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Moderators of the Dynamic Link between Alcohol Use and Aggressive Behavior among Adolescent Males

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Abstract

Although longitudinal evidence has linked alcohol use with aggressive behavior during adolescence, most studies have failed to adequately control for the numerous between-individual differences that may underlie this association. In addition, few studies of adolescents have examined whether the nature of the within-individual association between alcohol use and aggression depends on individual and contextual factors. To address these limitations, this study examined the association between within-individual changes in alcohol use and aggressive behavior across adolescence and determined whether impulsive behavior, positive attitudes toward violence, violent peers, neighborhood crime, and race moderated this association. Data from 971 adolescent males assessed annually from ages 13 to 18 were analyzed using a within-individual regression panel model that eliminated all stable between-individual factors as potential confounds. Findings indicated that within-individual increases in alcohol use quantity from one's own typical levels of drinking were concurrently associated with within-individual increases in aggressive behavior, and vice versa. However, increases in alcohol were more strongly linked to increases in aggressive behavior among boys with attitudes favoring violence and those who lived in high-crime neighborhoods. The association between alcohol and aggressive behavior was similar for White and Black young men. Interventions designed to reduce aggressive behaviors should consider targeting not only alcohol use, but also individual and environmental risk factors that contribute to this link.

Keywords

alcohol use; aggression; adolescents; moderators

Alcohol use and aggression have clearly been linked during adolescence, but it is unclear whether alcohol use causally increases aggressive behavior (White & Gorman, 2000). Early research suggested that the association between drinking and aggression during adolescence was due to the fact that alcohol use and aggression share several common risk factors (for reviews see White, 1990, 1997). More recent research, however, has suggested that alcohol use may have a direct effect on aggressive behavior among adolescents, and particularly on

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fighting (e.g., Felson, Teasdale, & Burchfield, 2008; White, Tice, Loeber, & Stouthamer-Loeber, 2002). In addition, laboratory research shows a direct effect of drinking alcohol on non-physical aggressive responding, including becoming angry and frustrated (Bushman, 1997). Nevertheless, most individuals who drink do not act aggressively and most occasions of aggression do not involve alcohol use, suggesting that individual and environmental factors may moderate the effects of alcohol on aggressive behavior. Most longitudinal studies, however, have not adequately accounted for the possibility that the association between alcohol and aggression may be accounted for by common risk factors that differ between individuals. To address these issues, this paper examines the extent to which within-individual changes in alcohol use and aggressive behavior are related across adolescence and evaluates whether individual and environmental factors moderate that association. These analyses are conducted with a group of adolescent males who were oversampled for antisocial behavior and annually assessed from ages 13 to 18.

Alcohol and Aggression

Survey research among adolescents provides strong support for an association between alcohol use and aggressive behavior (ranging from hitting to attacking and strong arming; e.g., White, Loeber, Stouthamer-Loeber, & Farrington, 1999). Some longitudinal studies have found that alcohol use predicts aggressive behavior (e.g., assault, fighting, using a weapon, robbery) over time (Fergusson & Horwood, 2000; Menard & Mihalic, 2001; Swahn & Donovan, 2004); others have found that early aggression (e.g., hurting someone badly) predicts later heavy drinking (Farrington, 1995; White, Brick, & Hansell, 1993; White & Hansell, 1996); and finally, others have demonstrated reciprocal effects during adolescence (Huang, White, Kosterman, Catalano, & Hawkins, 2001; Wei, Loeber, & White, 2004; White et al., 1999). However, these studies have primarily examined the association between rank-order changes between individuals (i.e., increase relative to others within the sample) in aggressive behavior and alcohol use over time, rather than addressing the more pertinent question of whether youth who increase their drinking behavior relative to their own norm also tend to increase their aggressive behavior during adolescence.

Several studies have focused specifically on the acute effects of alcohol use on aggressive behavior (e.g., Menard & Mihalic, 2001; White et al., 2002; White & Hansell, 1998) and found that alcohol, compared to other drugs, such as marijuana and cocaine, is more strongly related to violent offenses (e.g., robbery, vandalism, felony assault) and physical fighting. For example, Felson, Teasdale et al. (2008) examined the associations between alcohol use and fighting using a representative sample of U.S. high school students. They found that the association between prevalence of drinking (i.e., use vs. no use) and fighting was “spurious” because drinkers were more likely to engage in fighting than nondrinkers even when they were sober. However, individuals in the study who were drinkers were more likely to engage in fighting when drinking heavily and frequently relative to when they were sober, suggesting a potential causal, within-individual association. Further, individual characteristics moderated the association between drinking and fighting; the association was stronger for youth who were more frequently vs. less frequently involved in violence, White vs. Black, and older vs. younger. In a similar cross-sectional study of Swedish adolescents, drinkers were more likely to commit delinquent acts even when sober compared to non-drinkers, again suggesting a strong between-individual and possibly non-causal association (Felson, Savolainen, Aaltonen, & Moutgaard, 2008). However, after comparing delinquent acts committed when sober to the total number of delinquent acts committed (when both sober and under the influence of alcohol), results indicated that there was a possible “causal” link for violence, vandalism, car theft, and graffiti writing. The researchers suggested that this difference might be accounted for by the fact that these types of crimes are more impulsive than other types. Importantly, these studies were cross-sectional and unable to

demonstrate that when adolescents begin drinking more alcohol over time, they also tend to become more aggressive.

In general, the survey research reviewed above is consistent with psychopharmacological models suggesting that acute alcohol use may impair cognitive processes and, thereby increase the risk for aggressive behavior (for greater detail see Fagan, 1990; Parker & Auerhahn, 1999; Pihl, Peterson, & Lau, 1993). However, cross-sectional and longitudinal studies of associations between alcohol and aggression have failed to stringently examine a key element of this model. In order to demonstrate that alcohol has a “causal” effect on violence, longitudinal data must examine whether adolescents who increase their drinking behavior from one time point to the next relative to their own drinking norm (within-individual change) also experience a concurrent increase in their aggressive behavior (within-individual change) (see Farrington, Loeber, Yin, & Anderson, 2002). We are unaware of any studies that have convincingly demonstrated that there is a waxing and waning of aggression and alcohol use in concert across adolescence using analytic methods measuring within-individual change. Although this type of analysis would be a more stringent test of the pharmacological model than previously conducted studies because it rules out potential between-subjects confounds, it does not eliminate the possibility that increases in one’s level of aggression may also lead to increases in one’s level of drinking. In this paper, we focus on the former (psychopharmacological model) conceptualization (i.e., that increases in alcohol use lead to increases in aggression), although we acknowledge that the latter is a viable alternative and also evaluate it. We also acknowledge that within-individual changes in alcohol use do not result in increases in aggression for all adolescents, suggesting that between-individual differences in individual characteristics and contextual factors may moderate the association, a topic which we further address below.

Potential Moderators

Studies have found that the acute effects of alcohol on aggression are moderated by individual and environmental factors. Specifically, individuals with a higher propensity for aggression are more likely to engage in aggressive behavior when intoxicated than those with a lower propensity for aggression (Leonard, 2008). Because drinking can have both acute and chronic effects on behavioral regulation (White et al., 2011), we expect that a higher propensity for aggression will also moderate the effects of increases in drinking on aggressive behavior.

One factor that appears to moderate the association between alcohol use and aggressive behavior in both laboratory and survey studies is impulsivity (Felson, Teasdale et al., 2008; Giancola, 2002b; White et al., 2002). Impulsive behavior has clearly been identified as a predictor of heavy drinking during adolescence, but heavy drinking during adolescence has also been shown to increase impulsive behavior (White, Marmorstein, Crews, Bates, Mun, & Loeber, 2011). Furthermore, impulsive behavior is predictive of aggression (Pardini & Fite, 2010). Therefore, it is likely that increases in drinking increase the risks of aggression for those youth who are higher rather than lower in impulsive behavior because of the former’s greater propensity for aggression. Attitudes about violence may also be an important moderator of alcohol’s effect on aggression. Those youth who see violent behavior as acceptable may be particularly prone to engage in violence when drinking. Furthermore, it is possible that alcohol may serve as an excuse for youth who want to act aggressively or may give youth the ‘courage’ they need to engage in a fight (Fagan, 1990; White & Gorman, 2000). On the other hand, for teens who have very strong moral objections against the use of violence, alcohol use may have no effect on their aggressive behavior. Therefore, drinking more than one’s typical quantity may increase aggressive

behavior more so for those youth with positive or neutral attitudes toward violence compared to those with negative attitudes toward violence.

Besides individual characteristics, environmental factors may moderate the effects of increases in alcohol use on aggression. For example, several studies have found that having substance using peers is one of the strongest predictors of substance use among adolescents (for a review see Pandina, Johnson, & White, 2009) and that delinquent peer affiliation is one of the strongest predictors of delinquency among adolescents (for a review see Gorman & White, 1995). Spending time with violent peers may reinforce violent behavior and may also provide contexts in which aggressive and violent confrontations take place. Time spent with peers, especially when accompanied with drinking, is often unsupervised by adults; thus, there may be an escalation of aggressive behavior. Also, given that drinking among youth often takes place in a group context, it provides more opportunities for fighting and other forms of aggression towards peers (Felson, Teasdale et al., 2008). Furthermore, violent peers may indirectly affect aggression by socializing youth into the acceptance of violence. Thus, being involved with violent peers, which increases the propensity for aggression, may enhance the effects of increases in drinking on aggressive behavior.

Neighborhood context, which has been shown to influence adolescent delinquency (for a review see Sampson, Morenoff, & Gannon-Rowley, 2002) and substance use (for a review see Gardner, Barajas, & Brooks-Gunn, 2010), may moderate the effects of alcohol on aggression. Like violent peers who may model violent behavior, neighborhoods with high levels of crime may provide learning models for violent behavior. Nonetheless, how high-crime neighborhoods affect youth may be quite different depending on protective factors in their lives (e.g., supportive parents, teachers, high-quality community activities) (Pearce, Jones, Schwab-Stone, & Ruchkin, 2003; Peterson, Krivo, & Harris, 2000) and may also depend on the extent of informal social control within the neighborhood (Sampson, Raudenbush, & Earls, 1997). Even with protective factors, those youth living among aggressive neighbors, who provoke violence, may be less likely to walk away from such provocation partially because increases in drinking may have reduced their behavioral regulation (Bushman, 1997; Gustafson, 1993).

A key question in the literature is whether the associations between alcohol and aggression are similar for Whites and Blacks. Given the divergence in rates of drinking and violence among Whites and Blacks, one might expect that these associations might also differ. That is, White adolescents are more likely than Black adolescents to drink alcohol and drink in higher quantities (Lee, Mun, White, & Simon, 2010). Although rates of serious violence have been consistently higher among Black than White adolescents, even after controlling for socioeconomic status (SES) and possible police bias (Elliott, 1994; Hawkins, Herrenkohl, Farrington, Brewer, Catalano, & Harachi, 1998; Mooradian, 2003), few studies have examined racial differences in more minor forms of aggression (e.g., verbal aggression and destroying property). While studies typically find higher rates of physical aggression among Blacks than Whites in adolescence and young adulthood (Harris, 1992; McLaughlin, Hilt, & Nolen-Hoeksema, 2007), this association is largely accounted for by differential exposure to risk factors for Black youth, such as living in a high-crime neighborhood and having more delinquent peers (Fite, Wynn, & Pardini, 2009; Loeber, Farrington, Stouthamer-Loeber, & White, 2008; Loeber et al., 2005). Moreover, little is known about the extent of racial differences in the associations between within-individual changes in alcohol use and aggression during adolescence. Among adults, rates of violent crime under the influence of alcohol have been found to be somewhat higher for Whites than Blacks (Greenfeld & Henneberg, 2001; Roizen, 1981). Using national data from the U.S., Swahn and Donovan (2006) found that Blacks were more likely to report fighting, compared to Whites, but were *less* likely to report alcohol-related fighting than Whites. Using cross-

sectional data, Felson, Teasdale et al. (2008) also found that the direct association between alcohol and fighting was stronger for White than Black adolescents.

Current Study

The current study attempts to address several gaps in the literature by examining the dynamic association between within-individual changes in the quantity of alcohol consumed and within-individual changes in aggressive behavior during adolescence and whether individual and contextual factors moderate this association. We focus on quantity of drinking because it captures the nature of the drinking that we are trying to depict, that is, sufficient drinking to impair one's ability to exercise cognitive and emotional self-regulation. Instead of limiting our analysis to only physical aggression, we use a broader measure of aggressive behavior. Nonphysical aggression and verbal aggression are important aspects of "aggressive behavior" that are often ignored in research and can also be compromised by impaired decision-making and reductions in inhibitions due to alcohol use. In addition, increases in non-physical forms of aggression have been linked to alcohol intoxication in previous laboratory studies.

Analytically we focus on within-individual changes in alcohol in relation to within-individual changes in aggressive behavior for two primary reasons. First, this analytic framework eliminates the possibility that individual differences can account for the observed association between changes in alcohol use and aggressive behavior across adolescence (see for example, Gottfredson, Kearley, & Bushway, 2008; Horney, Osgood, & Marshall, 1995; Mulvey, Odgers, Skeem, Gardner, Schubert, & Lidz, 2006; Welte, Barnes, Hoffman, Wieczorek, & Zhang, 2005) by providing a more stringent test of the potential causal link between alcohol and aggression than previous studies (Farrington et al., 2002). Second, within-subjects analyses are best suited to test psychopharmacological explanations of the alcohol-aggression link, which assert that when adolescents increase their drinking, they will exhibit increased aggressive behavior.

This study uses an urban sample of young men, which overrepresented individuals at risk for higher antisocial behavior. Including high-risk youth ensures that the sample includes more aggressive youth than would be found in a lower-risk community sample, and that there will be good variability in our aggression measure, especially near the more extreme end of the continuum. Thus, the findings could have important implications for developing preventive interventions for those young men most at risk for later violent offending. We hypothesize that when individuals increase their drinking relative to their typical levels (e.g., established by averaging their drinking quantity across ages 13 to 18) they will experience a co-occurring increase in their typical level of aggressive behavior. However, we believe that this linkage may be moderated by several between-individual risk factors, including impulsive behavior, positive attitudes toward violence, violent peers, and neighborhood crime. Specifically, we hypothesize that increases in alcohol use will be more strongly related to increases in aggressive behavior at high, compared to low, levels of these potential moderators. Finally, we hypothesize that there will be a stronger association between increases in alcohol use and aggressive behavior for White than Black youth. This study extends previous research by examining these associations using repeated assessments across adolescence to measure within-individual change in both alcohol use and aggressive behavior and by examining multiple potential moderators, including race.

METHOD

Design and Sample

The data came from the Pittsburgh Youth Study (PYS), a prospective, multiple cohort, longitudinal study of the development of delinquency, substance use, and mental health problems (Loeber et al., 2008). In 1987–88, random samples of approximately 850 boys in each of the first (youngest cohort) and seventh (oldest cohort) grades of the City of Pittsburgh public schools were screened. Nonparticipation (15%) did not result in sample bias, at least in regard to achievement test results and racial distribution, which were the only two variables that could be compared from school records (Loeber, Farrington, Stouthamer-Loeber, & Van Kammen, 1998).

Boys who ranked in the top 30% in terms of antisocial behavior (based on parent, teacher, and child report at screening) were selected for a follow-up 6 months later along with an approximately equal number of boys randomly selected from the remainder, which resulted in 503 boys in the youngest cohort and 506 boys in the oldest cohort. After the first follow-up, the boys were subsequently followed up at 6-month intervals for five to eight additional assessments and then at yearly intervals for a total of 14 years. Boys were interviewed in person. Parents provided written consent and youths provided oral assent until the youth was 18 years old. Thereafter, the men provided written consent. The study was approved by the university Institutional Review Board and families were paid for their participation in the project.

Phase data were converted to age and we combined both cohorts using annual data from age 13 through age 18. Attrition has remained relatively low and the completion rate has averaged above 90% across the 14 years of data collection. The oldest and youngest cohorts combined are 55% Black, 41% White, and 4% other or mixed. At baseline more than one third of the boys' families received public assistance or food stamps. (For greater detail on participant selection and sample characteristics, see Loeber et al., 1998, 2008.) These analyses are limited to Blacks ($n = 556$) and Whites ($n = 415$).

Measures

Aggressive behavior—Aggressive behavior at ages 13–18 was measured by child responses on the Youth Self Report (YSR; Achenbach, 1991) aggression subscale. The scale includes 20 items (e.g., “get into many fights,” “tease a lot,” “destroy own things,” “disobedient at home”). Responses were scored on an ordinal response set of: 0 (“not true”), 1 (“somewhat or sometimes true”), and 2 (“very true or often true”) and then summed together to form a composite score (average $\alpha = .88$; range = .86–.91). A variable measuring within-individual change in aggressive behavior at each age was created by subtracting an individual's score at each age from his mean score across ages 13 to 18.

Alcohol use—At each age, youth reported their typical quantity consumed when drinking separately for beer, wine, and liquor (ranging from 0 = no drinks to 5 = six or more drinks, i.e., cans of beer, glasses of wine, and drinks of liquor). Across the three beverages, the highest quantity at each age was chosen as the measure of alcohol quantity. A variable measuring within-individual change in alcohol use quantity at each age was created by subtracting an individual's score at each age from his mean score across ages 13 to 18.

Moderators—Moderators were measured at ages 13–18, and their scores were averaged across age. This was done so that the moderators represented stable between-subject characteristics. *Impulsive behavior* was measured using a single item (“act impulsively or act without thinking”) from the YSR (Achenbach, 1991). (Note that this item is not part of

the YSR aggression subscale). This single item has been validated in a previous study examining adolescent impulsive behavior in relation to heavy drinking in this sample (White et al., 2011). The item was coded with the same response categories as the items for the aggressive behavior subscale. Impulsive behavior was moderately stable from one year to the next ($r_s = .36-.45$). *Positive attitudes toward violence* was based on the youth's report of how wrong he thinks it is to: hit someone; attack someone with a weapon or with the idea of seriously hurting that person; and use a weapon, force, or strong-arm methods to get money. This scale was adapted from the Attitude to Delinquent Behavior Scale (Elliott, Huizinga, & Ageton, 1985). Responses were coded on a 4-point scale ranging from not wrong to very wrong. The positive attitudes toward violence score was computed as the mean across the three items (average alpha = .79; range = .68-.87) and was moderately stable from one year to the next ($r_s = .41-.47$).

Environmental moderators at each age included peer violence and neighborhood crime. *Peer violence* was measured by the youth's report of the proportion of his friends who have hit someone; attacked someone with a weapon or with the idea of seriously hurting that person; and used a weapon, force, or strong-arm methods to get money. This scale was adapted from the Peer Delinquency Scale (Elliott et al., 1985). A summative score across items was used at each age (average alpha = .80; range = .67-.87). Peer violence was moderately stable from one year to the next ($r_s = .40-.54$). *Neighborhood crime* was a 10-item scale, which was reported by the primary caretaker until the youth's report was available (youths did not report until they were approximately age 16). This scale was adapted from the Neighborhood Impression Scale (Loeber et al., 2008). Respondents answered on a 3-point scale (1 = *not a problem*, 2 = *somewhat of a problem*, and 3 = *big problem*) the degree to which each of the following was a problem in their neighborhood: vandalism, prostitution, sexual assaults/rapes, burglaries, gambling, syndicate, mafia, or organized crime, assaults and muggings, delinquent gangs, drug use/dealing in the open, and peddling of stolen goods. The sum score across items was used at each age (average alpha = .93; range = .90-.99), and scores were moderately stable from one year to the next ($r_s = .45-.64$).

Demographic and control variables—*Race* was also included as a moderator. Participants were coded 0 for Black and 1 for White. We also controlled for within-individual changes in self-reported *marijuana use* (number of times used at each age) and *hard drug use* (coded 1 if any illicit drug besides marijuana was used in the last year and 0 for no drug use) at ages 13–18.¹ These change scores were computed in the same manner as the aggressive behavior and alcohol use change variables described above.

Analysis

Prior to performing the main analyses, descriptive statistics and correlations among study variables were calculated using SPSS 18 statistical software (2009). This was done across all time points, as well as within time points.

The primary research questions were then examined using a regression panel model (Osgood, Wilson, O'Malley, Bachman, & Johnston, 1996) in STATA 9.2 statistical software (reg function; StataCorp, 2006). In using mean change scores for alcohol use and aggressive behavior at each wave, we were able to evaluate if change from an individual's typical quantity of alcohol use was related to change from an individual's typical level of aggressive behavior at a particular point in time (for detailed descriptions see Osgood, 2005; Osgood et al., 1996). The basic formula for this model is:

¹Other illicit drug use was dichotomized given the limited amount of other drug use in this sample during adolescence (Lee et al., 2010).

$$(\bar{Y}_{agg_{\bullet i}} - Y_{agg_{ti}}) = \beta_1(\bar{X}_{alc_{\bullet i}} - X_{alc_{ti}}) + e_{ti}.$$

This equation eliminates all stable between-individual differences in both aggression (agg) and alcohol use quantity (alc) by subtracting each individual's score at each wave from his mean score across all waves (i.e., person-mean centering). As such, β_1 represents the within-individual association between changes in alcohol use and aggression across time. We chose to model contemporaneous (as opposed to time-lagged) associations between within-individual changes in alcohol use and aggressive behavior across adolescence because a concurrent association is consistent with psychopharmacological models that postulate that alcohol use will have acute effects on aggressive behavior. A strength of this procedure relative to autoregressive approaches is that it eliminates the possibility that any stable individual characteristic (e.g., race, stable impulsivity) can influence the dependent variable. Specifically, all between-subjects factors will be unrelated to the aggression outcome because this outcome variable has an aggregate mean of zero across the assessment waves for every subject (i.e., $\bar{Y}_{agg_{\bullet i}} - Y_{agg_{ti}}$). This approach produces generally equivalent estimates of time-varying effects in hierarchical linear models or intercept only growth models, as has been demonstrated in previous work (Osgood et al., 1996).² For the current study, within-individual changes in both marijuana and hard drug use across time are also included in the model to rule out the possibility that fluctuations in the use of these substances can account for the association between changes in alcohol and aggression over time.

We expand on the basic equation outlined above to examine the potential moderating effect that time-invariant individual and contextual variables have on the linkage between changes in alcohol and aggression over time. For example, the basic form of the model for testing the moderating effect of mean levels of peer violence would be:

$$(\bar{Y}_{agg_{\bullet i}} - Y_{agg_{ti}}) = \beta_1(\bar{X}_{alc_{\bullet i}} - X_{alc_{ti}}) + \beta_2((\bar{X}_{alc_{\bullet i}} - X_{alc_{ti}}) * \bar{X}_{peer_{\bullet i}}) + e_{ti}.$$

As indicated above, the between-individual factor representing stable (i.e., mean) levels of peer violence across all waves ($\bar{X}_{peer_{\bullet i}}$) will be orthogonal to the aggression outcome ($\bar{Y}_{agg_{\bullet i}} - Y_{agg_{ti}}$), which has a mean of zero for all participants. As a result, it is not necessary to include mean peer violence in the model as a main-effect variable even though this variable is probed for an interaction effect. It is possible that stable individual differences in peer violence may explain why within-individual changes in alcohol use are more strongly related to changes in aggression over time for some individuals compared to others. Along these lines, coefficient β_2 represents the interaction between stable (i.e., mean) levels of peer violence and within-individual changes in alcohol quantity predicting wave-to-wave changes in aggression. Again, it is unnecessary to include the main effect of peer violence in the model when testing this interaction (as is standard practice in most regression analyses) because all stable between-individual factors are orthogonal to the outcome variable and will not influence the estimated model parameters. For this study, the model above is expanded to include the potential moderators of race, impulsivity, positive attitudes toward violence, peer violence, and neighborhood crime simultaneously. All moderators were grand mean centered prior to conducting analyses (Cohen, Cohen, West, & Aiken, 2003). Significant interactions were probed at high (1 *SD* above the mean) and low (1 *SD* below the mean)

²Skewness of the within-individual alcohol and aggressive behavior changes scores was less than 1 (–.11 to .38), and for all time-invariant variables, except peer violence (1.69), was less than 1 (–.07 to .73), suggesting non-normality was not a concern for the current models.

values of the moderator to determine the nature of the interaction using standard procedures for continuous variables (Aiken & West, 1991). We also repeated these analyses with changes in alcohol use as the dependent variable and changes in aggression as the independent variable.

RESULTS

Descriptive Statistics

Correlations and descriptive statistics for study variables are presented in Table 1. Original measures of alcohol quantity and aggressive behavior (without any person-mean centering) are included in this table to demonstrate the correlations between these variables and the moderators (i.e., how closely the relative standings of individuals on these variables are associated). This was done because, as mentioned previously in the analysis section, the correlation between the time invariant moderators and the change scores for alcohol and aggression over time (which are used in the primary analysis) will be zero. All risk factors but neighborhood crime were moderately to strongly associated with aggressive behavior ($r_s = .44$ to $.69$, $p_s < .01$) and alcohol use ($r_s = .32$ to $.38$, $p_s < .01$). Correlations among risk factors ranged from $.09$ to $.51$, with the largest correlation found between positive attitudes toward violence and peer violence. Multicollinearity among risk factors was not a concern for the current study.

Whites (mean = 2.28) reported significantly ($t = -8.43$; $p < .001$) higher levels of alcohol use quantity averaged across all waves than Blacks (mean = 1.51). No significant racial differences in mean levels of aggressive behavior were found. (These data are not shown but are available from the first author upon request.)

Changes in Aggression in Relation to Changes in Alcohol Use

A model in which within-individual change in aggressive behavior was regressed on within-individual change in alcohol, marijuana, and hard drug use was first estimated (see Model 1, Table 2). Within-individual increases in alcohol use were associated with within-individual increases in aggressive behavior across adolescence, while increases in marijuana use were actually associated with decreases in aggressive behavior. The effect associated with changes in hard drug use was nonsignificant.

The interactions between change in alcohol use and the potential moderators were then simultaneously added to the model (see Model 2, Table 2). When simultaneously examining the interactions, positive attitudes toward violence and neighborhood crime moderated the link between change in alcohol use and change in aggressive behavior. At high levels (i.e., one SD above the mean) of positive attitudes toward violence ($\beta = .12$, $p < .001$) and neighborhood crime ($\beta = .10$, $p < .001$), increases in alcohol use were associated with increases in aggressive behavior. However, at low levels (i.e., one SD below the mean) of positive attitudes toward violence ($\beta = -.01$, $p = .62$; see Figure 1) and neighborhood crime ($\beta = -.003$, $p = .91$; see Figure 2), change in alcohol use was unrelated to change in aggressive behavior. Impulsive behavior, peer violence and race were not significant moderators.

Alternative Model - Changes in Alcohol Use in Relation to Changes in Aggressive Behavior

In order to evaluate an alternative model, where the effect of aggression on alcohol use was tested, analyses were repeated regressing within-individual change in alcohol use on within-individual change in aggressive behavior, marijuana use, and hard drug use. The results indicated that changes in aggression ($\beta = .04$, $p < .01$), marijuana use ($\beta = .23$, $p < .001$), and hard drug use ($\beta = .09$, $p < .001$) were all significantly positively associated with change in

alcohol use. When the interactions between changes in aggression and the potential moderators were added to the model, only attitudes toward violence was a significant moderator ($\beta = .05, p < .01$). As with alcohol, for those high in positive attitudes toward violence, increases in aggressive behavior were significantly related to increases in alcohol use ($\beta = .08, p < .001$) but for those low in positive attitudes toward violence, the relationship was not significant ($\beta = -.03, p > .28$).

DISCUSSION

This study evaluated whether within-individual changes in alcohol use were associated with within-individual changes in aggressive behavior during adolescence and whether impulsivity, positive attitudes toward violence, peer violence, neighborhood crime, and race moderated this association. Based on a pharmacological model, we hypothesized that when youth drink more than their usual alcohol quantity in one year, they would tend to show a parallel increase in their aggressive behavior in the same year, with reductions in drinking resulting in decreased aggressive behavior. Indeed we found evidence that changes in alcohol use quantity and aggressive behavior waxed and waned in concert across adolescence.

Unlike most previous investigations of adolescents, we were able to rule out the possibility that stable individual difference characteristics and a broad array of selection effects accounted for the observed linkage between alcohol use and aggressive behavior by explicitly examining within-individual change. However, the findings did suggest that the association between changes in alcohol use and changes in aggressive behavior may vary between individuals based on both individual and contextual factors.

It was expected that the strength of the association between changes in alcohol use and aggressive behavior would vary as a function of four risk factors: impulsive behavior, peer violence, attitudes favoring violence, and neighborhood crime. Significant interaction effects were found for two of the four moderators evaluated. Increases in alcohol use were associated with increased aggressive behavior for those boys with more favorable attitudes to violence and those who lived in high-crime neighborhoods. As demonstrated by laboratory studies, individuals with a higher, compared to lower, propensity toward aggression are more likely to engage in aggressive behavior when intoxicated (Leonard, 2008). Our data support these findings and show that individuals who had positive attitudes toward violence increased their aggressive behavior when they increased their quantity of drinking. In contrast, for those with less positive attitudes, increases in drinking were not related to increases in aggressive behavior. For youth who lived in higher-crime neighborhoods, increases in drinking were associated with increased levels of aggression. High-crime neighborhoods may provide models for aggressive behavior, as well as create more situations in which individuals feel that they need to engage in aggressive behavior (Aneshensel & Sucoff, 1996). Thus, increased drinking appears to be more strongly linked to increases in aggressive behavior in contexts in which aggressive behavior is more prominent (i.e., high-crime neighborhoods) relative to contexts and situations in which aggressive behavior is less prominent (i.e., low-crime neighborhoods), as well as in individuals more accepting of aggressive behavior.

We found no differences in the associations between increases in alcohol use and increases in aggressive behavior for Black and White young men. Therefore, although Black and White drinkers typically differ in their rates of alcohol use in adolescence, both groups tend to experience similar increases in aggressive behavior when increasing their quantity of drinking across adolescence. However, it is important to note that individuals who lived in high-crime neighborhoods were more likely to increase their aggressive behavior when their

drinking increased. Because Black males in this study are over-represented in the highest crime neighborhoods in the City of Pittsburgh (Loeber et al., 2008), this finding suggests that drinking may be a more risky proposition among Black adolescents in terms of escalating their aggressive behavior. It is also possible that the use of an aggression scale rather than a measure of more serious violence may have accounted for our finding of no race differences in the associations between within-changes in alcohol and within-individual changes in aggressive behavior. On the other hand, no previous studies have actually examined race as a moderator of the types of within-individual changes that we examined in this study.

In contrast to findings from prior laboratory studies (e.g., Giancola, 2002b), impulsive behavior did not moderate the association between increases in alcohol use and increases in aggressive behavior. This study did not measure acute use of alcohol and, therefore, cannot approximate a laboratory situation. While the measure of impulsive behavior encompassed only a single self-report item, it was aggregated across multiple time points to index trait-like levels of the construct. In addition, this single item was shown to be robustly related to alcohol use in a previous investigation (White et al., 2011). Despite this evidence that impulsive behavior could reasonably be approximated by a single item, previous research has found that impulsivity is multi-faceted (e.g., thrill-seeking, urgency) and different types may relate differently to drinking behavior (Dawe & Loxton, 2004; Dick, Smith, Olausson, Mitchell, Leeman, O'Malley, & Sher, 2010; Gullo & Dawe, 2008). Therefore, if we had a more multi-faceted measure of impulsivity and/or had more items assessing impulsivity, we may have found moderation effects consistent with prior research (e.g., Felson, Teasdale et al., 2008).

We also found that violent peers did not moderate the association between changes in alcohol use and changes in aggressive behavior. It is possible that the moderating effect of peers is better accounted for by violent attitudes or high-crime neighborhoods. Thus, when the interaction between change in alcohol use and violent peers is included in the same model with these other two interactions (i.e., alcohol use by high-crime neighborhoods and alcohol use by positive attitudes toward violence), the former loses its effect.

As noted earlier, there may be a number of common, within-person factors that increase the risks for both heavy drinking and aggressive behavior and thus youth who increase one behavior are likely to increase the other. However, increases in marijuana and hard drug use, which are also predicted by similar risk factors, were associated with increases in alcohol use, but these factors were not associated with increases in aggressive behavior. In fact, increased marijuana use was actually associated with decreases in aggressive behavior. Thus, the results support a unique association between alcohol use and aggression, which has also been found in laboratory research of acute effects (White & Gorman, 2000).

There are several limitations to this study that should be noted. The measures of aggressive behavior, alcohol use, and the moderators (except neighborhood crime) came only from the youths' self-reports, which could have biased the results. Nevertheless, alphas were more than acceptable and previous studies have found self-reports of substance use (Johnston & O'Malley, 1985) and delinquent behavior (Hindelang, Hirschi, & Weis, 1981) to be valid. Using multiple respondents, however, could strengthen the validity of the data. For the neighborhood variable, we used primarily data from the parent and then from the youth. Switching respondents could have affected the score for this variable across time. However, across time stability was similar during the periods for predominantly parent reports and predominantly youth reports and reliability coefficients were high ($>.9$) at all ages.

As discussed above, we examined typical quantity of drinking each year rather than acute intoxication at the time of an aggressive act. Thus, we did not measure the direct effects of alcohol use on aggressive behavior. Along these lines, it is possible that those who increase the quantity of their drinking become more aggressive because they are more likely to experience hangover-induced irritability following a night of heavy drinking (White & Gorman, 2000). Furthermore, we examined changes in typical quantity of drinking without taking into account frequency of drinking that amount. However, because we were primarily interested in psychopharmacological associations between alcohol use and aggressive behavior, we chose to model within-time effects and use a measure of quantity to better capture potential acute cognitive impairment. Nevertheless, other measures of alcohol use, such as levels of intoxication or problems, are also related to aggressive behavior (Leonard, 2008) and should be examined in future studies of adolescents.

In this study we used a broad measure of aggressive behavior rather than physical aggression or serious violence, which is often used in studies examining the associations between acute alcohol use and violence (e.g., Swahn & Donovan, 2004; White et al., 1999). Thus, a measure of physical aggression would have made our study more comparable to previous survey studies. Note, however, that laboratory studies use proxy measures of aggressive responding, which are not always physical aggression (Giancola, 2002a). Furthermore, our measure captured a range of behaviors, which can help to generalize previous findings to a broader range of aggressive behaviors. Nonetheless, future research should examine how drinking is similarly/differentially associated with various dimensions of aggressive behavior.

This study included only males, and the effects of drinking on aggression may differ for females. In addition, we only included Blacks and Whites from a single geographic area. Also, the sample was enriched by oversampling high-risk youth. If these youth began adolescence at relatively high levels of aggressive behavior or heavy drinking, then it could have limited their chances for experiencing changes in either behavior. On the other hand, the sample provides the opportunity for studying a broader range of aggressive behavior than found in typical community samples. Future studies, therefore, need to replicate these findings with more diverse samples. Further, this study focused on adolescents, and these associations may be different at younger or older ages (White, Lee, Mun, & Loeber, 2012). Finally, the magnitude of the effects found in this study was relatively modest. This finding is not surprising given that there are multiple factors besides increased alcohol use that cause individuals to become more aggressive over time and not all individuals become aggressive when drinking. In addition, small effects are common when investigating longitudinal associations between constructs using within-individual change models (Osgood et al., 1996).

Despite these limitations, this study had several advantages over prior research. First, as discussed above, we included a large sample of high-risk youth and were able to examine race differences and a broad range of aggressive behavior. Second, we focused on a large age span during adolescence and examined dynamic within-individual changes in aggressive behavior in relation to within-individual changes in alcohol use over time. This analytic design rules out the possibility that stable individual difference characteristics accounted for the linkage between changes in alcohol use and aggression, effectively eliminating a broad array of selection effects as potential confounds. Finally, we examined potential individual and contextual moderators, which have not been simultaneously evaluated in previous studies of adolescents.

Overall, the results suggest that when adolescents increase the quantity of their drinking they tend to exhibit increases in aggression and vice versa, a linkage that was not found for other

substance use. This difference between alcohol use and other drugs, especially marijuana, has been found in several other studies of substance use and violence (Gorman & White, 2000). In the U.S., there is currently a great deal of public health concern about underage drinking (U.S. Department of Health and Human Services, 2011). Despite the fact that annual prevalence rates for adolescents have declined in recent years, 29% of 8th graders, 52% of 10th graders and 65% of 12th graders report drinking in the past year and 14%, 29%, and 41%, respectively, report past month use (Johnston, O'Malley, Bachman, & Schulenberg, 2011). In addition, rates of heavy episodic drinking (5+ drinks in a row) increase from 16% of 8th graders to 37% of 10th graders to 54% of 12th graders. Given the strong acute and developmental associations between alcohol use and aggressive behavior during adolescence, it is clear that reductions in drinking would lead to reductions in rates of adolescent aggressive behavior. Therefore, from a public health perspective, we need to find ways to limit youth's access to alcohol. In addition, targeting aggressive youth for alcohol interventions might be an effective strategy to curb both drinking and aggression. Our findings also indicated that the association between alcohol use and aggressive behavior was stronger for boys who have positive attitudes toward violence and who live in high-crime neighborhoods. Thus, it may be cost-effective to target youth with permissive attitudes toward violence for interventions focused on preventing early drinking or decreasing heavy drinking as a way to reduce aggressive behaviors. In addition, alcohol interventions are needed for adolescents who live in high-crime neighborhoods and who have begun drinking at an early age not only to reduce their risks of developing later alcohol problems but also to reduce their potential for later aggressive behaviors. In conclusion, interventions for the prevention of aggression should consider targeting not only alcohol use, but also individual and environmental risk factors that contribute to this link.

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Figure 1.
Association between Change in Alcohol Use and Change in Aggressive Behavior Moderated by Positive Attitudes toward Violence

Figure 2.
Association between Change in Alcohol Use and Change in Aggressive Behavior Moderated by Neighborhood Crime

Table 1
Descriptive statistics on aggressive behavior, alcohol use, and the risk factors and the correlations among them

	Aggressive Behavior	Alcohol Quantity	Impulsive Behavior	Positive Attitudes toward Violence	Peer Violence	Neighbor-hood Crime
Alcohol Quantity	.37 ^a (.21–.34) ^b					
Impulsive Behavior	.69 (.51–.54)	.32 (.15–.26)				
Positive Attitudes toward Violence	.44 (.26–.38)	.38 (.19–.27)	.40 (.18–.30)			
Peer Violence	.49 (.36–.40)	.35 (.21–.33)	.40 (.24–.29)	.51 (.29–.39)		
Neighborhood Crime	.12 (.06 ^d –.22)	–.05 (–.05 ^d –.03)	.09 (.0 ^d –.21)	.10 (.02 ^d –.14)	.28 (.12–.34)	
Mean ^c	8.09	1.84	0.52	0.81	1.58	15.51
SD	5.29	1.42	0.41	0.60	1.73	4.32
Range of Means	6.59–9.19	1.01–2.71	0.40–0.63	0.72–0.87	1.43–1.66	15.12–15.68
Range of Values	0–35	0–5	0–2	0–3	0–12	10–30

Notes:

^aCorrelation (*r*) of one variable mean across ages 13–18 with the other variable mean across ages 13–18.

^bRange of correlations at each age (i.e., aggressive behavior at age 13, aggressive behavior at age 14, etc. through age 18).

^cMean value and Standard deviation (SD) for the variable across ages 13–18. Range of means is the mean for the variables at each age from age 13 to age 18. Range of values is range for the variable/scale score across all ages.

^dAll correlations significant ($p < .05$) except these.

Table 2

Results from the regression panel models predicting change in aggressive behavior

	Model 1: First-Order Effects Model $R^2 = .003$			Model 2: Interaction Model $R^2 = .01$		
	B^a	SE^b	β^c	B	SE	β
Change in Hard Drug	.238	.321	.011	.394	.323	.019
Change in Marijuana	-.002	.001	-.045*	-.004	.001	-.064*
Change in Alcohol	.109	.036	.048*	.117	.037	.051*
Change in X Impulsive Behavior				-.096	.098	-.016
Change in X Positive Attitudes toward Violence				.243	.073	.062*
Change in Alcohol X Peer Violence				.037	.028	.027
Change in Alcohol X Neighborhood Crime				.028	.010	.052*
Change in Alcohol X Race				-.047	.081	-.011

^a β = standardized regression coefficients^bSE = standard errors* $p < .05$