.15, −.08**	**<.001**	**−0.05**	**−.09, −.02**	**.00**
PC1	0.01	−.01, .03	.40	−0.01	−.04, .02	.66	0.02	.00, .03	.02	0.02	.00, .06	.04	−0.01	−.03, .02	.64
PC2	−0.00	−.04, .04	.86	0.00	−.05, .05	.95	−0.01	−.03, .01	.53	−0.04	−.08, .01	.11	−0.00	−.04, .04	.87
PC3	−0.02	−.06, .03	.22	0.02	−.02, .05	.37	−0.01	−.03, .02	.62	−0.04	−.07, −.00	.04	0.03	−.02, .07	.27
PC4	−0.04	−.08, −.00	.03	0.02	−.03, .07	.42	−0.05	−.04, −.00	.02	−0.05	−.10, −.01	.02	−0.00	−.05, .04	.88
PC5	−0.01	−.05, .04	.76	−0.03	−.07, .02	.22	−0.00	−.03, .02	.86	−0.00	−.04, .04	.94	0.04	−.01, .08	.11
PC6	0.01	−.02, .04	.50	0.01	−.02, .03	.74	−0.02	−.03, .01	.21	−0.01	−.04, .02	.43	0.02	−.01, .05	.13
PC7	0.01	−.02, .04	.41	−0.01	−.04, .03	.74	−0.02	−.03, .01	.21	−0.02	−.05, .01	.21	0.01	−.02, .04	.42
PC8	0.02	−.01, .04	.29	0.01	−.02, .04	.48	−0.01	−.02, .01	.64	−0.02	−.04,.01	.31	0.01	−.02, .04	.45
PC9	−0.02	−.06, .02	.37	0.02	−.03, .06	.50	−0.03	−.04, .01	.12	−0.02	−.06, .03	.42	0.02	−.02, .06	.29
PC10	0.02	−.01, .05	.20	−0.01	−.03, .02	.59	−0.00	−.02, .01	.75	−0.01	−.03, .02	.68	0.01	−.02, .04	.48
AUD-PRS	−0.01	−.03, .02	.68	0.01	−.02, .03	.69	0.00	−.01, .02	.83	−0.01	−.04,.02	.41	−0.01	−.03, .02	.55
Step 2															
Par monitor	**−0.08**	**−.11, −.05**	**<.001**	0.02	−.01, .05	.29	**−0.14**	**−.17, −.11**	**<.001**	**−0.19**	**−.22, −.16**	**<.001**	**−0.10**	**−.13, −.07**	**<.001**
Par accept	−0.03	−.06, −.00	.04	**0.04**	**.02, .07**	**.00**	**−0.17**	**−.20, −.14**	**<.001**	**−0.14**	**−.17, −.11**	**<.001**	−0.01	−.04, .02	.42
Fam conflict	**0.23**	**.20, .26**	**<.001**	0.02	−.01, .05	.10	**0.11**	**.09, .14**	**<.001**	**0.08**	**.05, .11**	**<.001**	**0.19**	**.16, .22**	**<.001**
Step 3															
AUD-PRS × monitor	−0.01	−.03, .02	.55	−0.01	−.03, .01	.27	−0.01	−.03, .02	.57	0.01	−.02, .04	.52	−0.01	−.04, .02	.46
AUD-PRS × accept	0.04	.01, .07	.02	0.01	−.02, .05	.51	−0.00	−.03, .02	.82	0.01	−.01, .04	.34	0.02	−.02, .05	.29
AUD-PRS × conflict	0.01	−.02, .05	.36	−0.02	−.04, .00	.09	0.02	−.01, .04	.31	0.02	−.02, .07	.28	.03	.00, .06	.04

Note. AUD-PRS = alcohol use disorder genome-wide polygenic score; Par Edu = parental education; Fam income = family income; PC = genetic ancestry principal components; Par monitor = parental monitoring; Par accept = parental acceptance; Fam conflict = family conflict. Sex was coded 1 = male, 0 = female. CI = 95% confidence intervals. Bolded coefficients $p < .01$.

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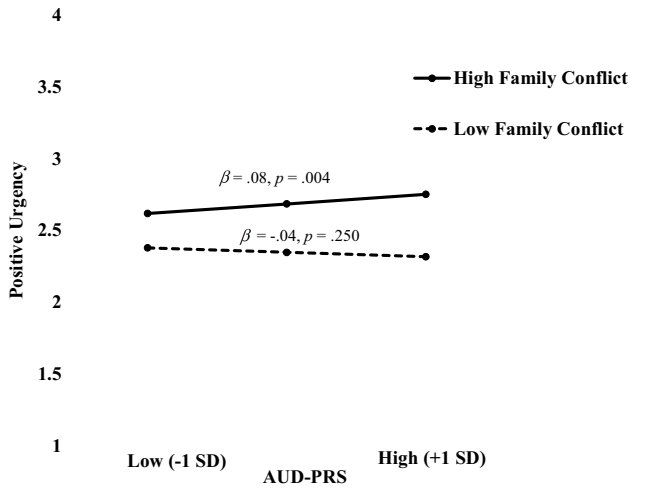

Figure 1. AUD-PRS by family conflict in relation positive urgency among Black/African American youth. Predicted values of positive urgency are plotted at prototypical values (+1/−1 *SD*) of AUD-PRS and family conflict.

levels of impulsivity, with associations varied to some extent across dimensions of impulsivity. In addition, findings suggest that family conflict may exacerbate the effect of genetic risk for AUD on childhood impulsivity (i.e., positive urgency), particularly among Black/African American youth.

It is well-known that genetics play an important role in AUD (Verhulst et al., 2015). Little is known about how genetic risk of AUD manifests early in development (e.g., childhood), because genetic studies of AUD have primarily focused on adolescents and adults (Dick et al., 2018). GWAS studies indicated that alcohol phenotypes have a polygenic architecture that overlaps with substance use and other psychiatric traits (Kranzler et al., 2019; Liu et al., 2019; Walters et al., 2018). Research using PRS to characterize genetic risk for alcohol and related phenotypes has shown that alcohol PRS predicts alcohol outcomes, impulsivity, externalizing behaviors, and related traits (Barr et al., 2020; Ksinan et al., 2019). However, most GWAS and PRS studies focused on adult samples, and limited research has examined whether and how PRS derived from adult-based GWAS predicts childhood traits. The present study filled this gap in the literature by examining the role of AUD-PRS in predicting childhood impulsivity. Contrary to our hypotheses, there was no significant main effect of AUD-PRS on various aspects of childhood impulsivity. This non-significant finding may suggest developmental changes in genetic influences. That is, genetic factors that influence behaviors and traits (e.g., AUD) in adulthood may be distinct from genetic factors that contribute to behaviors and traits earlier in development (Dick, 2011; Elam et al., 2021). However, there is some evidence suggesting that PRS for adult alcohol dependence and related traits are associated with childhood psychopathology (Akingbuwa et al., 2020; Jansen et al., 2021). For example, higher PRS for adult alcohol dependence predicted higher risk of case (versus control) status in a child and adolescent psychiatric sample with a variety of psychiatric disorders (Jansen et al., 2021). Thus, while AUD-PRS did not predict childhood impulsivity as measured in the present study, it is possible that it predicts other childhood traits. Future studies need to expand the present study to examine other childhood precursors of AUD, such as externalizing behaviors and other aspects of temperament (e.g., negative emotionality). Alternatively, the null finding could be due to low predictive power of the AUD-PRS. We attempted to maximize the predictive power of AUD-PRS in the present study by using estimates from the largest multi-ancestry GWAS and applying state of the science approaches (PRS-CS and PRS-CSx). However, we note that the MVP sample was of smaller sample size compared to other large GWAS of alcohol phenotypes (Liu et al., 2019), and thus may be underpowered. In addition, it is also possible that AUD-PRS derived from GWAS with veterans may not generalize to the broader population and to early adolescence.

Numerous studies have documented the role of parenting behaviors, such as parental monitoring and acceptance in influencing adolescent alcohol use outcomes (Ryan et al., 2010; Yap et al., 2017). We built on the literature to examine associations between these parenting behaviors and childhood impulsivity. Consistent with our hypotheses, higher parental monitoring and acceptance were associated with lower levels of impulsivity across various UPPS-P dimensions, with similar patterns of associations observed across racial/ethnic groups. These findings demonstrate that parental knowledge of adolescent's activities and supportive behaviors may be important pathways through which caregivers can improve the cognitive and socioemotional regulatory skills of their children. Somewhat unexpectedly, we found that higher parental acceptance was associated with higher sensation seeking among White and Hispanic/Latino youth. Sensation seeking in childhood may primarily involve seeking fun and new experiences that are not necessarily risky. It is possible that high parental acceptance offers a strong secure base for children to explore and seek out new experiences. Nevertheless, we consider this finding preliminary and future efforts to replicate this finding are warranted. Despite these main effects of parenting behaviors on impulsivity, we did not find any significant interaction effects between AUD-PRS and parenting behaviors in relation to dimensions of impulsivity. This is contradictory to our hypotheses, as well as prior evidence that parenting behaviors moderate genetic influence on alcohol use and related behaviors in adolescence and adulthood (Cooke et al., 2015; Salvatore et al., 2015; Su et al., 2019). It is possible that parenting behaviors play a stronger role in modifying genetic influences on behavioral outcomes later in development compared to temperamental traits in childhood. Alternatively, these findings could suggest that parenting behaviors are important influences on childhood impulsivity regardless of genetic predispositions. It is also possible that the present study was not well-powered to detect significant interactions between AUD-PRS and parenting behaviors, in part due to the limited predictability of AUD-PRS.

In addition to specific parenting behaviors, our findings indicated that the emotional climate in the family environment (i.e., family conflict) also plays an important role in relation to childhood impulsivity. Higher levels of family conflict were associated with higher levels of impulsivity across various UPPS-P dimensions and across racial/ethnic groups. These findings are consistent with prior research showing that family conflict was associated with lower self-control and higher impulsivity in children and adolescents (Wang et al., 2020; Willems et al., 2018, 2020). Furthermore, consistent with our hypothesis, we found suggestive evidence of interaction effect between AUD-PRS and family conflict in relation to one dimension of childhood impulsivity. Specifically, AUD-PRS was associated with higher positive urgency when family conflict was high but not when family conflict was low among Black/African American youth. This finding is consistent with the contextual triggering or diathesis-stress hypothesis of G×E (Shanahan & Hofer, 2005), which posits that contextual

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Table 3. Predicting childhood impulsivity from alcohol use disorder polygenic scores, parenting, and family conflict among Black/African American youth

	Negative urgency			Sensation seeking			Lack of premeditation			Lack of perseverance			Positive urgency		
	β	CI	*p*	*β*	CI	*p*	*β*	CI	*p*	*β*	CI	*p*	*β*	CI	*p*
Step 1															
Age	−0.01	−.05, .04	.74	−0.01	−.06, .03	.61	0.03	−.02, .08	.22	0.04	−.01, .09	.11	−0.02	−.01, .03	.46
Sex	**0.08**	**.03, .13**	**.00**	**0.13**	**.09, .18**	**<.001**	**0.14**	**.10, .19**	**<.001**	0.05	−.00, .09	.06	0.06	.01, .17	.02
Par Edu	−0.04	−.10, .02	.20	−0.00	−.06, .06	.97	0.03	−.03, .09	.36	−0.01	−.07, .05	.84	−0.02	−.03, .01	.49
Fam income	−0.02	−.09, .04	.49	0.00	−.06, .07	.98	0.02	−.04, .09	.52	0.03	−.03, .10	.35	−0.08	−.04, −.00	.02
PC1	0.00	−.13, .13	.99	0.08	−.04, .18	.18	0.11	−.03, .25	.13	0.04	−.06, .14	.43	−0.02	−.11, .08	.77
PC2	−0.01	−.12, .11	.91	−0.09	−.20, .01	.07	−0.01	−.15, .12	.83	0.02	−.08, .12	.66	−0.03	−.11, .06	.62
PC3	0.02	−.09, .13	.69	0.00	−.09, .09	.99	0.03	−.10, .11	.95	0.03	−.05, .12	.45	−0.04	−.11, .06	.50
PC4	0.04	−.03, .10	.25	−0.02	−.09, .05	.55	0.02	−.05, .08	.66	0.00	−.06, .06	.98	0.01	−.06, .07	.91
PC5	−0.04	−.13, .06	.41	−0.04	−.14, .06	.46	−0.02	−.11, .07	.63	0.02	−.08, .13	.65	−0.04	−.11, .04	.34
PC6	0.02	−.04, .07	.59	0.01	−.04, .07	.64	0.04	−.01, .09	.08	0.05	−.00, .10	.07	0.02	−.03, .06	.48
PC7	0.04	−.02, .10	.21	0.02	−.04, .08	.55	−0.03	−.09, .03	.30	−0.01	−.07, .04	.61	0.02	−.03, .06	.43
PC8	0.00	−.07, .08	.93	0.02	−.04, .09	.47	0.00	−.07, .07	.99	0.03	−.04, .10	.44	0.00	−.06, .06	.93
PC9	0.03	−.04, .10	.44	0.06	−.02, .14	.16	.0.00	−.07, .07	.99	−0.06	−.13, .02	.14	0.02	−.04, .08	.56
PC10	0.01	−.04, .06	.63	0.01	−.04, .06	.59	0.03	−.02, .08	.23	0.03	−.02, .08	.24	0.00	−.04, .04	.86
AUD-PRS	−0.02	−.07, .03	.37	0.01	−.04, .06	.62	−0.03	−.08, .02	.20	−0.02	−.06, .03	.41	0.02	−.02, .05	.38
Step 2															
Par monitor	−0.06	−.11, −.01	.03	0.02	−.03, .08	.36	**−0.14**	**−.20, −.09**	**<.001**	**−0.12**	**−.18, −.07**	**<.001**	**−0.08**	**−.13, −.03**	**.00**
Par accept	−0.01	−.06, .04	.65	0.04	−.01, .09	.14	**−0.18**	**−.22, −.12**	**<.001**	**−0.17**	**−.23, −.11**	**<.001**	0.02	−.03, .07	.45
Fam conflict	**0.18**	**.13, .23**	**<.001**	**0.06**	**.01, .11**	**.01**	**0.16**	**.12, .21**	**<.001**	**0.11**	**.06, .16**	**<.001**	**0.23**	**.18, .28**	**<.001**
Step 3															
AUD-PRS × monitor	−0.02	−.07, .04	.51	0.02	−.03, .08	.36	−0.02	−.08, .04	.55	0.02	−.04, .07	.52	0.03	−.03, .08	.35
AUD-PRS × accept	−0.03	−.08, .03	.32	0.00	−.05, .06	.88	0.01	−.05, .07	.80	−0.02	−.08, .05	.65	0.01	−.04, .06	.75
AUD-PRS × conflict	0.02	−.03, .08	.39	0.01	−.04, .06	.60	−0.01	−.06, .04	.62	0.00	−.05, .05	.89	0.06	.01, .11	.03

Note. AUD-PRS = alcohol use disorder genome-wide polygenic score; Par Edu = parental education; Fam income = family income; PC = genetic ancestry principal components; Par monitor = parental monitoring; Par accept = parental acceptance; Fam conflict = family conflict. Sex was coded 1 = male, 0 = female. CI = 95% confidence intervals. Bolded coefficients $p < .01$.

stressors can exacerbate genetic influences by triggering or activating a genetic diathesis. Our findings extend the literature by showing the role of family conflict in exacerbating polygenic risk of AUD in relation to a childhood precursor of alcohol use. Collectively, these findings highlight the importance of reducing and managing conflict in the family environment in order to lower impulsivity and promote well-being among children. Although AUD-PRS was not correlated with parenting and family conflict in the present study, prior research suggests that there are significant genetic influences on environmental factors, including parenting and family conflict (Kendler & Baker, 2007). Thus, efforts aimed at reducing family conflict and promoting positive family environment may be more effective by also considering child and parent genetic factors.

It is interesting that we only found suggestive evidence of G×E effects for positive urgency, but not other dimensions of impulsivity. This may suggest that positive urgency is a salient aspect of impulsivity in childhood where genetic risk of AUD manifests. Indeed, prior research suggests that positive urgency had the greatest representativeness of children's impulsivity compared to other UPPS-P dimensions (Wang et al., 2020). In our sample, positive urgency also had the highest factor loading among all UPPS-P dimensions on a latent factor of impulsivity (see Supplemental Figure 1). These findings further highlight the importance of examining impulsivity as a multidimensional construct related to alcohol use and AUD (Dick et al., 2010). We note that the interaction effect between AUD-PRS and family conflict in relation to positive urgency among Black/African American youth was the only significant interaction effect found among a total of 45 tests (five impulsivity dimensions, three parenting/family factors, and three subsamples). Thus, it is possible that this was a false positive, and we consider this finding preliminary. Future research is needed to replicate our findings of G×E effects.

There are several notable strengths of this study, including the use of a PRS approach to examine G×E, examination of multiple familial contextual factors (i.e., both specific parenting behaviors

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Table 4. Predicting childhood impulsivity from alcohol use disorder polygenic scores, parenting, and family conflict among Hispanic/Latino youth

	Negative urgency			Sensation seeking			Lack of premeditation			Lack of perseverance			Positive urgency		
	β	CI	*p*	*β*	CI	*p*	*β*	CI	*p*	*β*	CI	*p*	*β*	CI	*p*
Step 1															
Age	−0.04	−.08, .00	.05	0.02	−.02, .06	.37	−0.03	−.08, .01	.12	−0.04	−.08, .01	.09	−0.05	−.09, −.00	.03
Sex	**0.07**	**.03, .11**	**.00**	**0.12**	**.08, .16**	**<.001**	**0.10**	**.06, .15**	**<.001**	**0.07**	**.03, .12**	**.00**	**0.06**	**.02, .11**	**.00**
Par Edu	−0.01	−.07, .05	.66	0.01	−.05, .07	.79	0.02	−.04, .08	.47	−0.07	−.13, −.01	.03	−0.07	−.12, −.01	.02
Fam income	0.05	−.01, .10	.09	0.03	−.03, .09	.33	0.01	−.05, .07	.65	0.06	−.00, .11	.06	0.02	−.04, .07	.59
PC1	0.07	−.01, .15	.07	0.02	−.05, .10	.53	0.05	−.03, .12	.25	0.02	−.05, .10	.57	−0.01	−.09, .06	.75
PC2	−0.05	−.14, .04	.28	**0.14**	**.06, .22**	**.00**	−0.04	−.12, .04	.35	−0.05	−.14, .04	.29	0.04	−.06, .13	.42
PC3	0.00	−.14, .14	.99	0.14	.02, .26	.03	0.03	−.11, .17	.68	−0.06	−.17, .06	.33	0.00	−.12, .12	.99
PC4	−0.03	−.20, .13	.68	0.12	−.03, .27	.11	−0.08	−.23, .08	.33	−0.17	−.32, −.02	.03	0.00	−.16, .16	.98
PC5	0.07	−.01, .15	.08	0.02	−.05, .10	.52	0.03	−.05, .11	.40	**0.10**	**.02, .18**	**.01**	0.08	.00, .16	.04
PC6	**−0.08**	**−.13, −.03**	**.00**	−0.04	−.09, .01	.11	−0.01	−.06, .04	.60	−0.03	−.09, .02	.22	−0.04	−.09, .01	.14
PC7	0.01	−.04, .05	.79	−0.02	−.06, .03	.51	0.00	−.04, .04	.99	−0.01	−.05, .04	.75	−0.01	−.06, .03	.53
PC8	−0.01	−.06, .04	.72	−0.01	−.06, .04	.62	−0.01	−.06, .03	.66	0.01	−.05, .06	.76	−0.01	−.06, .05	.84
PC9	**−0.11**	**−.19, −.03**	**.01**	−0.01	−.09, .07	.79	−0.02	−.10, .05	.65	−0.09	−.17, −.01	.03	−0.08	−.16, .00	.05
PC10	−0.01	−.05, .04	.72	−0.03	−.07, .01	.10	0.02	−.03, .05	.50	0.00	−.05, .05	.96	−0.02	−.06, .03	.52
AUD-PRS	−0.02	−.06, .03	.43	0.03	−.02, .07	.23	−0.00	−.05, .03	.86	0.01	−.04, .05	.69	−0.01	−.05, .04	.77
Step 2															
Par monitor	**−0.09**	**−.13, −.04**	**<.001**	−0.01	−.06, .04	.59	**−0.21**	**−.26, −.17**	**<.001**	**−0.17**	**−.21, −.12**	**<.001**	**−0.13**	**−.18, −.08**	**<.001**
Par accept	−0.02	−.07, .03	.37	**0.08**	**.04, .13**	**<.001**	**−0.17**	**−.22, −.12**	**<.001**	**−0.19**	**−.24, −.14**	**<.001**	−0.02	−.06, .03	.50
Fam conflict	**0.20**	**.16, .25**	**<.001**	0.05	.01, .09	.02	**0.11**	**.06, .16**	**<.001**	0.05	.00, .09	.04	**0.17**	**.12, .21**	**<.001**
Step 3															
AUD-PRS × monitor	−0.02	−.07, .02	.37	−0.00	−.05, .05	.90	−0.04	−.09, .01	.10	−0.02	−.06, .02	.39	−0.02	−.07, .03	.50
AUD-PRS × accept	−0.01	−.06, .04	.73	0.04	−.01, .09	.16	−0.01	−.06, .05	.81	−0.01	−.07, .04	.60	0.01	−.04, .06	.70
AUD-PRS × conflict	−0.02	−.06, .03	.47	0.03	−.02, .07	.23	0.00	−.05, .05	.92	−0.02	−.06, .03	.49	−0.01	−.06, .03	.58

Note. AUD-PRS = alcohol use disorder genome-wide polygenic score; Par Edu = parental education; Fam income = family income; PC = genetic ancestry principal components; Par monitor = parental monitoring; Par accept = parental acceptance; Fam conflict = family conflict. Sex was coded 1 = male, 0 = female. CI = 95% confidence intervals. Bolded coefficients $p < .01$.

and family conflict), and the focus on racially and ethnically diverse youth. By studying G×E in a sample of White, Black/African American, and Hispanic/Latino youth, our findings contribute to the limited literature on genetically-informed research among racial/ethnic minority populations. In addition, unlike the focus of prior genetically-informed research on adult and adolescent alcohol use outcomes, the current study took a developmental approach by examining how genetic influences for adult AUD manifest in childhood. A developmental approach can allow us to better understand if the genetic influences for adolescent and adult AUD are associated with precursor traits in childhood, which may help identify at-risk children for intervention and prevention efforts. Despite these strengths, our findings need to be interpreted in light of several limitations. First, we used data from the baseline assessment in order to assess impulsivity in childhood (age 9–10) and maximize the sample size for analysis. This means that parenting and family conflict were measured at the same time as impulsivity. Although we conceptualized parenting and family conflict as predictors of impulsivity in the present study, we acknowledge the possibility of bidirectional associations between them (Wang et al., 2020). Second, we only used UPPS-P to measure dimensions of impulsivity. Despite that UPPS-P is a commonly used measure, we recognize that there are alternative approaches to conceptualize and measure impulsivity, such as using laboratory tasks (Dick et al., 2010). Third, some of the scales used in the study (e.g., parental monitoring [$\alpha < .50$], sensation seeking [$\alpha < .52$]) had low reliability. Measurement errors for these variables may result in bias in analysis and results. In addition, despite using the state-of-the-science polygenic scoring approach, the AUD-PRS in the present study still had limited predictability and we were underpower to detect G×E effects. Furthermore, we conducted a total of 45 tests of G×E effects, raising concerns about Type-I errors in our finding due to multiple testing. Finally, all of the measures were self-report and may subject to reporting bias.

In conclusion, our study extended the literature by taking a developmental approach to examine the role of genetic risk for AUD, in conjunction with parenting behaviors and family conflict, in relation to childhood impulsivity in racially and ethnically

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diverse youth. Our findings indicated that positive parenting behaviors such as monitoring and acceptance can play important role in reducing childhood impulsivity, whereas family conflict can be a risk factor associated with higher levels of childhood impulsivity among White, Black/African American, and Hispanic/Latino youth. In addition, we found suggestive evidence that family conflict may exacerbate genetic risk of AUD in relation to childhood positive urgency, although this was only found in the Black/African American subsample. These findings highlight the importance of efforts aimed at promoting positive parenting behaviors and managing family conflict as ways to reduce impulsivity among children.

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