HHS Public Access

Author manuscript

J Res Adolesc. Author manuscript; available in PMC 2016 December 01.

Published in final edited form as:

J Res Adolesc. 2015 December 1; 25(4): 638–651. doi:10.1111/jora.12154.

Sibling Facilitation Mediates the Association Between Older and Younger Sibling Alcohol Use in Late Adolescence

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Abstract

Previous research has shown adolescent siblings are similar in their alcohol use and that this similarity is largely due to their shared environment. Using a genetically-informed sibling sample (196 full-biological pairs, 384 genetically unrelated pairs), we confirmed that the extent to which older siblings facilitate younger siblings' alcohol use (i.e., help them get alcohol) was one factor contributing to this shared environmental association. All analyses controlled for parent and peer influences. Findings were not moderated by sibling differences in genetic relatedness, gender, or ethnicity. Proximity in sibling age strengthened these associations, somewhat. Results were especially strong for sibling pairs where the older sibling was of legal drinking age. Implications for prevention and intervention are discussed.

Keywords

Adolescent Alcohol Use; Shared Environment; Sibling Relationships

A large body of literature has shown that adolescent siblings are often similar in their alcohol and substance use (Boyle, Sanford, Szatmari, Merikangas, & Offord, 2001; Fagan & Najman, 2005; Fisher, Miles, Austin, Camargo, & Colditz, 2007; Harakeh, Engels, Vermulst, de Vries, & Scholte, 2007; Rowe & Gulley, 1992) and that this similarity reflects more shared environmental rather than shared genetic influences (Hopfer, Crowley, & Hewitt, 2003; Koopsman & Boomsma, 1996; McGue, Elkins, & Iacono, 2000; Rende, Slomkowski, Lloyd-Richardson, & Niaura, 2005; Rose, Dick, Viken, Pulkkinen, & Kaprio, 2001). For example, working with a twin sample, Koopmans and Boomsma (1996) found that shared environmental effects accounted for 58–88% of the total variance in whether adolescents ever used alcohol, although this study was not designed to identify the specific environmental factors that contribute to this effect. Other research has similarly confirmed substantial shared environmental influences (20–38%) on adolescent alcohol use more broadly defined (e.g., frequency, quantity of drinking; Fowler, Shelton, Lifford, Rice, McBride, Nikolov, et al., 2007; Pagan, Rose, Viken, Pulkkinen, Kaprio, & Dick, 2006; Samek, Keyes, Iacono, & McGue, 2013). Given the high prevalence of adolescent alcohol

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and substance use (Centers for Disease and Control, 2012), it is important to identify the specific components of the shared environment that are influencing sibling similarity in substance use.

Various environmental pathways have been proposed to explain how siblings influence each other's alcohol and substance use behaviors. Most tend to focus on aspects of modeling and the potential shared peer network between siblings, but few have incorporated the genetically informed designs necessary to evaluate the hypothesized environmental contributions. For example, research has long demonstrated that the sibling correlation in substance use tends to be consistently greater if siblings are close in age versus further apart (Samek & Rueter, 2011; Trim, Leuthe, & Chassin, 2006) and, to a lesser extent, if they are the same versus opposite gender (Boyle et al., 2001; Rowe & Gulley, 1992). These results suggest that siblings might be more likely to identify with one another or possibly share friends if they are close in age or are the same gender (Bandura, 1969). In fact, there is research that suggests that younger siblings are more likely to report modeling their older sibling's substance behavior when they share friends with the older sibling (Whiteman, Jensen, & Maggs, 2013). The degree of sibling collusion (defined as observed antisocial and substance use talk between siblings) is also strongly related to younger sibling substance use (Low, Shortt, & Snyder, 2012), and appears to contribute to adolescent delinquent behavior above and beyond the influence of deviant peers (Bullock & Dishion, 2002).

Behavioral genetic research has indicated that when siblings are high in social connection (e.g., share friends, hang out together), sibling similarity in alcohol and substance use is substantially influenced by shared environmental factors. On the other hand, when siblings are low in social connection, their similarity is predominately explained by shared genes (Slomkowski, Rende, Novak, Lloyd-Richardson, & Niaura, Rende et al., 2005). Taken together with other investigations demonstrating substantial shared environmental influences on adolescent substance use overall (e.g., Hopfer et al. 2003), this body of research suggests that processes of modeling and peer-like sibling relationships reflect shared environmental influences on adolescent alcohol and substance use behaviors. Notably, research has shown that siblings tend to share more friends based on their degree of genetic similarity, supporting gene-environment correlation in peer selection (McGuire & Segal, 2013). For example, monozygotic twins (who share 100% of their DNA) have about 82% of their peer group in common, compared to 67% for same-sex dizygotic twins, 39% for same-sex full sibling pairs, and 27% for opposite-sex full-sibling pairs (McGuire & Segal, 2013).

Of course, sibling relationships may be qualitatively different from peer relationships because they occur within a family context and siblings can differ markedly in age. Thus, an older sibling may serve as an attachment figure as well as be one of the first non-adult role models for substance use behavior for their younger siblings. In this vein, Samek and Rueter (2011) demonstrated that in addition to the substantial sibling correlation in adolescent substance use, the more warmth and closeness younger siblings reported they felt toward their older sibling, the less likely they were to use substances three years later. Notably, this effect was not moderated by the older sibling's substance use, suggesting independent risk and protective effects of the sibling relationship in predicting adolescent substance use. This finding was somewhat inconsistent with previous research demonstrating substantial shared

environmental influences on adolescent substance use when siblings are high in social connection (Rende et al., 2005; Slomkowski et al., 2005), perhaps because the reports of warmth and companionship tapped into dimensions of attachment and bonding rather than shared peer networks and collusion in deviant activities.

In addition to modeling and attachment influences, a third environmental pathway linking elder and younger sibling substance use that has long been hypothesized concerns an older sibling's facilitation of a younger sibling's substance use (Needle et al., 1986; Rowe & Gulley, 1992; Windle, 2000). This includes the extent to which an older sibling helps the younger sibling obtain alcohol or drugs, and the degree to which an older sibling approves of their use. For example, McGue and Iacono (2009) evaluated sibling facilitation as younger siblings' perceptions of whether their older siblings would help obtain drugs (tobacco, marijuana, or other drugs) or generally support younger siblings' drug use (e.g., "My sibling would be upset if I used tobacco"). They found that sibling facilitation of substance use fully mediated the relationship between elder and younger siblings' report of the number of psychoactive substances used. Because these findings did not differ whether siblings were genetically related or unrelated, the authors concluded that sibling similarity in substance use is due in part to the environmental effect of older siblings' modeling and encouragement of drug use.

To extend these findings and further evaluate the sibling facilitation hypothesis, we examined whether older sibling facilitation of alcohol use could account for adolescent sibling similarity in adolescent drinking, specifically. We focused on alcohol because it remains the most highly prevalent form of substance use during adolescence (Centers for Disease and Control, 2012), and because adolescent alcohol use is associated with diverse adverse outcomes in adulthood (Duncan, Alpert, Duncan, & Hops, 1997; Flory, Lynam, Milich, Leukefeld, & Clayton, 2004; Hicks, Iacono, & McGue, 2010). A second novel contribution of this study constituted an evaluation of the correspondence between the older siblings' *report* of their alcohol use and younger siblings' *perceptions* of their older siblings' alcohol use in relation to younger siblings' alcohol use. Research has shown that people tend to estimate the behaviors of others based on their own behaviors (Borsari & Carey, 2001; 2003; Iannoti & Bush, 1992; Lewis, Litt, Blayney, Lostutter, Granato, Kilmer, et al., 2011; Martens, Page, Mowry, Damann, Taylor, & Cimini, 2010), such that those who drink heavily tend to believe those around them drink heavily (even if they do not). Much of the literature on this topic relates to perceptions of peers' drinking behaviors and social norms in college-aged samples (Borsari & Carey, 2001; 2003), but less research has examined perceptions of sibling drinking (D'Amico & Fromme, 1997).

Based on this review, we hypothesized that compared to the older sibling's report of alcohol use, younger sibling's perceptions of their older siblings' alcohol use would relate more strongly to both younger sibling's perception of sibling facilitation and younger sibling's report of alcohol use. Distinguishing the predictive ability of older sibling's report of alcohol use versus younger sibling's perception of older sibling's alcohol use in relation to younger sibling's alcohol use might implicate which characteristics of the sibling relationship are particularly important to assess in adolescent alcohol prevention programs. Specifically, simply assessing the younger sibling's perception of older sibling's alcohol use and

willingness of their older sibling to facilitate their alcohol use may prove to be an adequate, if not more appropriate, measure than older sibling's direct report of alcohol use.

A third way we are extending prior research on the topic of sibling facilitation of substance use is by analyzing moderating influences of several contextual variables. In addition to comparing results across genetically related and unrelated pairs to confirm the shared environmental influence that has been demonstrated previously (e.g., Hopfer et al., 2003; McGue & Iacono, 2009), we also examined moderators such as sibling differences in gender, age, and ethnicity (our study contained adoptive families and siblings in these families were not always of the same ethnicity, making such a comparison possible). We expected effects to be stronger when siblings were the same sex, close in age, or shared the same ethnicity because they would be more likely to identify with one another under these conditions (consistent with expectations from a social learning perspective; Bandura, 1969).

Figure 1 depicts the conceptual model on which our hypotheses are based. As prior research has demonstrated important parent and peer influences on adolescent alcohol use (Needle et al., 1986; Rowe & Gulley, 1992; Windle, 2000), we include mother and father alcohol use, relationship quality, and a measure of peer deviance as covariates in our evaluation of whether sibling facilitation of alcohol use mediates the link between elder and younger sibling alcohol use. We expected that elder sibling facilitation of alcohol use would fully mediate the association between elder and younger sibling reported alcohol use (paths *c* and *e*), but partially mediate the association between younger siblings' perceptions of elder siblings' alcohol use and younger siblings' alcohol use (paths *d* and *e*). To determine whether these associations varied as a result of important sibling contexts, we tested for moderation by sibling pair genetic similarity (genetically related versus unrelated), age difference (within 2 years, 2–3 years, 3+ years), gender similarity (same versus mixed), and ethnic similarity (same versus mixed).

Method

The Sibling Interaction and Behavior Study (SIBS) was designed to evaluate shared environmental influences on adolescent substance use and related psychopathology (McGue, Keyes, Sharma, Elkins, Legrand, Johnson, et al., 2007). Two types of families were recruited: families with genetically-unrelated, adopted siblings and families with full biological siblings. Adoptive families were recruited through three large Minnesota (MN) adoption agencies. Eligibility included having an adopted child between the ages of 11 and 21 years at the time of the intake assessment who had been permanently placed into the adoptive home prior to age 2 (M_{age} = 4.7 months, *SD* = 3.4 months, 96% were placed prior to 1 year of age), and a second adolescent in the home who was not biologically related to the adopted adolescent. Notably, the majority of adoptees were internationally adopted (74%); international adoptees were predominantly female (61%) and of Asian ancestry (90%); domestic adoptees were predominately male (59%) and of European ancestry (79%). Families with biologically related children were ascertained through publicly available MN birth certificates and were recruited to match the adoptive sample in terms of age and sex but not ethnicity (matching MN demographics in the relevant birth years, 95% of the biologically-related children were of European ancestry). For all families, sibling pairs were

required to be no more than 5 years apart in age. Participation rates were not significantly different between non-adoptive (57%) and adoptive (63%) families. Comparisons of non-adoptive parents' education and marital status to 2000 census data show that they were generally representative of MN families with two children. A detailed overview of study recruitment and participation has been provided elsewhere; please see McGue et al. (2007) for further information.

Data from the first follow-up assessment, conducted 3.5 years after intake, was used for this study. This was due, in part, to the availability of the sibling facilitation measure (discussed below) at this assessment, and because alcohol use is more prevalent in late compared to early adolescence (CDC, 2012). Possible participants included 1,158 adolescents (94% retention, 563 complete pairs, 15 elder sibling singletons, and 17 younger sibling singletons) that completed the follow-up assessment. The sample size used for path analysis was N = 580 sibling pairs (missing values analysis described in detail in the Analysis Plan, below). This included 196 genetically related and 384 genetically unrelated pairs (where at least one member of the pair was adopted), 352 same-sex and 228 mixed-sex pairs, and 464 same-ethnicity and 116 mixed-ethnicity pairs. Same-sex pairs consisted of slightly more sisters (57%) than brothers (42%). While the sample contained ethnic diversity, it was primarily limited to European and Asian ethnic ancestry only. Specifically, the same-ethnicity pairs were predominately of European (56%) and Asian (36%) ancestry. Of the mixed ethnicity sibling pairs, the majority (77%) consisted of pairs where one sibling was of European ancestry and the other sibling was of Asian ancestry. On average, younger siblings were 17.0 years old (SD = 1.8) and elder siblings were 19.4 years old (SD = 1.7). The average age difference in sibling pairs was 2.4 years (SD = .88).

Procedure

Participating family members visited the lab for a day-long assessment. All provided written informed assent or consent, including parental consent for minor participation, as appropriate. A variety of measures were completed, including computerized assessments and surveys. Approximately, 14% of participants could not visit the lab and were instead given a shortened assessment via telephone. These participants did not complete the *Computerized Substance Use Assessment* (described below) and had missing alcohol use data (missing values analysis described in detail in the Analysis Plan, below). Chi-square analyses revealed no statistically significant differences between those with and without computerized data across key demographic variables (adoptive status, sex, ethnicity) or alcohol abuse or dependence diagnoses at the Intake assessment.

Measures

Adolescent alcohol use (last 12 months)—Adolescent alcohol use was assessed using the *Computerized Substance Use Assessment*. In a private room, adolescents answered a series of questions relating to alcohol and substance use via the computer. This study's measure of alcohol pertained to the last 12 months only. Items included frequency of alcohol use, frequency of intoxications (both answered on a scale of 0 = *Never* to 9 = *Every day or nearly every day*), maximum number of drinks on a single occasion (answered on a scale of 0 = *0 drinks* to 10 = *10+ drinks*), and the proportion of times they were intoxicated when

they drank (answered on a scale of 0 = *Never* to 5 = *Nearly every time or every time*). These 4 items were standardized and summed to create a composite score of elder sibling alcohol use (α = .96) and younger sibling alcohol use (α = .97).

Perceived older sibling alcohol use—Younger sibling perception of older sibling alcohol use was assessed using younger sibling's report on the *Sibling Relationship Supplement*. The 3-item scale (α = .89) included: "Has your sibling ever used alcohol without your parent's permission?" answered on a scale of 1 (*My sibling has never tried alcohol*) to 4 (*My sibling has tried alcohol and used it a lot in the past 12 months*), " In the past 12 months, how often has your sibling used alcohol?", answered on a scale of 1 (*Every day or nearly every day*) to 5 (*My sibling has not used alcohol in the past 12 month*s), and "In the past 12 months, how many times have you seen your sibling use alcohol?", answered on a scale of 1 (*Never*) to 3 (*Many times*). These 3 items were coded so a higher score indicated more alcohol use, then were standardized and summed to create a composite score of perceived older sibling alcohol use.

Perceived sibling facilitation of alcohol use—Younger sibling report of elder sibling facilitation of alcohol use was assessed using the younger sibling's report on the *Sibling Relationship Supplement*. Three items were used: "My sibling would help me get alcohol if I wanted some," "My sibling's friends would help me get alcohol if I wanted some," both answered on a scale of 1 (*Strongly Agree*) to 4 (*Strongly Disagree*) and "Has your sibling ever given you alcohol," answered on a scale of 1 = *No*, 2 = *Yes, but just a few times*, 3 = *Yes, many times*. These three items were coded so that a higher scored indicated greater facilitation, then were standardized and summed to create a composite score of perceived sibling facilitation of alcohol use, α = .84.

Parent alcohol use (last 12 months)—Parent report of alcohol use was measured using the Parent Substance Use Screen, which assesses tobacco, alcohol, and illicit substance use behavior for the last 12 months. Only one parent visited at the follow-up assessment (usually the mother); however, the visiting parent reported on the non-visiting parent's substance use behavior in a separate interview. Thus, mother and father alcohol use was assessed using the frequency of alcohol in the last 12 months (answered on a scale of 0 = *Never* to 10 = *3 or more times a day*) as reported by the visiting parent.

Parent-child relationship quality—Younger sibling's report of parent-child relationship quality was measured using the Parental Environment Questionnaire (PEQ; Elkins, McGue, Iacono, & Tellegen, 1997). Adolescents rated statements concerning the parent-child relationship (e.g., "I feel close to my [Mother/Father") on a scale of 1 (*Definitely true*) to 4 (*Definitely false*). The PEQ assess major dimensions of parent-child relationship quality, including conflict, involvement, and positive regard (α's ranged from .80 to .89; assessed using 8–12 items each). The average across the PEQ scales was computed to assess mother-child and father-child relationship quality, coded so that the higher the score, the better the parent-child relationship quality.

Deviant peer affiliation—Younger sibling's report of affiliation with substance-using peers was measured using the Friends Survey (Walden, McGue, Iacono, Burt, & Elkins, 2004; Samek et al., 2013). Adolescents rated friendships on a scale of 1 (*All my friends are like that*) to 4 (*None of my friends are like that*). An 8-item scale was used to assess deviant peer affiliation, e.g., "My friends drink alcohol or beer" (α = .88.) Items were coded so that a higher score indicated a greater level of deviant peer affiliation.

Analysis Plan

Figure 1 describes the path analytic model, which was analyzed using Mplus, 6.12 (Muthén & Muthén, 1998–2013). As SIBS is diverse in terms of demographics (described above), the effects of adolescent sex (1 = *Male*, 2= *Female*), age, ethnicity (1 = *White*, 0 =*African-*, *Asian-*, *Hispanic- American*, *Mixed*, *Other*), and family SES (standardized composite of mother's and father's education level, highest occupational prestige rating, and family income) were regressed out of all composite scales prior to analysis. We used the default maximum likelihood (ML) estimator for all analyses. After demonstrating a significant association between the independent variables (elder sibling alcohol use, perceived elder sibling alcohol use) and the mediator (perceived sibling facilitation of alcohol use) in relation to the dependent variable (younger sibling alcohol use), we tested the full mediation model. As illustrated in Figure 1, we tested for the extent to which the mediator (perceived sibling facilitation of alcohol) carried the influence of the independent variable to the dependent variable by using MODEL INDIRECT statements (this provides an estimate of indirect effect size by taking the product of mediating paths, e.g., paths *c* and *e* in or *d* and *e* in Figure 1; see Preacher & Kelly, 2011; Hayes, 2009). Significant coefficients for both direct and indirect effects suggest partial mediation. Significant indirect but not direct coefficients suggest complete mediation.

Missing data were handled using full information maximum likelihood for all analyses. The proportion of data present in all possible pairs of variables (i.e., covariance coverage) ranged from 65% to 95%. Valid data on at least one of the nine variables (see Figure 1) was necessary for inclusion in the path analysis; *n* =33 of the eligible sample of 613 pairs (5.4%) were missing on all nine variables and were therefore excluded from the analysis. Thus, the final sample size consisted of 580 sibling pairs.

Finally, we tested for moderation of the full model across several contextual variables using multiple group modeling. Siblings were either genetically related (*n* = 196) or genetically unrelated (*n* = 384). Sibling age difference ranged from 1 to 5 years. Due to small numbers of siblings pairs less than 1 year of age apart or more than 3 years of age apart), sibling age difference was defined as those within 2 years of age (*n* = 229), 2–3 years of age (*n* = 227) and 3+ years of age (*n* = 124). Those classified by gender composition were either same sex (*n* = 352) or mixed sex (*n* = 228). Ethnic similarity was classified by same ethnicity (*n* = 464) or mixed ethnicity (*n* = 116).

In multiple group modeling, all paths were allowed to vary across the different levels of the moderator (e.g., genetically related siblings versus genetically unrelated siblings). Then, all paths were constrained across groups. Differences in the total variant and invariant models were analyzed using the chi-square difference test. If a significant difference was found,

paths were constrained one at a time to determine which path was significantly different across groups.

Results

Table 1 describes the overall levels of alcohol use for both elder and younger siblings. In general, the sample was comparable to national statistics on adolescent alcohol use. For example, about 48% of youth (through grade 12) ever used alcohol in 2013 (Johnston, O'Malley, Miech, Bachman, & Shulenberg, 2014). This is generally comparable to the 54% of younger siblings (*M* age = 17.0, *SD* = 1.8). As one would expect given their older age (*M* age = 19.4, *SD* = 1.7), 76% of elder siblings reported ever using alcohol in this sample. Follow this, 32% of youth (through grade 12) have been intoxicated in 2013 (Johnston et al., 2014), which is comparable to the 39% of younger siblings and 65% of elder siblings that have reported ever being intoxicated in this sample.

Correlations among age, sex, ethnicity, and SES-corrected study variables relevant to the hypothesized conceptual model (Figure 1) are shown in Table 2. All independent variables were significantly correlated with the dependent variable, younger sibling alcohol use (see bottom row of table, all *p*'s < .01). Additionally, all independent variables were significantly correlated with each other, with the exception of parent alcohol use and parent-child relationship quality variables and elder sibling alcohol use and father-child relationship quality (see Table 2 for details).

Before evaluating the hypothesized mediation model, we first evaluated the significance of the direct associations among study variables. As expected given correlations presented in Table 2, elder sibling's report of alcohol use significantly predicted younger sibling's report of alcohol use ($\beta = .27$, $t(456) = 6.34$, $p < .001$), as did younger sibling's perceptions of elder sibling alcohol use ($\beta = .45$, $t(402) = 11.23$, $p < .001$), and perceived sibling facilitation ($\beta = .50$, $t(495) = 15.73$, $p < .001$). With evidence of direct associations, we went on to test the hypothesized mediation model (Figure 1) using path analysis.

Mediation results

Our central question was whether perceived sibling facilitation of alcohol use mediated the direct association between *a*) elder and younger sibling alcohol use and *b*) younger sibling's perceptions of elder sibling's alcohol use and younger sibling's alcohol use. Results are shown in Figure 2. Evidence of significant indirect but not direct effects of elder sibling alcohol use supported our expectations and showed complete mediation between elder and younger sibling's alcohol use by perceived sibling facilitation (indirect effect size: $\beta = .05$, $t(580) = 3.16$, $p = .002$). As evidenced by both the significant direct and indirect effects of younger sibling's perceptions of elder sibling's alcohol use, there was partial mediation between younger siblings' perceptions of elder sibling alcohol and their own alcohol use by perceived sibling facilitation of alcohol use (indirect effect size: $\beta = .11$, $t(580) = 4.76$, $p < .001$).

Notably, 46% of the total variance in younger sibling alcohol use was explained the combination of parent, peer, and sibling factors tested. The model fit adequately by SRMR (.

03), CFI (.93), and (TLI .80) criteria, but somewhat poorly by RMSEA criteria (.11; 90% Confidence Interval: .08, .15); χ^2 (5, N = 580) = 41.28, p < .001. As this first analysis demonstrated significant sibling influences after controlling for parent and peer influences, we conducted a separate more parsimonious analysis which excluded all parenting and peer covariates, as well as the non-significant direct path of elder sibling alcohol use on younger sibling alcohol use. This more parsimonious model showed excellent fit by all fit criteria: χ^2 (1, N =580) = .76, p = .38, RMSEA = .00; 90% CI: .00, .11, CFI = 1.0, TLI = 1.0, SRMR = .01. In this parsimonious model, 28% of the variance in younger sibling alcohol use was explained by factors related to elder sibling alcohol use, perceived elder sibling alcohol use, and perceived facilitation, alone. Altogether, results from the full mediation model shown in Figure 2 and this more parsimonious model suggest substantial influence of sibling facilitation in the relationship between elder and younger sibling alcohol use.

Of note, there were 12 cases where the younger sibling was 21 or older at the time of data collection; excluding these cases did not impact study results (i.e., there was evidence of complete mediation by sibling facilitation for path *a*, as described in Figure 1, but not for path *b* – for both the full mediation model described in Figure 1 and the parsimonious model that excluded parenting and peer covariates). There were 97 cases where the elder sibling was 21 or older; excluding these cases also did not impact study results (by the same criteria reviewed above).We also ran an analysis only including the 97 pairs where the elder sibling was 21 or older and legally able to buy alcohol. The full mediation model included a sample size of 96 (as 1 case was missing on all 9 variables). Results showed a different pattern; here there was evidence of complete mediation by sibling facilitation for path *a*, and path *b* (as described in Figure 1) for both: 1) the full mediation model shown in Figure 2; and 2) the more parsimonious model that excluded parenting and peer covariates (described above). These results suggest that sibling facilitation of alcohol use may be particularly influential if the elder sibling is of legal drinking age. Because of this finding, we added whether or not elder sibling was of legal drinking age to our list of moderators to evaluate, described next.

Moderation results

We evaluated whether paths were moderated by several sibling contextual variables. Some zero-order correlations were stronger in magnitude among some context groups compared to others, but few were significantly different from one another at p < .05 (see Table 3). For example, the correlation between elder and younger sibling alcohol use was stronger for genetically related siblings (r = .37) than unrelated siblings (r =.22), but not significantly so; χ^2 (1, N = 516) = 3.10, p = .08. The only significant differences that were found were for sibling age difference (the correlations between siblings 3+ years in age apart tended to be lower than siblings within 2 years of age or 2–3 years in age) and elder sibling legal drinking age (the correlation between elder sibling report of alcohol use and younger sibling's perceptions of elder sibling alcohol use was less correlated for pairs where the sibling was 21 years of age or older compared to pairs where the sibling was less than 21 years of age; no other significant differences were found). Please see Table 3 for details.

Next, we tested whether the entire path analysis model (Figure 2) was significantly moderated by these sibling contextual variables. Following expectations given the

correlations reported in Table 3, there was no significant moderation of the model by genetic relatedness (related versus not: χ^2 (6, N = 580) = 7.48, p = .28), gender composition (same versus mixed: χ^2 (6, N = 580) = 10.24, p = .12), ethnic similarity (same versus mixed: χ^2 (6, N = 580) = 4.33, p = .63), or elder sibling legal drinking age (χ^2 (6; N = 564) = 11.58, p = .07).

The only significant differences involved sibling age difference (χ^2 (12, N = 580) = 26.64, p = .009). Follow-up analyses that constrained one path at a time showed the only significant difference in paths was for the association between elder sibling's report of alcohol use and perceived sibling facilitation of alcohol, which was stronger for those within 2 years of age (β = .35, t(229) = 4.87, p < .001) compared to those 3+ years of age a part (β = .00, t(124)= .03, p = .98; χ^2 (1; N = 580) = 8.95, p = .003). No other significant differences were found. In total, the indirect effect size of sibling facilitation as a mediator on the relationship between elder sibling's alcohol use and younger sibling's alcohol use was stronger for siblings within 2 years (β = .13, t(229) = 3.40, p < .001) compared to siblings 2–3 years of age apart (β = .03, t(227) = 1.51, p = .13), and siblings 3 or more years of age apart (β = .00, t(124) = .15, p =.88).

Based on the pattern of correlations shown in Table 3, we also evaluated for differences across age groups of siblings less than 3 years of age apart (n = 456) versus 3 or more years of age apart (n = 124). The same pattern of results was found, where the only significant difference across groups was for the association between elder sibling's report of alcohol use and perceived sibling facilitation, which was stronger for siblings within 3 years of age (β = .25, t(456) = 4.66, p < .001) compared to siblings 3 or more years of age apart (β = .02, t(124) = .15, p = .88). The indirect effect size of sibling facilitation as a mediator on the relationship between elder sibling's alcohol use and younger sibling's alcohol use was stronger for siblings within 3 years (β = .06, t(456) = 3.67, p = .001) compared to siblings 3 or more years of age apart (β = .00, t(124) = .15, p = .89). In total, results suggest fairly consistent evidence that associations hold up across a variety of sibling contexts, perhaps more so for siblings within 2 years of age compared to siblings further apart in age.

Discussion

Previous research has consistently demonstrated that adolescent siblings are often similar in their report of alcohol and substance use (Fagan & Najman, 2005; Fisher et al., 2007; Rowe & Gulley, 1992), primarily due to shared environmental rather than shared genetic factors (Hopfer et al., 2003; Koopsman & Boomsma, 1996; McGue et al., 2000; Rende et al., 2005). This study provided evidence that perceived sibling facilitation of alcohol use is one specific shared environmental factor linking older and younger sibling alcohol use in late adolescence. Mediation of perceived sibling facilitation of alcohol use in adolescent sibling pairs was consistent across a variety of sibling contexts, including whether siblings were genetically related or unrelated (confirming shared environmental influence), the same or opposite gender, and the same or of different ethnicity. Consistent with expectations from previous literature (Samek & Rueter, 2011; Trim et al., 2006), there was some evidence the associations were stronger for siblings closer in age compared to those further apart in age. All of these findings were significant above and beyond the effect of parent and peer

influences, suggesting substantial older sibling influence on late adolescent alcohol use. In total, this study's findings extend previous research by showing that one possible route through which an older sibling influences the drinking of a younger sibling is through facilitation of alcohol use by the older to the younger sibling. While the data are cross-sectional and longitudinal investigation is needed to support the timing of these effects, this study provides initial support for the notion that older siblings may increase or reduce the likelihood of younger sibling's teen drinking based on the extent to which they facilitate alcohol use directly.

We hypothesized, and our results supported, two pathways by which elder sibling alcohol use might influence younger sibling alcohol use. First, results showed full mediation of sibling facilitation in the association between elder sibling's reported alcohol use and younger sibling's reported alcohol use. This was particularly salient for siblings within 2 years of age compared to siblings further apart in age. These results are consistent with the notion that older siblings who drink appear to be more likely than those who do not drink to create an environment that encourages and facilitates younger sibling alcohol use, and that younger siblings may be more likely to model their older siblings drinking behavior, particularly when siblings are close in age.

Second, we found younger sibling's perceptions of elder sibling's alcohol use was a significant predictor of their own alcohol use even after accounting for sibling facilitation of alcohol use (i.e., evidence of partial but not complete mediation in this pathway). This is likely because perceptions are more relevant to adolescent alcohol use than the actual alcohol use behavior of their older sibling, as has been demonstrated in prior research on peers (Borsari & Carey, 2001; 2003) and siblings (D'Amico & Fromme, 1997).

On the other hand, when evaluating sibling pairs where the older sibling was of legal drinking age, results showed complete mediation of both pathways (actual report and perception), although results were not significantly different across pairs where the elder sibling was 21 years of age or older compared to less than 21 years. While caution should be warranted in generalizing these finding due to a small sub-sample comparison of pairs where the elder sibling was 21 years of age or older (n = 96), this indicates that sibling facilitation of alcohol use is relevant for sibling pairs whether the older sibling can legally buy alcohol or not.

Overall, results suggest that sibling facilitation of alcohol use is an important environmental influence on adolescent alcohol use. It may be important to incorporate an assessment of sibling influences when working within a substance use prevention or intervention context. Notably, characteristics of the parent-child, peer, and school environments have been widely-assessed within the adolescent substance use prevention and intervention context (for a review, see Griffin & Botvin, 2010). There has been surprisingly little research aimed at using siblings to reduce adolescent alcohol and substance use. In fact, a review of the literature on sibling-based prevention and intervention research suggests that these strategies have been primarily focused on siblings in middle childhood in order to reduce sibling conflict (Kennedy & Kramer, 2008; Kramer & Radey, 1997), have involved educating and providing support for siblings of those with a disability (Lobato & Kao, 2005; Williams,

Hanson, Karlin, Ridder, Liebergen, Olson, et al., 1997; Williams, Graff, Hanson, Stanton, Hafeman, Liebergen, et al., 2003), or have targeted siblings to assist in the development of pro-social skills for those with autism (Celiberti & Harris, 1993; Tsao & Odom, 2006).

One exception was a study conducted by Donovan and Levin (2011), in which researchers recruited adolescent siblings of those in substance use treatment. Only those with ADHD were recruited, and the treatment was ADHD medication. While the sample size was too small to adequately model long-term outcomes, this study demonstrated the ability to recruit and retain such a sample. At the very least, results from our study suggest that when treating adolescents with alcohol use problems, a good first step would be to assess the extent to which younger siblings think their older siblings drink, as well as the degree which siblings may be facilitating or modeling substance use (either to the target adolescent, or from the target adolescent to their other siblings).

Notably, Feinberg, Solmeyer, and McHale (2012) introduced the *Siblings are Special* (SAS) universal prevention program that targets 5th graders and their younger sibling's with the long-term goal of reducing adolescent substance use and negative adjustment outcomes. Groups of siblings meet for 1.5 hours after school over the course of 12 weeks, where teamwork, emotional regulation, and problem-solving skills are encouraged and practiced in order to promote positive sibling relationship quality. This prosocial sibling relationship dynamic is expected to impact additional prosocial peer relationships and a reduced likelihood of adolescent substance use. It will be important to note the immediate and long-term outcomes of SAS as results become available.

Limitations and Future Research

While this study showed strong associations between perceived sibling facilitation and adolescent alcohol use, we examined these cross-sectional associations in late adolescence; it remains to be determined whether the magnitude of sibling facilitation is just as crucial in early adolescence and how these sibling dynamics may relate to alcohol use in later adulthood. Also, while we adjusted for possible effects of ethnicity and SES in our analyses, children in this study come from families with predominately white, married parents, and adoptive parents had relatively high socio-economic status. It is unclear how effects might be replicated in different family cultures and structures. However, previous research has demonstrated substantial sibling effects in low SES, single-parent, Latino, and African American families (East & Khoo, 2005), and no difference in sibling factors in predicting substance use across African American and white youth (Williams, Ayers, Abbott, Hawkins, & Catalano, 1999).

It is important to note that the majority of adopted adolescents in this sample were of Asian ancestry. Those of Asian ancestry are more likely to have a version of the ALDH2 gene that codes for a deficient form of aldehyde dehydrogenase, important to metabolizing the effects of alcohol. A previous SIBS analysis has confirmed those with this ALDH2 mutation are less likely to report problematic alcohol use, but not other substance use problems (Irons, Iacono, Oetting, & McGue, 2012; Irons, McGue, Iacono, & Oetting, 2007). It remains unclear if the present study's results would be replicated across sibling pairs, for example, where the older and younger sibling differed on the presence of the ALDH2 mutation.

However, prior SIBS research (Irons, McGue, Iacono, & Oetting, 2007) has demonstrated that sibling (but not parent) past year drinking predicted past year drinking among youth with the ALDH2 mutation, suggesting the protective effect of the ALDH2 gene is offset by sibling drinking behavior. Thus, we might expect that the present study's results would not be affected by sibling differences in the ALDH2 gene. Nonetheless, future studies are necessary to specifically test this hypothesis.

In addition, we analyzed sibling facilitation of alcohol use in terms of younger siblings' perceptions of older sibling support of their alcohol use and whether their older sibling had ever given them alcohol; using the same reporter has the potential for introducing method error as it inflates associations. It would be useful for future research to obtain the older sibling's report to evaluate potential differences or similarities in these reports. It would also be useful to understand how siblings may facilitate other forms of specific substance use, such as nonprescription drug misuse or marijuana use.

Conclusion

Using a genetically-informed sibling sample in late adolescence, this study demonstrated at least one possible mechanism for adolescent sibling similarity in alcohol use: older siblings may be facilitating alcohol use to their younger sibling. We found younger sibling's perception of older sibling's alcohol use was a stronger predictor of their alcohol use in comparison to older sibling's report of alcohol use, particularly for siblings within 2 years of age. Results were consistent across a variety of sibling contexts and remained significant after controlling for parenting and peer influences. In total, results indicate sibling facilitation of alcohol use is an important shared environmental influence in the development of adolescent alcohol use. Findings suggest alcohol preventions and interventions might include an assessment of sibling influences on adolescent alcohol use (e.g., the extent younger siblings perceive their older siblings use alcohol or would get it for them) to better understand and potentially treat or reduce the likelihood of adolescent alcohol use and misuse.

Acknowledgements

This research was supported by Grant AA11886 from the National Institute on Alcohol Abuse and Alcoholism, Grant MH66140 from the National Institute of Mental Health. Diana R. Samek was also supported by Grant MH017069 from the National Institute of Mental Health postdoctoral training grant. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

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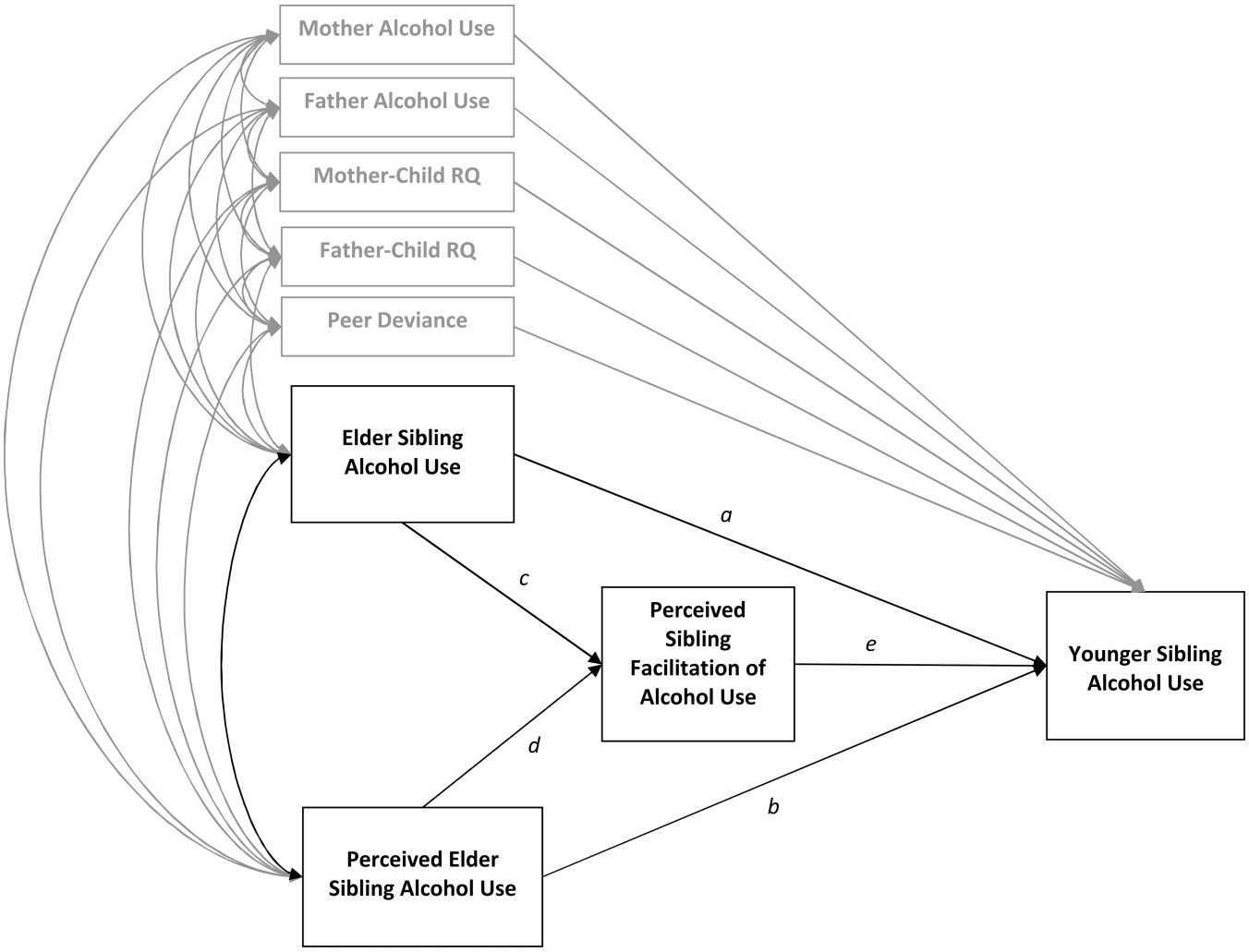

Figure 1. Conceptual Model Depicting Study Hypotheses

RQ = Relationship Quality. Our goal was to evaluate a full mediation model of perceived sibling facilitation in the association between elder and younger sibling alcohol use (path *a*) and in the association between perceived elder sibling alcohol use and younger sibling alcohol use (path *b*), after controlling for parenting and peer influences (shown in gray for clarity of presentation). Direct associations are shown for paths *a* and *b*. Indirect associations are shown by paths *c* and *e*, and *d* and *e*. Significant coefficients for both direct and indirect effects suggest partial mediation. Significant indirect, but not direct coefficients, suggests complete mediation. To test for contextual influences, follow-up analyses examined moderation of all paths as a function of genetic relatedness (genetically related versus unrelated), sibling age difference (within 2 years, 2–3 years, 3+ years), sibling gender composition (same versus mixed), and shared ethnicity (same versus mixed).

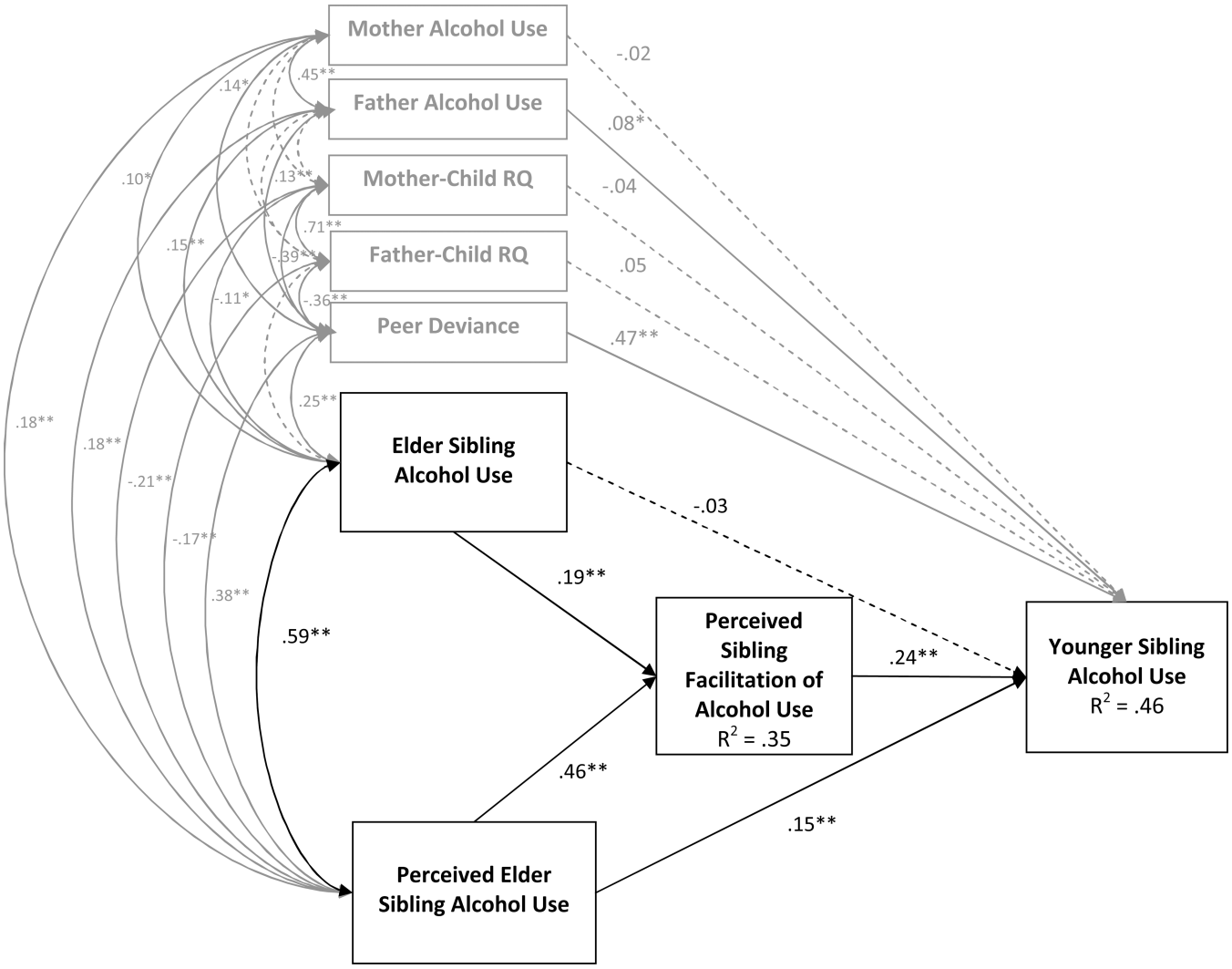

Figure 2. Sibling Facilitation of Adolescent Alcohol use: Path Analysis Results (*N*= 580)

Standardized coefficients are shown for each path Significance is denoted by ** $p < .01$, * $p < .05$. For ease of presentation, standardized coefficients are not shown for correlations among independent variables that are non-significant from zero and all non-significant paths are dashed. Proportion of variance explained (R^2) are shown for all dependent variables. In total, results suggest that the association between elder and younger sibling alcohol use was completely mediated by perceived sibling facilitation of alcohol use, and the association between perceived elder sibling use and younger sibling alcohol use was partially mediated by this variable. Fit statistics and indirect effect sizes are reported in text.

Table 1

Means (Standard Deviations) on Elder and Younger Sibling Alcohol Use Measures

	Range	Elder Sibling	Younger Sibling	χ^2 on 1 *df*	*p*-value
Ever used alcohol	0 – 1	.76 (.43)	.54 (.50)	62.41	<.001
Frequency of alcohol use[a]	0 – 9	3.32 (2.51)	1.89 (2.22)	97.63	<.001
Ever intoxicated	0 – 1	.65 (.48)	.39 (.49)	71.26	<.001
Frequency of intoxications[a]	0 – 9	2.49 (2.36)	1.35 (2.04)	72.79	<.001
How often drink to get drunk[b]	0 – 5	2.41 (2.05)	1.40 (1.95)	68.89	<.001
Max drinks in one sitting[c]	0 – 10	5.05 (3.78)	3.13 (3.76)	74.43	<.001

NOTE:

[a]Frequency items answered on a scale of 0 = *Never* to 9 = *Every day or nearly every day*,

[b]how often they drank to get drunk answered on a scale of 0 = *Never* to 5 = *Nearly every time or every time*, and

[c]max drinks on a single occasion answered on a scale of 0 = *0 drinks* to 10 = *10+ drinks*. Significant differences between elder and younger siblings were tested by constraining the parameters to be equal across groups and utilizing the chi-square difference test (χ^2) on 1 degree of freedom (*df*) change to compare the chi-square value from the free and constrained models.

Table 2

Correlations Among the Composite Variables Modeled in Figure 1

	1	2	3	4	5	6	7	8	9
1. Mother Alcohol Use	--								
2. Father Alcohol Use	.45**	--							
3. Mother-Child Relationship Quality	−.01	−.04	--						
4. Father-Child Relationship Quality	−.02	−.05	.71**	--					
5. Peer Deviance	.14**	.13**	−.39**	−.35**	--				
6. Elder Sibling Alcohol Use	.10*	.15**	−.10*	−.07	.24**	--			
7. Perceived Elder Sibling Alcohol Use	.18**	.18**	−.21**	−.17**	.38**	.59**	--		
8. Perceived Sibling Facilitation of Alcohol	.14**	.11*	−.19**	−.15**	.42**	.46**	.57**	--	
9. Younger Sibling Alcohol Use	.14**	.18**	−.26**	−.21**	.61**	.29**	.45**	.50**	--

NOTE: All variables were adjusted for age, sex, ethnicity, and SES prior to analysis. All variables were standardized prior to analysis and adjusted for age, sex, SES, and ethnicity. For all variables, means = .00 and standard deviations = 1.0. Significance is denoted by

* $p < .01$,

** $p < .05$.

Table 3

Zero-order Correlations (95% Confidence Intervals) for all Pairs of Composite Variables Across Sibling Contextual Groups

	Elder Sibling Alcohol Use with Younger Sibling Alcohol Use	Perceived Elder Sibling Alcohol use with Younger Sibling Alcohol Use	Elder Sibling Alcohol Use With Perceived Sibling Facilitation of Alcohol Use	Perceived Elder Sibling Alcohol Use with Perceived Sibling Facilitation of Alcohol Use	Perceived Sibling Facilitation of Alcohol Use with Younger Sibling Alcohol Use	Elder Sibling Alcohol Use with Perceived Elder Sibling Alcohol Use
Genetic Similarity						
Related	.37 (.24, .50)	.42 (.29, .56)	.53 (.42, .64)	.60 (.50, .70)	.56 (.46, .67)	.68 (.59, .77)
Unrelated	.22 (.11, .33)	.45 (.36, .55)	.41 (.31, .51)	.56 (.48, .63)	.47 (.39, .55)	.56 (.47, .64)
Age Difference						
Within 2 years	.31 (.18, .44)[a]	.42 (.30, .54)	.55 (.45, .65)[a]	.54 (.44, .64)	.54 (.44, .64)[a]	.65 (.57, .74)
Within 2–3 years	.34 (.21, .48)[a]	.53 (.42, .64)[a]	.47 (.35, .59)[a]	.64 (.56, .73)[a]	.52 (.41, .62)[a]	.60 (.50, .70)
3+ Years apart	.05 (-.14, .25)[b]	.30 (.12, .49)[b]	.23 (.05, .41)[b]	.51 (.37, .65)[b]	.41 (.26, .56)[b]	.50 (.34, .66)
Gender Similarity						
Same gender	.35 (.24, .45)	.48 (.38, .57)	.48 (.39, .57)	.59 (.52, .67)	.57 (.49, .65)	.61 (.53, .69)
Mixed gender	.17 (.03, .30)	.38 (.26, .51)	.41 (.29, .53)	.55 (.45, .64)	.40 (.28, .52)	.58 (.48, .69)
Ethnic Similarity						
Same ethnicity	.29 (.19, .38)	.42 (.33, .51)	.43 (.35, .52)	.58 (.52, .64)	.51 (.44, .58)	.60 (.53, .67)
Mixed ethnicity	.23 (.04, .42)	.52 (.36, .67)	.53 (.38, .68)	.53 (.39, .67)	.49 (.34, .63)	.60 (.46, .74)
Elder Sibling Legal Drinking Age						
Elder sibling is ≥ 21 years	.29 (.06, .52)	.37 (.17, .57)	.44 (.25, .63)	.52 (.36, .67)	.51 (.34, .67)	.38 (.17, .66)[a]
Elder sibling is < 21 years	.28 (.19, .67)	.45 (.37, .54)	.48 (.40, .55)	.60 (.53, .66)	.50 (.42, .67)	.64 (.58, .70)[b]

NOTE: All variables were adjusted for age, sex, ethnicity, and SES prior to analysis. Correlations were significant at $p < .05$ if the 95% confidence did not overlap zero. Significant differences in correlations across groups (calculated by the chi-square difference test on 1 *df*, $p < .05$) are indicated if the correlations have different subscripts.