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Developmental associations between substance use and violence

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Abstract
This study examined the developmental associations between substance use and violence. We examined the trends in each behavior throughout adolescence, how the behaviors covaried over time, and the symmetry of associations taking into account frequency and severity of each behavior. We also examined whether changes in one behavior affected changes in the other behavior over time. Six years of annual data were analyzed for 506 boys who were in the seventh grade at the first assessment. Concurrent associations between frequency of substance use and violence were relatively strong throughout adolescence and were somewhat stronger for marijuana than alcohol, especially in early adolescence. Type or severity of violence was not related to concurrent alcohol or marijuana frequency, but severity of drug use was related to concurrent violence frequency. Depending, to some degree, on the age of the subjects, the longitudinal relationships between substance use and violence were reciprocal during adolescence and slightly stronger for alcohol and violence than for marijuana and violence. Further, increases in alcohol use were related to increases in violence; however, when early alcohol use was controlled, increases in marijuana use were not related to increases in violence. Only in early adolescence was the longitudinal relationship between marijuana use and later violence especially strong. The strength of the longitudinal associations between violence and substance use did not change when common risk factors for violence and substance use were controlled. Overall, the data lend more support for a reciprocal than for a unidirectional association between substance use and violence. Prevention efforts should be directed at aggressive males who are multiple-substance users in early adolescence.

A statistical association between substance use and violence has been well documented in criminal and addict populations as well as community samples (for a review, see White, 1997a). Although correlation does not establish causality, social policy has often been based on the assumption of causality with proponents supporting a psychopharmacological model for alcohol and a systemic model for other drugs, such as marijuana and cocaine (for a review, see White, 1997a). Those who adhere to a psychopharmacological model believe that the effects of intoxication (disinhibition, cognitive–perceptual distortions, attention deficits, bad judgment, neurochemical changes, etc.) and the situational factors accompanying occasions of intoxication cause aggressive behavior (Collins, 1981; Fagan, 1990; Pernanen, 1993; Pihl & Peterson, 1993). In contrast, those who support a systemic model postulate that the system of drug distribution and use is inherently connected with violent crime (Goldstein, 1985; Miczek, DeBold, Haney, Tidey, Vivian, & Weerts,

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1994). Given that there are no legal mechanisms to resolve disputes (e.g., over organizational and territorial issues or quality and amount), violence or the threat of violence is used to enforce rules in the illicit drug market.

However, research findings have consistently shown that these supposed causal processes are moderated by individual characteristics and situational contexts, and, in fact, the associations between violence and substance use are more likely the result of a spurious association than a causal one (see Fagan, 1993; White, 1997a). For example, it has been demonstrated that violent individuals are attracted to the illegal drug market rather than that drug dealing causes individuals to initially become violent (Fagan & Chin, 1990; Van Kammen & Loeber, 1994). In addition, research demonstrates that the psychopharmacological effects of alcohol on aggression are more prominent among those who already have an elevated inclination to be aggressive (for a review, see Lang, 1993).

Reviews of the research on drug use and violence among adolescents conclude that there is little evidence that alcohol or drug use cause violence (Osgood, 1994). Rather the association between substance use and violence in adolescence is assumed to be spurious (for reviews, see White, 1990, 1997a,b). Those who support a spurious model suggest that substance use and violent behavior are predicted by the same common set of risk factors or that drug use and violence cluster together as a result of experimentation with a wide range of deviant behaviors during the adolescent stage in the life cycle (see Jessor, Donovan, & Costa, 1991; Jessor & Jessor, 1977).

Numerous common risk factors have been identified within the individual (such as difficult temperament, impaired executive cognitive functioning, internalizing problems, attention deficit–hyperactivity disorder, risk taking, and inability to delay gratification), the family domain (such as parental alcoholism, harsh and erratic discipline, abuse or rejection in the family, and lack of parental nurturance), and the environment (such as deviant peer groups and community disorganization) (Brewer, Hawkins, Catalano, & Neckerman, 1995; Chermack & Giancola, 1997; Hawkins, Catalano, & Miller, 1992; Reiss & Roth, 1993; Tremblay & Craig, 1995; White, 1997b). It remains to be demonstrated which of these and other factors are "necessary" causes for both substance use and violence and whether the relationship between substance use and violence is weakened when these risk factors are controlled.

Other researchers have advocated a more differentiated approach (e.g., Fagan, Weis, Cheng, & Watters, 1987; Gillmore, Hawkins, Catalano, Richard, Day, & Moore, 1991; Loeber, 1988; McGee & Newcomb, 1992; Osgood, Johnston, O'Malley, & Bachman, 1988; White & Labouvie, 1994; White, Pandina, & LaGrange, 1987). These researchers claim that although substance use and violence share several common causes or predictors, there are also specific factors that determine which adolescents will specialize in each behavior. In a review, White and Labouvie (1994) argued that, overall, the literature on the relationship among problem behaviors in nonclinical samples of adolescents would seem to argue against the generality of deviance hypothesis because of the generally low correlations among problem behaviors, the fact that various problem behaviors follow different developmental paths, the fact that problem behaviors do not cluster together for all adolescents, and the fact that there are several distinct influences on each behavior (Elliott, Huizinga, & Menard, 1989; White, 1990). Further, the clustering of different problem behaviors tends to change with age (see, e.g., McGee & Newcomb, 1992). Thus, in studying the relationship between drug use and violence, one needs to consider common and specific risk factors.

Laboratory studies of adults suggest that it is also necessary to address differences among categories of drugs. Studies on acute effects in laboratory studies have found that alcohol compared to other drugs, such as marijuana and heroin, is more strongly associated with aggression (Miczek et al., 1994). The question remains, however, as to whether there are differences between alcohol and other drugs in their *developmental* associations with vio-

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lence. Knowledge of developmental associations is relevant for both the definition of risk groups as well as the targeting of factors for prevention and intervention (Cicchetti, 1993; Cicchetti & Toth, 1992; Kellam & Rebok, 1992; Koretz, 1991). Statistically significant developmental associations between different types of substance use and violence, however, do not have to reflect causation. For instance, studies on the acute effects of marijuana use have found that moderate doses are likely to suppress violence (Miczek et al., 1994). In the case that a developmental association between marijuana use and violence is found, a critical test is whether the association will disappear once prior violence and alcohol use are taken into account. If this is the case, then the initial observation of an association between marijuana use and violence is spurious.

Another question concerns the strength of association between various substances and violence. In general, correlational analyses in survey studies have indicated that the relationship between drug use and violence is the same as or stronger than the relationship between alcohol use and violence (Cohen, Lipsey, Wilson, & Derzon, 1994; Osgood, 1994; White, 1997b). Elliott, Huizinga, and Menard (1989) found that there were greater levels of violence among polydrug users and marijuana users (who also used alcohol) than among those who only used alcohol. In a multiethnic study of adjudicated delinquents and high school students, Watts and Wright (1990) found that across ethnic and racial groups the best predictor of violent delinquency was use of illegal drugs. In the multivariate analyses including all categories of drugs, alcohol use was not a significant predictor of violent delinquency for any of the three ethnic groups. Overall, the literature suggests that the relationship between alcohol use and violence in adolescence is not specific and, if anything, multiple drug use compared to alcohol use is more strongly related to violence (White, 1997a).

Regardless of the reasons for the association, drug users as opposed to nonusers are more likely to be involved in violence, both as perpetrators and as victims (Carpenter, Glassner, Johnson, & Loughlin, 1988; Elliott et al., 1989; Kingery, Pruitt, & Hurley, 1992; Osgood, 1994). In fact, several studies have demonstrated a synchrony in the progression through the stages of drug use and the stages of delinquency (Le Blanc & Loeber, 1998). Elliott and colleagues (1989) found that serious delinquents (which included the most serious violent offenders) had by far the highest rates of consumption of alcohol, marijuana, and other drugs and the rates decreased moving down the typology from serious delinquents to nonserious, to exploratory, and finally to nondelinquents. Similarly, for virtually all offenses (including violent offenses), polydrug users reported the highest prevalence rates and nonusers reported the lowest rates (see also Fagan et al., 1987; White, Johnson & Garrison, 1985).

Developmentalists have pointed to the fact that the development of substance use often takes place in an orderly fashion, starting with tobacco use and alcohol use as initial steps depending on sex, marijuana use as next step, and hard drug use as a last step (Kandel, Yamaguchi, & Chen, 1992). Those who advance to hard drugs tend to continue to use substances from lower steps in the developmental progression, which helps to account for the polydrug users. As to the development of delinquency, there is increasing evidence for developmental progressions in delinquency, starting with the least serious forms of delinquent acts and escalating to the most serious acts (Kelley, Huizinga, Thornberry, & Loeber, 1997; Loeber, Wung, Keenan, Giroux, Stouthammer–Loeber, Van Kammen, & Maughan, 1993). Among those who engage in both delinquency and drug use, delinquent behavior (including aggressive delinquency) developmentally precedes the initiation into drug and usually alcohol use (Elliott et al., 1989; see also White, 1990, for a review). However, studies also show that increases in property crime and acquisitive violence occur subsequent to regular use of hard drugs among adolescents (Loeber, 1988). Further, for those who engage in both behaviors, progressions in substance use and in delinquency do not occur independently over time. Re-

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cently Le Blanc and Loeber (1998) have superimposed the developmental sequences in substance use and delinquency and demonstrated the synchronous development between the two sets of behavior.

The synchronous nature of the developmental association between substance use and violence, certainly in a broad window of a year, means that the exact developmental interactions between the two are often difficult to disentangle. Thus, we would expect that in a synchronous fashion substance use is predictive of violence, but that violence is also predictive of substance use. For example, Fagan, Weis, and Cheng (1988) studied the synchrony of drug use and delinquency using a similar typological approach to Elliott et al. (1989). Their findings suggested that the strength of the association between substance use and delinquency depended on the severity of the delinquency and the types of substances used. It is, therefore, important to examine the relationship between substance use and violence taking into account frequency and severity.

From a developmental perspective, correlational studies of adolescents have found significant but relatively weak to modest associations between alcohol or drug use and violence, which tend to peak in middle adolescence and then decrease in strength in late adolescence (White, Pandina, & Labouvie, 1985). This fits with findings that show a much stronger overlap between substance use and delinquency in early adolescence compared to later adolescence (Loeber, 1985; Wechsler & Thum, 1973). Fagan and colleagues (1988) claim that it is not surprising that there is an association between these behaviors at this time because experimentation occurs during a relatively narrow life period. Thus, in early to middle adolescence, the associations may be stronger because all these behaviors fit one general problem behavior syndrome (Jessor & Jessor, 1977). However, the decline in the strength of the relationships in late adolescence may be due to the occurrence of differentiation between behaviors. At that point, deviance may become diffused and individuals may begin to specialize in either drug use or crime (see White & Labouvie, 1994).

While several studies have examined the longitudinal associations between drug use and delinquent and criminal behavior (see Kaplan, 1995), few studies have examined the longitudinal relationships between drug use and aggression specifically. In a meta-analysis, Cohen and colleagues (1994) reported fairly weak associations between alcohol use and aggression across time. The average correlation between Time 1 alcohol use and Time 2 violence was .01 and between Time 1 violence and Time 2 alcohol use was .09, suggesting that perhaps violence was more strongly related to later alcohol use than alcohol use was to later violence. A similar meta-analysis by Derzon and Lipsey (1999) on the association between marijuana use and aggressive behavior reported relatively weak weighted mean correlations (coefficients ranged from .11 to .13), but the strength of the relationship was similar in both directions. The strongest relationships between marijuana and aggression occurred in early adolescence, and the analysts did not find a consistent relationship between marijuana and aggressive delinquency after early adolescence. They concluded that use of marijuana does not establish a developmental trajectory to aggressive behaviors.

Farrington (1995) found that males who were aggressive in childhood or adolescence were more likely to be heavier drinkers and drug takers in adulthood. He suggested that this continuity is probably not specific to aggression but rather part of a general continuity in antisocial behavior from childhood to adulthood. Similarly, White and colleagues (White, Brick, & Hansell, 1993; White & Hansell, 1996) found that aggression in early adolescence predicted later alcohol use but alcohol use did not significantly affect later aggression at any point during adolescence. Alternatively, a study of juvenile offenders in Finland found that those juveniles who had arrests for drunkenness were more likely to have arrests for violent crimes 5–10 years later (Virkkunen, 1977; see also Pulkkinen, 1983). As well, in a study of adolescent of-

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fenders, Dembo and colleagues (1991) found that alcohol use predicted violent offending approximately 1 year later. Both Kandel and colleagues (Kandel, Simcha–Fagan, & Davies, 1986) and Kaplan and Damphousse (1995) have shown that drug use in adolescence increases aggression in adulthood. White and Hansell (in press) found that marijuana and cocaine use in late adolescence predicted increases in aggressive behavior in early adulthood, but marijuana use in early adolescence predicted decreases in aggressive behavior in midadolescence. Further, aggressive behavior did not predict later increases in drug use at any point in time.

In sum, the few longitudinal studies that have examined the temporal associations between drug use and aggressive behavior report mixed findings. Most studies have found that early aggression predicts later alcohol problems, yet the findings are equivocal as to whether early alcohol use predicts later aggression. Many studies have found that early drug use predicts later aggression. Few of the longitudinal studies have examined the impact of specific drugs on later violence and the extent to which relationships tend to be reciprocal in strength or be asymmetrical.

In this study we examine the co-occurrence of substance use and violence within a developmental framework. Specifically, we are interested in determining whether the data fit a general model in which substance use and violence are reciprocally interrelated, or if the data fit a specific model in which substance use is more strongly predictive of violence over time than violence is predictive of substance use. We address the following questions:

1. What are the trends in the frequency of substance use and violence throughout adolescence and how do they covary over time?
2. Do the strengths of the associations between substance use and violence vary by frequency or severity of the behaviors?
3. Is substance use more predictive of later violence (while controlling for earlier violence) than violence is predictive of substance use (while controlling for earlier substance use), or is there a reciprocal relationship? And is the relationship with violence stronger for alcohol use than for other substance use?
4. Is the relationship between substance use and violence spurious? That is, do the longitudinal associations between violence and substance use remain strong when one controls for common risk factors?
5. Do individuals who increase their substance use also become more violent over time, compared to those who stay stable or decrease in substance use, and similarly do those who increase their violence compared to those who decrease or remain stable also increase their substance use over time?

Method

Design and sample

Data were collected as part of the Pittsburgh Youth Study (PYS). The PYS is a prospective longitudinal study of the development of delinquency, substance use, and mental health problems (Loeber, Farrington, Stouthamer–Loeber, & Van Kammen, 1998a). In 1987–1988, random samples of first, fourth, and seventh grade boys enrolled in the City of Pittsburgh public schools were selected. Approximately 850 boys in each grade (85% of the target sample) were screened. About 500 boys in each grade (the 250 most antisocial and another 250 randomly selected from the remaining 600) were selected for the first follow-up 6 months later. For the present analyses we used only the oldest cohort ($N = 506$). After the first follow-up, the boys in the oldest cohort were subsequently followed up at 6-month intervals for four additional assessments and then at yearly intervals for another three assessments. Attrition has remained relatively low and 92.7% of the original sample was followed up at the last assessment.

In order to use a common 1-year period for our analyses, we combined the first and second 6-month assessments, the third and fourth, and the fifth and sixth. Merging these

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three combined assessments with the next three yearly assessments gives us six waves of annual data from average age 13.25 years to 18.5 years. The sample is 57.5% African American, with the remainder almost all White. In addition, 36.2% of the boys' families received public assistance or food stamps. (For greater detail on subject selection and sample characteristics, see Loeber et al., 1998a).

Measures

Much of the data come from self-report questionnaires from the subjects, which are supplemented by some parent and teacher reports. Self-reports are generally accepted as reliable and valid indicators of delinquent behavior and drug use (Farrington, Loeber, Stouthamer–Loeber, Van Kammen, & Schmidt, 1996; Hindelang, Hirschi, & Weis, 1981; Single, Kandel, & Johnson, 1975) if conducted in appropriate settings under nonthreatening circumstances (see Dembo, Williams, Wish, & Schmeidler, 1990). In addition, self-reports provide a more direct, sensitive, and complete measure of various forms of deviant behavior than do measures based upon official law enforcement and institutional records and avoid the problem of false negatives (i.e., "hidden" cases; Elliott et al., 1989). (For greater detail on the advantages and disadvantages of self-report data, see Elliott et al., 1989; Farrington et al., 1996; Hindelang et al., 1981.)

Violence measures

We examined the frequency of six forms of violent behavior: carried a hidden weapon, strong arming, attacked with a weapon or with intent to seriously hurt or kill someone, gang fights, hurt or threatened to hurt someone to have sex with you, and forced sex or attempted to. Frequency was the sum of the number of times subjects engaged in all of the behaviors in the scale during the last year. For some analyses subjects were dichotomized into the worst fourth (top 25% in terms of frequency) versus the rest.

In order to assess severity of violence, we created a violence-stage classification based on reports from the child, parent or guardian, and teacher (Loeber et al., 1998a): 1, none; 2, minor (gang fighting or carrying a hidden weapon); 3, moderate (strong-arming); and 4, serious (attacked with a weapon or with intent to seriously hurt or kill someone, hurt or threatened to hurt someone to have sex with you, or forced sex or attempted to). Subjects were classified by the most serious category of behavior that they engaged in at least once within the last year.

Drug-use measures

Frequency of alcohol use was the sum of the number of times subjects used beer, wine, or hard liquor during the past year. We also measured frequency of use (number of times) of marijuana during the past year. For other drugs (hallucinogens, cocaine, crack, heroin, PCP, and nonmedical use of tranquilizers, barbiturates, codeine, amphetamines, and over-the-counter medications), frequency was the sum of the number of times for all of the other drugs listed above. For some analyses subjects were dichotomized into the worst fourth (top 25% in terms of frequency) versus the rest.

To measure severity of drug use at each year, we created a drug-stage variable which was 1, no use; 2, alcohol use at least once but no marijuana or other drug use; 3, marijuana use at least once but no other drug use; 4, other drug use at least once (see Kandel et al., 1992).

Common risk factors

We selected several common risk factors for drug use and violence based on the results of our previous analyses (e.g., Loeber, Farrington, Stouthamer–Loeber, & Van Kammen, 1998a,b). All measures were based on subject self-report at Phase A (first follow-up) unless otherwise noted. We included other problem behaviors, such as frequency of property crime (S plus A), number of times subjects engaged in sexual intercourse, and academic achievement (assessed by parents, teachers, and subjects at S and A). Within the psychological domain we included depressed mood

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and hyperactivity–impulsivity–attention problems (assessed by the parent and teacher at S and A). In the family domain, we included poor communication with parents (assessed by the subject and parent) and poor supervision by parents (assessed by the subject and parent). Finally, we included a measure of bad neighborhood (assessed by the parent). (For greater detail on these measures see Loeber et al., 1998a,b.)

Analyses

As stated above, we combined the first (S) and second (A) phases, the third (B) and fourth (C) phases, and the fifth (D) and sixth (E) phases in order to assess subjects on a yearly basis. For frequency items we summed the two combined phases, and for stage we took the maximum value of the two phases.

Correlational analysis is one way to determine the association between substance use and violence. However, product moment correlations depend on normally distributed and linearly related interval scales. If variables are skewed or measured in a small number of categories, the maximum *r* that can result is substantially less than 1 (Farrington & Loeber, 1998). Given that substance use and violence are highly skewed, and the variance changes in each measure over time, it is difficult to interpret correlation coefficients. In this study, we dichotomized our measures and used odds ratios in order to assess the associations between frequency of substance use and violence throughout adolescence. (For details on the advantages of using dichotomized variables to measure associations, see Farrington & Loeber, 1998.) The analyses of the concurrent relationships are developmental in the sense that they examine the cross-sectional associations for the same subjects over time from age 13.25 to 18.5 years in order to determine whether the strengths of the associations vary at different stages of adolescence.

For the longitudinal association analyses we used logistic regression for the frequency associations in order to allow comparisons of odds ratios across analyses. In the longitudinal analysis we were also interested in changes within individuals over time. The modeling of individual growth curves was based on the method of orthogonal polynomials (Cohen & Cohen, 1983). Because we were interested in change over time, we chose the first-order polynomial, which represents the linear trend. This trend indicates the rate and direction of change (i.e., increases and decreases across the total time period). The weights for the equation (see Results below) were based on orthogonal polynomial coding for six test occasions with equal (1-year) spacing between test occasions (Cohen & Cohen, 1983, table 6.3.1, p. 243). (For greater detail, see White, Bates, & Labouvie, 1998.)

Results

Prevalence and frequency of substance use and violence

Table 1 presents the prevalence rates for the four violence stages. At each wave the majority of subjects are in the no-violence level. The no-violence group appears to increase somewhat from early to late adolescence. While the no-violence group increases, the minor-violence group (i.e., fighting, weapons) decreases (i.e., more subjects move from minor violence to no violence over time). As well, the strong-arming group decreases over time. On the other hand, the serious-violence group appears to remain relatively consistent in terms of numbers over time. Keep in mind that these numbers do not necessarily represent the same subjects at each point in time.

The prevalence of drug stage over the 6-year period is also shown in Table 1. There is a decline in the no-use group with age from age 14.25 until age 18.5 years. On the other hand, the marijuana and other-drug groups increase with age. Because the drug-stage groups are mutually exclusive, the changes in the numbers of subjects in the alcohol group reflect both movement of some subjects from no use to alcohol only as well as other subjects from alcohol only to other drugs. Given the very small number of other drug users, we omitted other drugs and compared marijuana users with alcohol users in the analyses below.

Examination of trends in frequency for the

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Table 1. *Prevalence (%) of violence stage and drug stage by age*

	Age					
	13.25	14.25	15.25	16.5	17.5	18.5
Violence stage						
None	54	60	64	70	67	72
Minor	24	26	23	21	23	19
Moderate	13	7	5	3	2	1
Serious	9	7	8	7	9	8
Drug stage						
None	44	57	50	42	38	23
Alcohol	46	31	34	43	34	41
Marijuana	8	8	11	12	24	31
Drugs	2	3	4	3	5	5

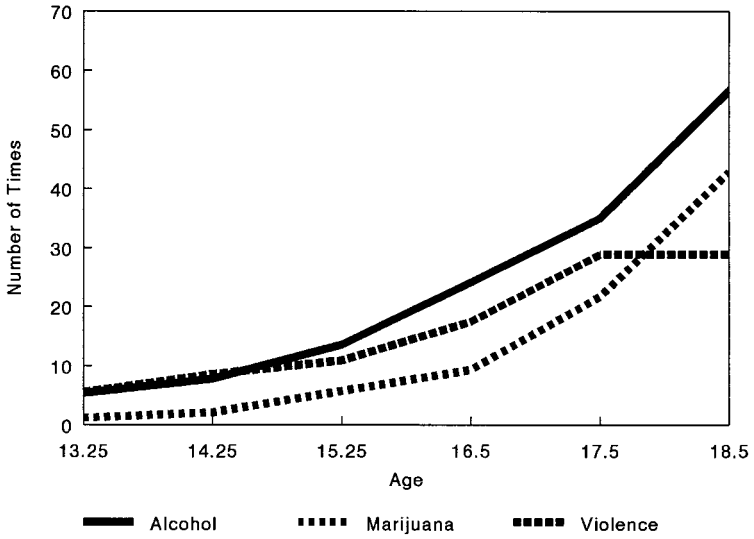


Figure 1. Mean frequency of alcohol use, marijuana use, and violence by age.

three behaviors demonstrates clear distinctions between substance use and violence. Figure 1 presents the mean number of times subjects engaged in violence and substance use over the 6-year period. By middle adolescence (age 15.5 years), there is an increase in the frequency of violent behavior with a leveling off from age 17.5 to age 18.5 years. The overall linear trend for violence is significant ($p < .001$) and positive indicating an increase in the frequency of violence over the course of the study. The linear trends for alcohol and marijuana frequency are also significant ($p < .001$) and positive. The frequencies of alcohol and marijuana use increase steadily over time and do not level off by age 18.5 years. These findings for age trends in delinquency and drug use are consistent with other longitudinal studies (e.g., Elliott et al., 1989; White, 1997b).

Concurrent associations between substance use and violence over time

In order to assess the concurrent associations between substance use and violence, we examined the associations between frequency of substance use and frequency of violence at each year. For these analyses we divided subjects into the worst quarter (approximately the

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Table 2. *Concurrent associations between frequent alcohol and marijuana use and violence*

	Odds Ratios	
Age	Alcohol by Violence	Marijuana by Violence
13.25	6.0	10.5
14.25	5.8	5.5
15.25	7.4	7.3
16.5	4.2	5.5
17.5	5.5	4.3
18.5	3.5	4.7

Note: Odds ratios were derived from two by two cross-tabulations in which frequency was dichotomized into the top 25% versus the rest. All odds ratios are significant at $p < .001$

top 25%) versus all others for each of the three frequency scales at each point in time and examined the associations among these behaviors in two-by-two cross-tabulations (see Farrington & Loeber, 1998). The results are presented in Table 2. The odds ratios (ORs), all of which are significant, for frequency of alcohol use and violence range from a low of 3.5 to a high of 7.4. They are somewhat higher in early to middle adolescence than in later adolescence, although they are fairly consistent over time. Note how the associations between frequent alcohol use and violence are the same as or lower than those for frequent marijuana use and violence. Hence, these data indicate that frequent drinkers as compared to nondrinkers and light drinkers are at least 3.5 times more likely to be frequently violent. Alternatively, the worst violent offenders as compared to the other subjects are at least 3.5 more likely to drink alcohol frequently and are at least 4 times as likely to frequently use marijuana. We conducted these same analyses for prevalence of use, and the findings were extremely similar. (The results are not shown here but are available from the first author upon request.) Thus, not only do substance use and violence cooccur during adolescence, but also the extent of involvement in one behavior is strongly related to the extent of involvement in the other.

For our second set of analyses examining concurrent associations, we looked at severity. We conducted a series of analyses of variance (for unequal cell size; SAS, 1990) to examine violence-stage effects on alcohol and marijuana use and drug-stage effects on violence. Least-squares (LS) means (which are generally used to compare groups of unequal size) on alcohol use for the four violence-stage groups are presented in Figure 2. Nonviolent as compared to violent subjects report the lowest frequency of alcohol use at each age. The moderate violent offenders (i.e., those who strong-arm) report less alcohol use than either minor or serious offenders at all ages except age 18.5 years (when there are only five subjects in the moderate group). These differences are statistically significant at ages 14.25, 15.25, and 16.5 years. There are no significant differences between minor and serious delinquents in terms of frequency of alcohol use except at age 13.25 years. Overall these data do not support a linear relationship between seriousness of violence and frequency of alcohol use.

Nonviolent subjects report the lowest levels of marijuana use at each age, and seriously violent offenders report the highest (see Figure 3). However, the seriously violent offenders differ significantly from the minor offenders only at ages 15.25, 16.5, and 17.5 years and from the moderate offenders only at age 15.25 years. In addition, there are no significant differences between minor and moderate offenders at any age. In general, once nonviolent youths are eliminated, seriousness of violent offending is not significantly related to extent of marijuana use.

The LS means for violence frequency for the drug stages are presented in Figure 4. There is a significant linear relationship between level of drug use and frequency of violence. At each age, nonusers report significantly less violence than alcohol only users who report significantly less violence (except at age 17.5 years) than marijuana and other drug users. In addition, marijuana-only users as compared to other-drug users report significantly less violence at ages 13.25, 15.25, and 18.5 years. These findings suggest an asymmetrical relationship between severity of violence and severity of substance use. Although violent youths report more frequent use of al-

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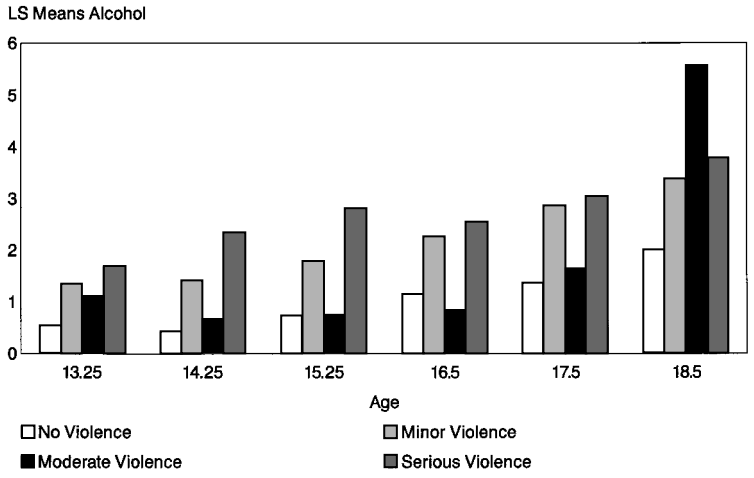


Figure 2. Least-squares means on alcohol use for violence-stage groups by age.

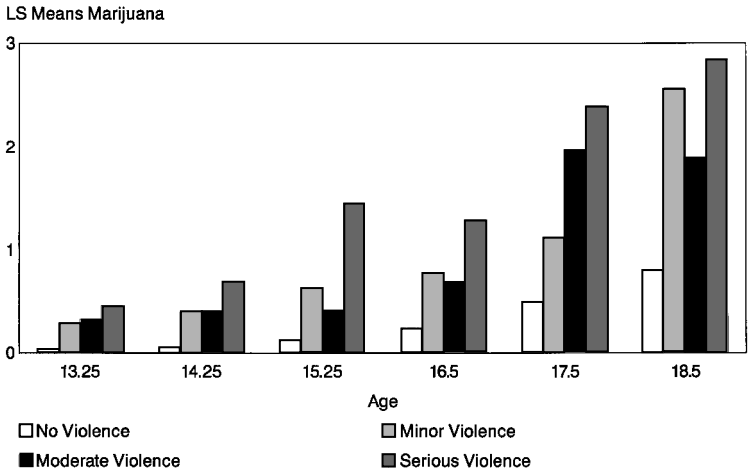


Figure 3. Least-squares means on marijuana use for violence-stage groups by age.

cohol and marijuana than nonviolent youths, frequency of alcohol and marijuana use does not vary significantly among different types of violent offenders. On the other hand, frequency of violence increases as severity of drug use increases.

Longitudinal associations between substance use and violence

The analyses presented thus far have examined concurrent associations over time. We next examined longitudinal associations over time. To further explore the symmetry of the relationships, we examined the longitudinal relationships between the frequency of violence and substance use at each age with the frequency at the next. We conducted logistic regression analyses in which we examined how well frequency of alcohol use and marijuana use could predict the frequency of violence the following year (controlling for current frequency of violence) and how well frequency of violence could predict the frequency of alcohol and marijuana use the following year (controlling for current frequency of alcohol and marijuana use), respectively. For these analyses we divided subjects into

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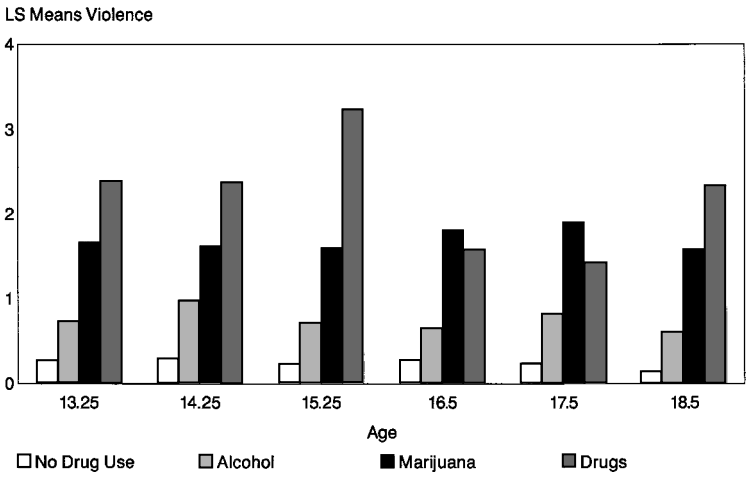


Figure 4. Least-squares means on violence for drug-stage groups by age.

Table 3. *Longitudinal associations between frequent alcohol and marijuana use and violence*

	Odds Ratios			
Age	Alcohol → Violence	Marijuana → Violence	Violence → Alcohol	Violence → Marijuana
13.25 → 14.25	1.8*	3.1**	2.0*	1.1
14.25 → 15.25	2.3**	1.9	2.3**	2.6**
15.25 → 16.5	2.2**	1.6	2.0*	2.2*
16.5 → 17.5	2.2*	1.5	2.6***	1.3
17.5 → 18.5	1.8*	1.7	1.4	2.9***
13.25 → 14.5–18.5[a]	2.5***	5.0***	2.7***	1.9*
13.25 → 14.5–18.5[b]	2.2**	5.4**	2.4**	1.2*

Note: Odds ratios were derived from logistic regression analyses in which frequency was dichotomized into the top 25% versus the rest. The alcohol and marijuana use to violence analyses control for the frequency of current violence and the violence to alcohol and marijuana use analyses control for the frequency of current alcohol and marijuana use.
[a]The alcohol and marijuana use to violence analyses control for the frequency of violence at age 13.25 and the violence to alcohol and marijuana use analyses control for the frequency of alcohol and marijuana use at age 13.25.
[b]The alcohol and marijuana use to violence analyses control for the frequency of violence at age 13.25 and the violence to alcohol and marijuana use analyses control for the frequency of alcohol and marijuana use at age 13.25. All analyses control for the common risk factors at age 13.25.
*$p < .05$. **$p < .01$. ***$p < .001$.

the top quartile versus the rest for frequency of alcohol use, marijuana use, and violence at each age.

The ORs for the predictor variables are presented in Table 3. (The ORs for the control variables were omitted for ease of presentation and are available from the first author upon request.) The ORs are similar for frequency of alcohol use to frequency of violence as for violence to alcohol use. The strengths of the longitudinal relationships are fairly consistent over time, except for a lack of a significant relationship from violence at age 17.5 years to alcohol use at age 18.5

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years. For the most part, the ORs for marijuana use to violence are weaker than those from violence to marijuana use. Most of the marijuana use to violence relationships are not significant. (Note, however, that some of the ORs for the alcohol and violence relationship are significant, although not much greater in magnitude than those for marijuana and violence.) Hence, controlling for violence frequency, marijuana frequency is not a very strong predictor of later frequency of violence. The one exception is that frequent marijuana use at age 13.25 years is a strong predictor of frequent violence the following year.

The next question concerned whether predictions applied when the outcome was aggregated over multiple waves. In the second to last line of Table 3 we present the odds ratios between frequency of violence at Phase SA (age 13.25 years) and the maximum frequency of substance use in Phases B–K (ages 14.5–18.5 years) and between frequency of drug use at Phase SA and maximum frequency of violence in phases B–K with controls for the frequency of the dependent variable at Phase SA. The data indicate that those adolescents who frequently use marijuana at age 13.25 years have 5 times the risk of frequent violence at some later age, whereas those who frequently drink alcohol at this young age have only 2.5 times of the risk of later frequent violence. Whereas the odds ratios are similar for alcohol and violence in either direction, for marijuana very early frequent use is a much stronger predictor of later frequent violence than very early frequent violence is of later frequent marijuana use.

We wanted to know if substance use and violence remained predictive of each other over time (from SA to BK) after controlling for common risk factors. Thus, we repeated these logistic regression analyses, not only including the predictor variable and the dependent variable at Phase SA but also including the common risk factors at Phase SA to predict the maximum frequency of each behavior from Phases B–K. The odds ratios for the predictor variables are presented in the bottom row of Table 3. (The rest of the odds ratios are available from the first author upon request.) Even within controls for common risk factors, frequent alcohol use (OR of 2.2) and, especially, frequent marijuana use (OR of 5.4) in early adolescence are strong predictors of later frequent violence. Note also that hyperactivity–impulsivity–attention problems is the only common risk factor that also significantly predicts later violence. Frequent violence in early adolescence also increases the risk of later frequent alcohol use 2-fold when common risk factors are included in the model. Frequent sexual intercourse and poor school achievement also predict later frequent alcohol use. Once one controls for common risk factors, frequent violence does not significantly predict later frequent marijuana use, although frequent sexual intercourse, frequent property crime, and hyperactivity–impulsivity–attention problems do.

For our final set of analyses we examined the relationships between intraindividual changes in substance use and violence. We regressed linear changes in alcohol use and marijuana use on linear changes in violence (controlling for initial levels of violence). We also regressed linear changes in alcohol use on changes in violence (controlling for initial level of violence and linear changes in marijuana use) and linear changes in marijuana use on changes in violence (controlling for initial level of violence and linear changes in alcohol use). Finally, we regressed linear changes in violence on linear changes in alcohol and marijuana use (controlling for initial levels of alcohol and marijuana use), respectively. To determine the linear changes for intraindividual change in violence and substance use intensity from Phase SA to Phase K, we used the following formula derived from Cohen and Cohen (1983, Table 6.3.1, p. 243): Change = -5 (SA) $-$ 3(BC) $-$ 1(DE) + G + 3(I) + 5(K) for six equally spaced test occasions. The results (unstandardized coefficients) are presented in Table 4.

Changes in each behavior are significantly ($p < .001$) related to changes in the other. Hence, patterns of change in substance use and violence are reciprocally related during adolescence. The coefficient for changes in violence is larger for predicting changes in alcohol than changes in marijuana. The coefficient for changes in alcohol use is not reduced

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Table 4. *Longitudinal associations between linear changes in alcohol and marijuana use and violence*

Model	Unstandardized Regression Coefficient
Alcohol → violence (controlling for violence)	0.21***
Marijuana → violence (controlling for violence)	0.21***
Violence → alcohol (controlling for alcohol)	0.35***
Violence → marijuana (controlling for marijuana)	0.26***
Alcohol → violence (controlling for violence and marijuana)	0.17***
Marijuana → violence (controlling for violence and alcohol)	0.09

***$p < .001$.

substantially when linear changes in marijuana use are included in the model (from .21 to .17). On the other hand, the coefficient for changes in marijuana use is no longer significant once changes in alcohol use are included in the model. Hence changes in alcohol compared to marijuana use appear to be a stronger predictor of changes in violence. We also conducted these analyses controlling for the common risk factors used in the previous analyses, and the coefficients remained virtually the same. (These data are not shown here but are available from the first author upon request.)

Discussion

The availability of repeated measurements over 6 years in this study allowed us to examine the developmental associations between substance use and violence. As reported in previous studies, we also found diverging patterns of violence and substance use (Elliott et al., 1989; White, 1997b). There was a slight increase in the frequency of violence in middle to late adolescence and then a leveling off. In contrast there was a large increase in the frequency of alcohol and marijuana use at this same time with no indication of a leveling off.

We were also interested in the developmental covariation between substance use and violence. The data indicated that the concurrent associations between alcohol use and violence were relatively strong throughout adolescence. Frequently violent subjects had at least 3.5 the risk of using alcohol frequently, and, alternatively, frequent alcohol users had at least 3.5 times the risk of being frequently violent. For marijuana and violence the risk was at least 4 times. Thus, in adolescence the concurrent alcohol–violence relationship is not specific (see Osgood, 1994; White, 1997b), and, if anything, in early adolescence frequent marijuana use compared to frequent alcohol use is more strongly related to concurrent frequent violence. This finding is consistent with the results of Derzon and Lipsey's (1999) meta-analysis, which found a strong association between marijuana use and aggressive behavior only in early adolescence. The finding would also fit a model of convergence between different problems at a young age, representing the early developmental stages of the emergence of a multiproblem group of males (Loeber et al., 1998a), who are probably at highest risk for serious substance use, delinquency, and other problem behaviors later on (Moffitt, 1993).

Our second question concerned whether the strengths of the associations between substance use differed for frequency and severity. The symmetry between substance use and violence varied with respect to severity. Type or severity of violence was not related to frequency of alcohol or marijuana use. Although nonviolent subjects reported significantly lower levels of substance use than violent offenders, there were few significant differences between minor and serious violent offenders in their reported substance use. In fact, adolescents who were involved in strong-arming (moderate level) reported less alcohol involvement than those involved in gang fighting or carrying a concealed weapon (minor level). Perhaps, gang activities involve heavy drinking as well as fighting which could account for the higher rates of alcohol use among minor violent offenders (see Fagan, 1993). Also, in order to be a successful armed robber, one needs to be careful and diligent. Thus, it is possible that those adoles-

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cents who engage in strong-arming may avoid or limit their alcohol use (see Carpenter et al., 1988). On the other hand, severity of drug use was significantly related to violence. Marijuana and other-drug users were more strongly involved in violence than alcohol-only users, which supports other data suggesting that polydrug users are at the greatest risk for violence (see also Elliott et al., 1989; White, 1997b). In other words, it may be the onset or extent of multiple-substance use that is the critical factor for the co-occurrence of substance use and violence or other forms of delinquency.

We also assessed symmetry in terms of whether substance use was a better predictor of violence than violence was of substance use. Relatedly we were interested in assessing whether alcohol use compared to marijuana use was a better predictor of violence. The answer to the first question differed depending on the substance. In the longitudinal frequency analyses reciprocity was observed between alcohol use and violence. In contrast, violence was a slightly better predictor of marijuana use than marijuana use was of violence (although the predictive strength was relatively weak in either direction). Finally, although the concurrent associations were generally stronger for marijuana and violence than for alcohol and violence, the longitudinal associations were opposite. In general, alcohol compared to marijuana use was a better predictor of later violence. There was one exception to these generalizations: the strongest longitudinal association observed was between frequent marijuana use at age 13.25 years and later frequent violence (see Derzon & Lipsey, 1999).

However, we do not consider our finding of a relation between early marijuana use and later violence as indicating a causal association, for the following reasons. First, as mentioned before, studies on acute effects in laboratory studies have found that marijuana is not strongly associated with aggression, and, in fact, moderate doses reduce aggression (Miczek et al., 1994). Second, in a study of adolescents who were adjudicated for a violent crime, marijuana was selected as the drug most likely to decrease assaultiveness (Tinklenberg, Murphy, Murphy, & Pfefferbaum, 1981). Third, our observed association between increases in marijuana use and increases in violence became nonsignificant once prior violence and alcohol use were taken into account. Fourth, the association between marijuana use and violence may merely reflect a selection effect in that those who advance to marijuana use usually are those who use alcohol heavily (Kandel et al., 1992) and also tend to be more aggressive (Derzon & Lipsey, 1999). Fifth, penetration into polydrug use may be associated with a delinquent lifestyle in which aggressive behavior is condoned. Finally, the need to purchase illicit drugs may force the user to get involved in the illegal drug distribution market, which is associated with high rates of systemic violence (see White, 1997a). It is, therefore, probable that what we are seeing is a selection effect (i.e., that marijuana use at the start of adolescence is atypical and merely helps to identify a group of males who are at high risk for several serious outcomes, including violence; Loeber et al., 1998a). Yet, as subjects age, marijuana use becomes more normative and, hence, less predictive of more deviant behaviors such as violence.

In contrast, the longitudinal associations between alcohol use and violence remained strong even when we controlled for earlier marijuana use and were stronger, in general, than those between marijuana and violence (except marijuana use at age 13.25 years). Thus, these developmental finding are consistent with short-term findings from acute laboratory studies (Miczek et al., 1994). Yet, these associations were symmetrical, suggesting a reciprocal relationship between heavy alcohol use and violence (i.e., that each behavior reinforces the other; see White, 1997b). Hence, our data do not support a unidirectional causal association between heavy drinking and subsequent violence. Rather, other more complicated mediation and moderation models are probably more applicable to the alcohol–violence relationship (Pernanen, 1981). For example, the developmental associations probably occur because heavy-drinking individuals compared to less heavy drinkers or abstainers are more likely to emerge from those who al-

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ready are somewhat higher in prior aggression (Lang, 1993). In addition, heavy drinkers often select settings such as bars in which other inebriated individuals tend to congregate and in which interpersonal conflicts are more likely to occur and to escalate to violence (Fagan, 1993). Finally, chronic intoxication may contribute to subsequent aggression due to factors such as withdrawal, impairment of neuropsychological functioning, or enhancement of psychopathologic personality disorders (White, 1997b).

Although we believe that our findings do not support a causal association between drug use and violence, they also do not support a spurious, common cause model. That is, the relationships remained strong even when common risk factors were controlled. Therefore, there is a relationship between drug use and violence that transcends their common risk factors. This relationship appears to be reciprocal. Early drug use predicts later violence, but violence also predicts later drug use, especially alcohol use. We can only speculate on reasons for this association. It may be that early involvement in the most deviant behaviors such as multiple-substance use and violence place an individual into a developmental trajectory that escalates and becomes more deviant over time (Moffitt, 1993). These individuals may become part of a deviant subculture in which their continued frequent drug use and violence are reinforced. It should be noted, however, that when we controlled for the number of deviant peers (i.e., those who were delinquent and used drugs) in the analyses presented in Table 3, the findings were almost identical to those shown in Table 3. Deviant peers predicted later violence, but not substance use. We chose to exclude deviant peers in the final analyses because one could argue that friendship with deviant peers is a result of the prior deviance (i.e., selection) rather than a predictor of deviance (i.e., socialization; see Kandel, 1996, for a review). Other factors besides deviant peers, however, could account for the escalation of a deviant career trajectory. For example, negative consequences resulting from deviance (such as arrest or school failure), involvement in drug dealing, or the development of drug dependence are all factors that could preclude reentry into a nondeviant trajectory. Because we did not control for every potential common risk factor, it is possible that we may have excluded some important risk factor that may have accounted for the entire relationship between substance use and violence. However, this is unlikely given that we included predictors from each of the important domains.

It was interesting that most of the hypothesized common risk factors were not predictive of violence or drug use once earlier violence and drug use were taken into account. The only exceptions were that early hyperactivity–impulsivity–attention deficit problems remained a significant predictor of later violence and marijuana use; early sexual behavior continued to predict marijuana and alcohol use; school failure predicted alcohol use; and involvement in property crime predicted marijuana use.

We also assessed how changes in one behavior affected changes in the other and found significant associations between changes in substance use and changes in violence over time. There was reciprocity in terms of changes in one behavior affecting changes in the other. Further, the results suggested that changes in alcohol use compared to marijuana use were more predictive of changes in violence. These results suggest that as severity of deviance in one domain increases, the severity of deviance in another domain also increases. We postulate that this process reflects the further winnowing of the multiple-problem group from less deviant groups of males during adolescence.

The study has several limitations. Substance use and violence, although repeatedly assessed, were measured at yearly intervals, which could not elucidate the more proximal moment-by-moment interactions between substance use and violence. Nor could we assess the pharmacological effects of drug use on violent activity. For that purpose, we plan to analyze subjects' self-reports on the effects of substance use on them and the degree to which they used substances close to the commission of delinquent acts. Thus, the study was restricted to relatively broad developmental trends between substance use and vio-

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lence. Second, both substance use and violence were measured by self-reports, rather than by independent measurements. Third, the study did not distinguish between temporary and persistent problem behavior.

Despite the limitations of the study, the present findings clearly support a developmental approach to the substance use–violence link and suggest that this association can be better understood when individual differences over time are taken into account, particularly by distinguishing between different risk groups. This means that future research needs to focus on persistent problem behavior as distinct from occasional problem behavior or experimental substance use (see Labouvie & White, 1998; White et al., 1998). We have started to undertake such analyses in a separate report, which focuses on persistent substance users as a function of persistent delinquency, persistent internalizing problems, and attention deficit–hyperactivity disorder between ages 7 and 18 years, and which attempts to clarify better the emergence of multiproblem males (Loeber, Stouthamer–Loeber, & White, 1999). It is reasonable to expect that these multiproblem youths will be least likely to make successful transitions into adulthood and most likely to develop full-blown substance abuse or psychopathology in adulthood (White & Labouvie, 1994). We anticipate that the present paper and the papers that will follow will help clinicians to better identify at an early stage those youth at risk for multiple-problem behaviors and to focus early interventions on this high-risk group especially.

Prevention experts have argued that efforts to prevent violence and substance abuse should be combined because the risk factors for violence overlap with those for substance abuse (Hawkins, Catalano, & Brewer, 1995). We cannot describe all the effective programs here, but we can suggest some effective elements (for reviews, see Brewer et al., 1995; Gorman, 1996; Gorman & Speer, 1996; Hawkins, Arthur, & Catalano, 1995; Hawkins, Catalano, & Brewer, 1995; Loeber & Farrington, 1998; Reiss & Roth, 1993; Tolan & Guerra, 1994; Tremblay & Craig, 1995). The general consensus is that (a) prevention approaches need to be developmental due to the fact that risk factors differ over the life course, (b) early prevention is needed, (c) working with parents or soon-to-be parents is advantageous, (d) programs should be aimed at multiple risk factors, and (e) continuity from birth into adolescence is important (Brewer et al., 1995; Hawkins, Catalano, & Brewer, 1995; Tremblay & Craig, 1995). Although less well evaluated, some societal-level approaches seem worthwhile, including reducing exposure to violence in the media, reducing access to lethal firearms, and changing norms regarding alcohol use (Hawkins, Arthur, & Catalano, 1995; Tolan & Guerra, 1994). In contrast, most peer programs have not been effective for violence (Brewer et al., 1995; Tolan & Guerra, 1994) or substance abuse (Gorman, 1996). Many of the current prevention programs have not been properly evaluated, and when they have been, data are weak (Tolan & Guerra, 1994). Nevertheless, the existing data from well-evaluated programs are optimistic. That is, early childhood prevention has had a positive effect in reducing the risk factors for later violence and substance abuse (Tremblay & Craig, 1995). Yet, more research is needed to identify those interventions which will be most successful with multiproblem youth.

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