Addiction (1995) 90, 1647–1660

RESEARCH REPORT

The consistency of family and peer influences on the development of substance use in adolescence

TERRY E. DUNCAN, ELIZABETH TILDESLEY, SUSAN C. DUNCAN & HYMAN HOPS

Oregon Research Institute, Eugene, Oregon, USA

Abstract

Latent growth modeling (LGM) was used to analyse longitudinal data for adolescent substance use from five overlapping age cohorts (11, 12, 13, 14 and 15 years at first assessment) measured at four annual time points. An associative cohort–sequential model was tested for alcohol, cigarette and marijuana use with a sample of 345 adolescents (11–18 years old) from an urban area in the Pacific Northwestern region of the United States. Hypotheses concerning the shape of the growth curve, the extent of individual differences in the common trajectory over time, and the influence of family cohesion, peer encouragement and gender on initial substance use and shape of the growth curve were tested. Results indicated similarities between alcohol, cigarette and marijuana initial use and development, with peer encouragement and family cohesion predictive of initial levels of use, and changes in peer encouragement influencing the developmental trajectories of the three substances. Females were higher than males in initial status and developed less rapidly in their use of the substances than did males. Findings are discussed in terms of the similarities and differences in the developmental trajectories of the three substances and the importance of family and peer influences on these trends.

Introduction

Research of the past several decades has shown clearly that adolescent drug use is integrally linked to various social psychological processes. In particular, those processes involving parents and peers have received considerable attention (e.g. Kandel, 1985; Chassin *et al.*, 1986; Ary *et al.*, 1993) where family conflict and aversive interactions have been associated with higher levels of drug use (e.g. Newcomb, Maddahian & Bentler, 1986; Brook *et al.*, 1988; Hops *et al.*, 1990; Patterson, Reid & Dishion, 1992), and a breakdown in family relationships has been associated with problem drinking (Dishion & Loeber, 1985). Moreover, the peer group, which generally adopts greater influence as the adolescent grows older (Douvan & Adelson, 1966; Kandel & Andrews, 1987) has consistently been shown to be a powerful correlate and predictor of the use of licit and illicit substances (e.g. Kandel, 1985; Fisher & Bauman, 1988). However, the nature of the influence of family and peers on adolescent substance use, and particu-

Correspondence to: Terry E. Duncan, PhD, Oregon Research Institute, 1715 Franklin Blvd, Eugene, Oregon 97403, USA.

0965–2140/95/121647–14

larly on the development of substance use, is far from clear.

The salience of the peer group in adolescent drug use is consistent with traditional theorizing in which adolescence is conceptualized as a period during which the family and the peer group gradually exchange their respective degrees of influence. Patterson *et al.* (1992) suggest that family influences precede peer group influences on delinquent behavior. Others (e.g. Parke *et al.*, 1988) suggest a bidirectional process between families and social systems outside the family reaching its peak during adolescence. However, while peers may be the primary influence in substance use, the family can continue to be a moderating or augmenting source of influence throughout adolescence (Krosnick & Judd, 1982; Brook *et al.*, 1985).

Despite evidence for the effects that family and peers have on the development of substance use, an important question regarding the concept of substance use itself remains. That is, should substance use among adolescents be conceived of as a unitary construct, with similar causes, regardless of the specific substance in question, or is it more appropriate to consider the social context for use of each substance as unique? One hypothesis for the strong inter-relationships among the various substances is that they all have common causes or influences (Jessor & Jessor, 1977; Donovan & Jessor, 1985). Some research suggests that substance use could be considered a unitary concept and that the social variables which contribute to its various forms are similar across multiple substances (Huba, Wingard & Bentler, 1979; Hansen *et al.*, 1987). If this is the case then intervention efforts could be designed to target reduction in use of all substances. On the other hand, if there are important substance specific relationships, little may be gained by assuming similarity. Hansen *et al.* (1987) provided a test of the degree to which the use of tobacco, alcohol and marijuana by young adolescents could be described by a common theoretical model. Utilizing structural equation methodology their findings suggested that, in many respects, parent/adult caregiver and peer tobacco, alcohol and marijuana use were equal contributors to a single substance use construct, arguing support for the notion that the social psychological processes underlying use of the various substances have essentially the same characteristics, and that a unitary concept of drug use among young adolescents is a viable one.

Many of these conceptualizations, however, have been developed at the inter-individual level, primarily from measures taken at only one point in time. Effective preventive intervention strategies for adolescents at risk for substance use and abuse are dependent not only on an understanding of the concurrent relationships among these behaviors, but also on an examination of the developmental nature of these behaviors and their antecedents as they unfold over time. With increased interest in the development of substance use, greater emphasis has been placed on the time dimension and the development of dynamic models pertaining to both intra- and inter-individual development of substance use and its etiology during adolescence. Recent developments in statistical techniques expand the opportunity to examine trends and individual differences in substance use, and to explore the effects of the social context on these developmental trends.

One methodology which provides a means of modeling a developmental function as a factor of repeated observations over time has been termed a latent growth model or LGM. A recent paper by Duncan & Duncan (1994) demonstrated the utility of LGM for determining trends in adolescent alcohol, cigarette and marijuana use across a 5-year period. Using an associative model which incorporated all three substances simultaneously, these data provided initial support for similarities in the development of these substances during adolescence. Other applications of LGM may be found in McArdle & Epstein (1987), McArdle (1988), McArdle & Hamagami (1991), Duncan & Stoolmiller (1993), Stoolmiller *et al.* (1993), Duncan, Duncan & Hops (1994) and Duncan & Duncan (1995). Different approaches to growth modeling can be found in Bryk & Raudenbush (1987), Francis *et al.* (1991) and Willet, Ayoub & Robinson (1991).

Although latent growth methodology is generally applied to data generated from a true longitudinal design, it is possible to approximate a long-term longitudinal study by conducting several short-term longitudinal studies of different age cohorts simultaneously. This method consists of limited repeated measurements of independent age cohorts resulting in temporally overlapping measurements of the various age groups. Bell (1953) advocated this method of "convergence" as a means for meeting research needs not satisfied by either longitudinal or cross-sectional methods. The cohort–sequential design has gained recent popularity as a method in which adjacent segments of longitudinal data on a specific age cohort can be linked together with similar segments from other temporally related age cohorts to determine the existence of a common developmental trend (Nesselroade & Baltes, 1979). This technique is beneficial because it allows the researcher to investigate a longer developmental span than would otherwise be possible and it enables the determination of whether trends observed in the repeated observations are corroborated within short time periods for each of the age cohorts (Duncan *et al.*, 1994).

Utilizing a latent growth modeling methodology within a cohort sequential design, Duncan *et al.* (1994) found that with limited (i.e. four annual assessments) repeated measures of alcohol use data on five cohorts of 11, 12, 13, 14 and 15-year-olds, a common developmental trajectory for alcohol use between 11 years and 18 years was tenable. By applying the mean slope to the developmental curve, the average adolescent was expected to increase their alcohol use by approximately 94% over an 8-year period. Furthermore, these analyses indicated that family cohesion as perceived by the adolescent reduced initial levels of alcohol use, thus delaying its upward trajectory. Peer encouragement, on the other hand, was predictive of higher initial levels of alcohol use and suggestive of higher rates of change. Adolescents reporting more peer encouragement had elevated initial levels of alcohol use and appeared to increase their use more so than those with less encouragement from peers.

In this paper, we extend the work of previous researchers (e.g. Hansen *et al.*, 1987; Duncan *et al.*, 1994) by utilizing an associative cohort–sequential growth curve model to examine developmental changes in alcohol, marijuana and cigarette use among adolescents aged 11–18 years. By using data from five separate age cohorts (11, 12, 13, 14 and 15 years old at the first assessment) each measured at annual time points over a 4-year period, the developmental trajectories for these substances were examined across the 8 years represented by the cohort–sequential analysis. In addition, the associative nature of the present study not only provides an examination of the similarities and differences in the developmental trajectories for all three substances, but also allows for a test of the degree to which the use of these substances can be described using a common theoretical model.

Based on previous research it was hypothesized that the same set of social factors, family cohesiveness and peer encouragement to use various substances, would account for individual differences in the growth parameters of adolescent alcohol, cigarette and marijuana use. Initial levels of family cohesion and peer encouragement to use each of the substances were hypothesized to predict initial status and slope of substance use. Simple difference scores representing change in family cohesion and peer encouragement were used as predictors of individual differences in the development of substance use over the 8-year period estimated within the cohort–sequential analysis. Because of the potential importance of gender in adolescent substance use, the adolescents' gender was also included as a predictor in the model.

Method

Subjects

The sample for this analysis was recruited as part of a longitudinal study on the predictors and consequences of substance use among adolescents (Hops *et al.*, 1990; Andrews *et al.*, 1993; Ary *et al.*, 1993; Duncan & Duncan, 1994; Duncan *et al.*, 1994). Seven hundred and sixty-three families were originally recruited through advertisements in the newspaper, on the radio and television, and through flyers distributed at various middle and high schools in two north west urban areas of the United States with populations of approximately 50 000 and 100 000. Families were required to have at least one adolescent between 11 years and 15 years old at the first assessment. Family members completed parallel questionnaires on their substance use behaviors as well as on a number of psychosocial variables. Assessments were conducted annually.

As a result of attrition over the 4 years (12.2% T1–T2; 7.6% T2–T3; 14.4% T3–T4) and the need for listwise data, the sample utilized in the present analyses consists of 345 target adolescents between 11 years and 15 years of age at their first assessment. Adolescents were 146 male and 199 female adolescents, from 152 single-parent families and 193 two-parent families. Ethnic make-up of the sample was 85% white, 8% Afro-American, 2% Hispanic, 1% Asian and 4% Native American. Socio-economic levels were 1% unskilled, 9% semi-skilled, 20% skilled, 40% minor professional, 27% professional and 2% missing using the Nam-Powers Socio-economic Scale (Nam & Terrie, 1988).

Procedures

Several procedures were used to increase the validity of adolescent reports of their substance use and various psychosocial variables. Targets and other family members completed parallel questionnaires at the same time but in separate rooms from each other, allowing adolescents to feel free to ask questions during the session without violating their assurance of confidentiality. Expired air samples were taken for physical validation of smoking behavior. This procedure has also been shown to increase the validity of self-reported smoking behaviors and is assumed to transfer to other substances as well (Murray *et al.*, 1987). Families were initially paid $35 for their participation in the project.

Measures

Substance use. A 5-point scale was created to reflect the adolescent's use of each of the three substances: alcohol, marijuana and cigarettes. These scales were constructed based on self-reports of drug use status (e.g. (1) "I have never tried an alcoholic beverage" to (8) "I drink alcohol at least once a day") and on frequency of use of each drug during the previous 12-month, 6-month and 1-month periods (e.g. "How many times have you smoked marijuana in the last 12 months/6 months/1 month?"). Levels on these 5-point scales reflect: (1) Never used the substance; (2) No current use but have used previously; (3) Current use of less than four times a month; (4) Current use of between 4 and 29 times a month; and (5) Current use of 30 or more times a month. Average correlations across the four assessments between the 5-point scale and the original items for alcohol were 0.79, 0.72, 0.76; for cigarettes, 0.92, 0.84, 0.87; and for marijuana, 0.87, 0.67, 0.75, for the status variable, 1-month frequency items, and 6-month frequency item, respectively. These scales were validated with self-reports of deviance and a general deviance construct, where a linear increasing function was noted for each level of substance use. Although this variable was created from status and frequency information, the assumption is made that its underlying properties are continuous in nature. For further information regarding these scales see Duncan & Duncan (1994) or Duncan *et al.* (1994).

Family cohesion. Perceived family cohesion was measured using the Cohesion Subscale of the Family Environment Scale (FES; Moos, 1974), a frequently used scale in a true/false format with well-established psychometric properties (Jacob & Tennenbaum, 1988). The nine-item cohesion subscale is designed to assess individuals' beliefs regarding the extent to which family members support, help and are involved with one another. The means of the scale were 6.01 (SD = 2.44) and 5.75 (SD = 2.57) at the first and fourth assessments, respectively. Internal consistency for the scale at each time point was adequate, with alphas (Cronbach, 1951) ranging from 0.77 to 0.81 across the four assessments.

Peer encouragement. Subjects' self-reports of peer encouragement were measured via single items which asked how much the subject's best friend presently encourages his or her use of alcohol, cigarettes and marijuana. Each item was measured on a 5-point Likert-type scale, ranging from (1) Strongly discourages to (5) Strongly encourages. Individual items were highly correlated, ranging from 0.68 to 0.79; therefore, an average of the three items was used as a measure of "Peer Encouragement to Use Substances".

Results

Heuristically, growth curve methodology can be thought of as consisting of two stages. In the first stage, a regression curve, not necessarily linear, is fitted to the repeated measures of each individual in the sample. In the second stage the parameters for an individual's curve become the focus of the analysis rather than the original measures. Therefore, the modeling task involves identifying an appropriate growth curve form which will describe individual development accurately and parsimoniously and allow the study of individual differences in the parameters that control the pattern of growth over time. If, for example, the trajectories were well described by a collection of straight lines for a sample of individuals, the developmental model should reflect individual

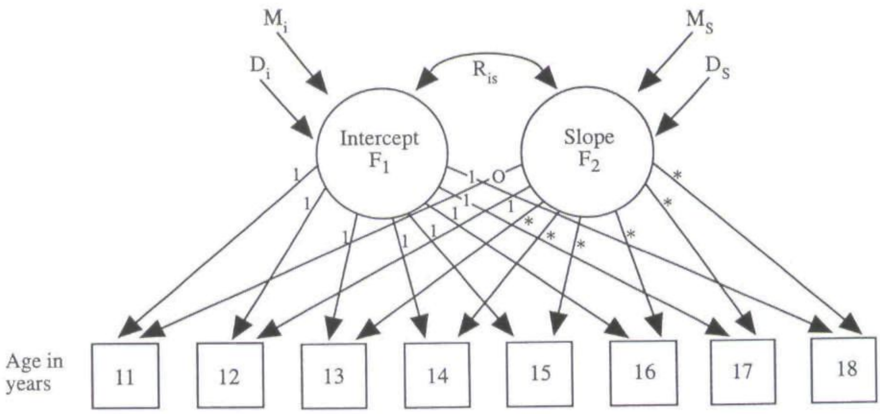

Figure 1. *Representation of the latent growth curve model.*

differences in the slopes and intercepts of those lines. Beyond describing and summarizing growth at the group and individual level, however, the model can also be used to study predictors of individual differences to answer questions about which variables exert important effects on the rate of development.

Latent growth curve models (LGM) are basically variants of the standard linear structural model. Repeated measures analysis of variance (ANOVA) models are actually special cases of latent growth curve models in which only the factor means are of interest (Meredith & Tisak, 1990). In contrast, a fully expanded latent growth curve analysis takes into account both factor means and variances. Although most repeated measures methodologies conducted at the individual level utilize very explicit or specified growth functions, the basic formulation of latent growth models is very general, in that neither the individual saliences nor the longitudinal curves or group functions need to be specified.

The model shown in Fig. 1 represents a latent growth model where the basic parameters describe a systematic pattern of individual differences in change over time. The statistical basis for LGM estimation and testing is developed from well-known SEM theory. However, the LGM approach depicted here requires that the model be fitted to data collected from five independent age cohorts (11-, 12-, 13-, 14- and 15-year-olds), each measured at four approximately equal time intervals over a 4-year period, and providing data for different segments of the overall developmental curve. The same model is assumed in each cohort, allowing for tests of hypotheses concerning convergence across separate groups and the feasibility of specifying a common growth trajectory over the 8 years represented by the latent variable cohort sequential design. Descriptive statistics for the combined sample are presented in Table 1.

As can be seen from the figure, the first common factor is labeled the intercept. The intercept is a constant for any individual across time and represents information in the sample concerning the mean, represented by M_i, and variance, represented by D_i, of the collection of individual intercepts that characterize each individual's growth curve. Thus, in the model, all measured variables have loadings with the common factor representing the intercept, or height of the reference curve, constrained at 1.0. The second factor, labeled slope, represents the slope or shape of an individual's trajectory determined by the repeated measures. The slope factor has a mean, M_s, and variance, D_s, across the whole sample and, like those associated with the intercept, can be estimated from the observed data. One can also control the scaling of the slope by the choice of loadings on the slope factor. Rather than utilizing a model with fixed parameter restrictions, we have chosen instead to fit a developmental function which reflects a set of parameters that represent an optimal patterning over occasions for the changes in substance use scores. Within this approach, the freely estimated parameters reflect the developmental function with maximal fit to the data (Rao, 1958; Tucker, 1958).

Table 1. *Descriptive statistics for the associative latent growth model*

	Mean	SD	Kurtosis	Skewness
Family cohesion	6.05	2.48	−0.46	−0.72
Change score	−0.29	2.84	0.07	−0.07
Friends' encouragement	2.08	0.99	−0.91	0.37
Change score	0.34	1.11	0.24	0.02
Gender	1.57	0.50	−1.93	−0.29
Cigarette use t1	1.92	1.18	1.01	1.34
Cigarette use t2	2.11	1.28	0.19	1.10
Cigarette use t3	2.30	1.32	−0.28	0.87
Cigarette use t4	2.58	1.40	−0.92	0.55
Alcohol use t1	2.34	1.05	−0.66	0.24
Alcohol use t2	2.59	0.98	−0.42	0.05
Alcohol use t3	2.73	0.94	−0.10	0.04
Alcohol use t4	3.02	0.94	0.11	0.00
Marijuana use t1	1.58	0.97	1.10	1.46
Marijuana use t2	1.74	1.01	0.33	1.12
Marijuana use t3	1.90	1.07	−0.21	0.88
Marijuana use t4	2.02	1.09	−0.53	0.69

In our example, the loadings of the measured variables from the first and second assessments, with the common factor representing the shape or slope of the reference curve, are constrained at values of 0 and 1.0, respectively. While the values selected for these loadings are arbitrary, they are necessary for model identification. Fixing the parameter estimates at these values, however, scales the metric for rate of growth and allows for an unambiguous interpretation of the intercept factor as the initial developmental status which has been corrected for measurement error. The non-constrained parameter estimates for the measured variables from the subsequent assessments form the basic shape of the reference curve. The two factors, slope and intercept, are allowed to covary, R_{is}, which is represented by the double-headed arrow between the two factors. Model testing procedures were carried out utilizing the EQS (Bentler, 1989) structural equation modeling program.

It was assumed that one line could characterize the various sets of staggered age group curves shown in Fig. 2, which resulted from the longitudinal cohort-sequential design. The model was estimated and fit to the data by assuming that common parameters were invariant over all groups. This approach combines both the cross-sectional and longitudinal information into a single curve, a hypothesis that in and of itself can be tested. In addition, because the various age groups may be different in many different ways, the analysis allows for statistical tests of whether there are specific parameters which show a relatively poor convergence over groups. Results from the model estimation procedures, in which specific parameters relating to a common growth trajectory for each substance were invariant across groups, indicated that the hypothesis of a common developmental trajectory from age 11 to age 18 years was tenable.

Table 2 represents the reproduced means for the model testing a common growth trajectory across groups for alcohol, cigarettes and marijuana. There are moderate increases across age groups for all three substances with the most dramatic increase for all three between the ages of 13 and 14 years. The error variances for specific substance use variables at each time point were constrained to be equal across cohorts for common age groups. Increases in error variance coincide with the period of greatest mean level of increase in the developmental trajectories for each substance, between 13 and 14 years of age. The highest error variance for all three substances was in the 18th year, indicating the highest variability for this group. We would expect more individual differences for those at the highest levels of use.

Fitting the latent growth model to the data for alcohol, cigarette and marijuana use resulted in the following mean intercepts and mean slopes for each substance: alcohol: $M_i = 1.715$, $t = 16.709$, $p < 0.001$; $M_s = 0.349$, $t = 4.060$, $p < 0.01$; cigarettes: $M_i = 1.349$, $t = 17.806$, $p < 0.001$, $M_s = 0.248$, $t = 4.254$, $p = 0.01$;

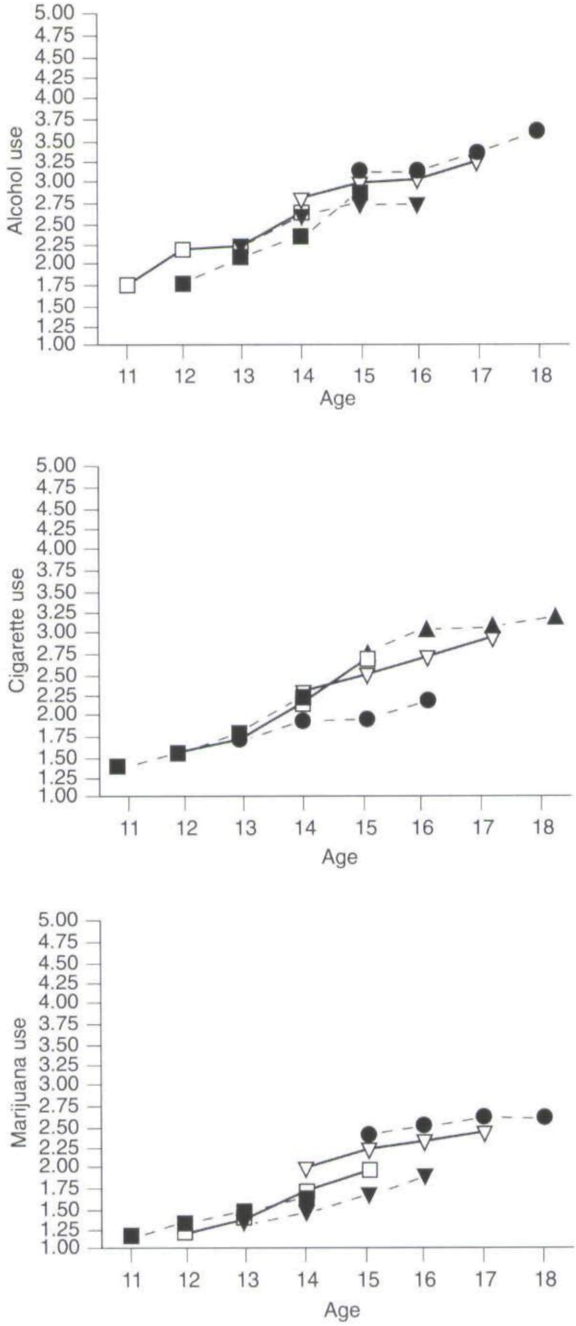

Figure 2. *Staggered age group means for adolescent alcohol, cigarette and marijuana use. (□ Group 1; ■ Group 2; ▼ Group 3; ▽ Group 4; ● Group 5).*

marijuana: $M_i = 1.080$, $t = 21.253$, $p = 0.001$; $M_s = 0.212$, $t = 5.208$, $p = 0.01$. All slope means were significant showing evidence of substantial development in the use of all three substances over an 8-year period. Applying the mean slope to the developmental curve,

Table 2. *Reproduced developmental trajectories in adolescent substance use*

	Reproduced means							
Alcohol	1.715	2.064	2.249	2.613	2.888	2.900	3.164	3.412
Error variance	*0.375*	*0.226*	*0.248*	*0.315*	*0.393*	*0.341*	*0.363*	*0.489*
Cigarettes	1.349	1.597	1.781	2.128	2.424	2.580	2.689	2.734
Error variance	*0.194*	*0.154*	*0.161*	*0.357*	*0.399*	*0.369*	*0.383*	*0.530*
Marijuana	1.080	1.292	1.438	1.722	1.972	2.111	2.164	2.142
Error variance	*0.062*	*0.127*	*0.170*	*0.250*	*0.336*	*0.282*	*0.224*	*0.395*
Age in years	11	12	13	14	15	16	17	18

the average adolescent would increase 84% in alcohol use, 102% in cigarette use and 98% in marijuana use over an 8-year period.

The latent variances were also estimated. The variances for intercepts and slopes are provided for all three substances: alcohol: $D_i = 0.943$, $t = 6.390$, $p < 0.01$; $D_s = 0.047$, $t = 1.831$, $p < 0.05$, (1-tailed); cigarettes: $D_i = 0.634$, $t = 7.280$, $p < 0.01$; $D_s = 0.056$, $t = 2.092$, $p < 0.01$; marijuana: $D_i = 0.284$, $t = 6.380$, $p < 0.01$; and $D_s = 0.045$, $t = 2.562$, $p < 0.01$. All latent variances were significant. Intercept variances indicate that substantial variation existed in individual differences regarding initial status for all three substances. There was also significant variability in the individual differences in developmental trajectories for all three substances.

Estimated correlations for all three substances, between initial status and slope, are presented in Table 3. As expected, levels of initial status for all three substances are highly related. Those individuals who use greater amounts of one substance are more likely to use more of another. In addition, those adolescents who increase their use of one substance more rapidly over an 8-year period are also more likely to increase their use of the other substances. Model fitting procedures produced a χ^2 test statistic, χ^2 (381, $n = 345$) = 878.170, $p < 0.001$ and fit indices, NNFI = 0.888 and CFI = 0.876. Although the indices of fit for this model are less than that suggested by some researchers to represent an adequate fit to the data, considering the number of observed and unobserved, or "missing", variables in the model, and the complexity of the cohort–sequential analyses, this model was considered acceptable.

Having modeled common trajectories across three substances which accounted for individual as well as group differences in growth over an 8-year period, several new models were tested, including three covariates assumed to have a significant impact on the growth parameters representing individual differences in both initial status and change in substance use over time. These included the effects of family cohesion, peer encouragement to use substances and gender, on both initial status and development of drug use, as well as change in family cohesion and change in peer encouragement (between initial assessment and the fourth assessment) on the shape of each developmental trajectory.

Ideally, one would typically want to assess development of the various substances separately by gender. If the cohort–sequential approach were carried out in a multiple population model, the corresponding analysis would involve as many subgroups as there are age cohorts in all the different samples. However, one limitation of the cohort–sequential approach is that for each subgroup there must be more than $p + 1$ sample units, yielding positive definite covariance matrices. Unfortunately, there are gender-by-age cohorts in the present study where the number of observations in each group falls below the number of variables. When this occurs it becomes necessary to simplify the model so that a feasible number of groups with large sample sizes remain. Therefore, in order to control for the effect of gender, we incorporated this effect as a predictor of initial status and development of the various substances.

We were specifically interested in the similarities and differences in the impact of these covariates on each substance. Model fitting procedures for the tests of convergence (i.e. specifying that the effects of the covariates on the developmental

Table 3. *Correlations among the substances*

	Alcohol use		Cigarette use		Marijuana use	
	Inter	Slope	Inter	Slope	Inter	Slope
Alcohol Inter	1.000					
Alcohol Slope	−0.724*	1.000				
Cigarette Inter	0.711*	−0.613	1.000			
Cigarette Slope	−0.031	0.476*	−0.102	1.000		
Marijuana Int	0.724*	−0.785*	0.950*	−0.308*	1.000	
Marijuana Slope	−0.028	0.615*	−0.050	0.816*	−0.149	1.000

*Denotes correlations significant at $p < 0.05$ or greater.

parameters are the same across the various substances) yielded a χ^2 statistic of χ^2 (673, $n = 345$) = 1277.73, $p < 0.001$, and fit indices of NNFI = 0.859, CFI = 0.861. Parameter estimates for this converged model indicated that adolescent perception of family cohesion reduced initial levels of substance use, $\beta = -0.118$, $t = -3.497$, $p < 0.01$. Family cohesion did not significantly affect the slope, $\beta = 0.071$, $t = 1.772$, $p > 0.05$, nor did change in family cohesion have a significant impact on individual differences in the development of drug use over the eight years, $\beta = 0.044$, $t = 1.776$, $p > 0.05$. Peer encouragement to use various substances, on the other hand, did have both a significant impact on initial levels of use, $\beta = 0.183$, $t = 4.175$, $p < 0.01$, and individual differences in development of use over time, $\beta = 0.307$, $t = 4.304$, $p < 0.01$. Increases in peer encouragement over 4 years also had a significant impact on the development of substance use over time, $\beta = 0.374$, $t = 4.711$, $p < 0.01$. Females tended to be higher in initial levels of substance use than males, $\beta = 0.157$, $t = 3.692$, $p < 0.01$; however, males were more likely to significantly increase their use over time, $\beta = -0.117$; $t = -2.402$, $p < 0.05$.

Although the model with the predictor effects constrained to be equal was considered an adequate representation of the relationships which existed among the observed variables, we also tested a model in which specified constraints were relaxed. The Lagrange Multiplier Test (EQS, Bentler, 1989) indicated that only one constraint was statistically inappropriate, thus we tested a final model with the effect of family cohesion on cigarette use freely estimated. Fit values for this model were χ^2 (672, $n = 345$) = 1272.353, $p < 0.001$, NNFI = 0.860, CFI = 0.862. When this constraint was relaxed effects were, $\beta = -0.112$, $t = -3.334$, $p < 0.01$, and $\beta = 0.054$, $t = 1.381$, $p > 0.05$, for family cohesion on the intercept and slope, and, $\beta = -0.206$, $t = -4.127$, $p < 0.01$, for family cohesion on the cigarettes intercept specifically. Change in family cohesion on the slope was $\beta = 0.042$, $t = 1.259$, $p > 0.05$. For friends' encouragement the effects were: $\beta = 0.176$, $t = 4.028$, $p < 0.01$ on the intercept; $\beta = 0.314$, $t = 4.386$, $p < 0.01$ on the slope; and $\beta = 0.371$, $t = 4.832$, $p < 0.01$ for the effect of change in friends' encouragement on substance use development. Gender effects were $\beta = 0.156$, $t = 3.719$, $p < 0.01$ on initial levels of use, and $\beta = -0.116$, $t = -2.418$, $p < 0.05$ on development of substance use over time. Thus, relaxing this one constraint suggested that family cohesion had a stronger effect on the initial status of cigarettes than on the other substances but did not change the interpretation of any of the other results. Although it is not appropriate to compare the chi-squares for the two models, given that neither model has a non-significant chi-square, the differences between the other indices of fit and the estimated regression coefficients for the two models were considered trivial.

Discussion

Utilizing a latent growth curve methodology for analysing longitudinal data for adolescent substance use, the present study tested hypotheses concerning the form of growth in alcohol, cigarette and marijuana use, the extent of individual differences in the common trajectory over time and covariates influencing both initial status and form of growth. Using a cohort sequential design, complete longitudinal curves spanning an 8-year period were successfully estimated using only 4 years of data. This procedure provides an efficient and more cost-effective method of examining longitudinal data. Results indicated an upward trend in the development of adolescent alcohol, cigarette and marijuana use between 11 years and 18 years of age, consistent with other developmental studies (e.g. Jessor & Jessor, 1984; Stein, Newcomb & Bentler, 1987; Duncan *et al.*, 1994). In addition, there appear to be more similarities than differences among the trends. Both initial levels of use and the shapes of the developmental curves were strongly correlated, indicating that use of one substance at a higher level is likely to be reflective of use in other substances at elevated levels and that increases in their use progress at similar rates. These findings lend support to other literature (e.g. Hansen *et al.*, 1987; Duncan & Duncan, 1994) documenting the similarities between adolescents' use of various substances by demonstrating that the developmental nature of these behaviors was very similar over the estimated 8-year period.

Mean levels and variances for each of the substances also reflect the stages phenomenon reported by Andrews *et al.*, (1991), Kandel & Faust (1974), and Donovan & Jessor (1985). Andrews *et al.* (1991) constructed a Guttman scale indicating a temporal sequence in which adolescents progress across substances. Most adolescents try alcohol first; of those that continue into the progression, the next substance of choice is cigarettes and subsequent to that, marijuana. This temporal sequence identified 90% of adolescents in that study. Moreover, adolescent substance use reflected in the Guttman scale covaried inversely with both adolescent and parent reports of family cohesion.

The greatest increase in mean level of initial use occurred between 13 years and 14 years of age for all three substances, corresponding to the adolescent's transition from middle school to high school. This period of adolescence in the United States is characterized by expanding opportunities for social relationships and availability of substances. A plausible mechanism for the developmental outcomes observed during this period of early adolescence, therefore, is the interaction that occurs between the adolescent and his/her social environment. Many researchers conclude that parent and peer influences constitute primary contextual risk factors influencing this development. This conceptualization provides a framework for testing the role risk and protective factors have in the adolescent's development of substance use, and specifies the factors that must be addressed if problematic development of substance use is to be prevented.

An important issue in investigations of adolescent substance use, however, is the degree to which the various explanations are generalizable across substances. Results from the present study, hypothesizing that family cohesiveness and peer encouragement to use various substances would account for individual differences in the growth parameters of adolescent alcohol, cigarette and marijuana use, suggest that these social factors, in many respects, have a common influence across the various substances. Higher levels of family cohesion appeared to suppress initial levels of use, whereas friend's encouragement was associated with higher initial levels of use and with greater increases in rates of use over the estimated 8-year developmental period. The similarity of the predictive relationships across substances was marked, given that only one constraint for the effects of the predictors across the various substances was untenable. This supports the notion that the social psychological processes underlying the use of substances among adolescents have essentially the same characteristics (Hansen *et al.*, 1987).

Of the social influences that have been hypothesized to effect tobacco, alcohol and marijuana use in adolescence, peer influences predominate (Dishion & Loeber, 1985; Kandel 1985; Fisher & Bauman, 1988). Our results appear consistent with this notion. Overall, both peer encouragement to use drugs and family cohesion were predictive of initial levels of use, although in opposing directions. Peer influence demonstrated powerful effects across the age range for initial levels of use, and was predictive of the developmental trajectories for the various substances. This finding is consistent with other research demonstrating the importance of peer influences in early adolescence (e.g. Berndt, 1979), and suggests that early peer influences may serve to maintain higher levels of subsequent substance use over time. Furthermore, the influence of changes in peer encouragement on the developmental trajectories suggests that susceptibility to peer influences throughout adolescence provides a major impetus to maintain higher levels of such use.

The findings for gender indicate that across all three substances females were higher than males in initial status and increased less rapidly in their use of the substances than did males, partly because of their elevated initial status. Although these gender effects may appear to contradict other research suggesting that adolescent males tend to be higher users of some substances than are adolescent females (e.g. Bachman, Johnston & O'Malley, 1981), other studies have failed to find substantial gender effects (e.g. Stein *et al.*, 1987). Moreover, in the present study, while tests of convergence indicated that a common effect of gender was tenable, tests for the specific effect for gender on each substance suggested that, when tested separately, only the effect of gender on initial marijuana use and change in that use reached significance. While the effect of gender approached significance for initial cigarette use, the effect for change in cigarette use and the effect of gender on alcohol use was non-significant.

We acknowledge that one would typically want to assess development of the various substances separately by gender. Clearly, subsequent investigations of this nature should endeavor to fully explicate these relationships. However, one limitation of the cohort–sequential approach is the necessity of very large samples when subgroup analyses, such as those separated by gender, are indicated. Given the generally limited resources available for subject recruitment and assessment, researchers are likely to encounter situations where the number of observations available for various subgroup analyses is prohibitively small. When this occurs it will become necessary to simplify the model so that a feasible number of groups with large sample sizes remain, acknowledging that the generalizability of the results may be limited by this particular specification of the latent variable model.

These findings suggest that it may be reasonable for intervention efforts to target substance use behaviors more broadly rather than limiting themselves to a single substance. It appears that relatively little understanding of the effects various social determinants have on the development of substance use is lost by considering their effects to be parsimonious across the various substances. However, even when adopting this more parsimonious view of adolescent substance use behavior it is important to acknowledge antecedents whose effects might be more specific in nature. For example, results from the present study indicated that family cohesion appeared to be more efficacious in delaying the eventual increase observed in cigarette use than for the other substances. It should be remembered that there may also be an advantage in considering the specific influences these behaviors have on later developmental outcomes when the adolescent enters young adulthood.

The causal relationships hypothesized to exist in the present data appear to hold reasonably well. However, we acknowledge that in using change scores, in addition to static measures, for family cohesion and peer encouragement in which the difference occurred at the same time change was occurring in the dependent variables, we have introduced concurrency into the design and potential confounds as to probable cause and effect. Regardless of how the data are collected, one might ask by what magic a symmetrical variance–covariance matrix would lead researchers to the asymmetric inference that family and peer influences "cause" changes in adolescent substance use. Like most cross-sectional models, the relationships among the variables representing one form of change or another in the present study have other alternative interpretations, making it difficult to isolate why the inference is so clearly in one direction. We agree that an equally tenable perspective is that adolescent substance use development is the result of reciprocal processes that occur between the individual and the environment and that adolescents' substance use will probably influence both family and peer processes. Further studies are necessary in which long-term longitudinal data are examined to fully explore this alternative conceptualization.

Although these findings provide evidence of similarities between different substances in their developmental trajectories over time, and in the effect parent and peer influences have on this development, it should be noted that a limitation of the present study is that all of the data are based on self-reports by the adolescent and thus may be partly affected by confounds due to a single informant perspective. Validity and reliability would be increased with the use of multi-agent and multi-item constructs. Even so, the results here indicate that the data fit developmental trends found by others with independent reporters (Steinberg & Silverberg, 1986).

When investigating developmental change in adolescent substance use and examining possible covariates of such change, an obvious advantage of utilizing an accelerated design over the reliance on the single–cohort longitudinal design is that the total follow-up period is shorter, results can be produced more quickly and shorter follow-up periods reduce the problems of cumulative testing effects and attrition. Another advantage is that the follow-up of several cohorts, rather than one, allows the researcher to determine whether those trends observed in the repeated observations are corroborated within short time periods for each age cohort. The main disadvantage of the accelerated design in comparison with the single-cohort longitudinal design is that within-individual developmental sequences are tracked, and behavioral continuity and prediction are studied, over shorter periods. As a result, some researchers have questioned the efficiency of the accelerated or cohort–sequential approach in adequately recovering information concerning the full longitudinal curve from different cohort-segments. In addition, questions still remain concerning the optimal number of time points per subject, the optimal number of points of overlap across adjacent cohorts and the optimal number of subjects per cohort given available resources, and the ability of the cohort–sequential approach to assess the impact of important events and intervening variables on the course of development (Raudenbush & Chan, 1992).

Despite these concerns, the findings reported here appear to underscore the utility of time-ordered approaches for investigating the effects exerted by social psychological variables on adolescent substance use during a rapidly changing developmental period. Using statistical techniques such as LGM provides an opportunity to more comprehensively investigate the developmental nature, antecedents and sequelae of a variety of adolescent problem behaviors.

Acknowledgements

This research was supported by Grant No. DA 03706 from the National Institute on Drug Abuse. Preparation of this manuscript was supported in part by Grant No. CA327273 from the National Cancer Institute and Grant No. DA07389 from the National Institute on Drug Abuse.

References

ANDREWS, J. A., HOPS, H., ARY, D., LICHTENSTEIN, E. & TILDESLEY, E. (1991) The construction, validation and use of a Guttman scale of adolescent substance use: an investigation of family relationships, *Journal of Drug Issues*, 21, 557–572.

ANDREWS, J. A., HOPS, H., ARY, D., TILDESLEY, E. & HARRIS, J. (1993) Parental influence on early adolescent substance use: specific and nonspecific effects, *Journal of Early Adolescence*, 13, 285–310.

ARY, D. V., TILDESLEY, E., HOPS, H. & ANDREWS, J. (1993) The influence of parent, sibling and peer modeling and attitudes on adolescent use of alcohol, *International Journal of the Addictions*, 28, 853–880.

BACHMAN, J. G., JOHNSTON, L. D. & O'MALLEY, P. M. (1981) Smoking, drinking, and drug use among American high school students: correlates and trends, 1975–1979, *American Journal of Public Health*, 71, 59–69.

BELL, R. Q. (1953) An experimental test of the accelerated longitudinal approach, *Child Development*, 25, 281–286.

BENTLER, P. M. (1989) *EQS Structural Equations Program Manual* (Los Angeles, BMDP Statistical Software).

BERNDT, T. J. (1979) Developmental changes in conformity to peers and parents, *Developmental Psychology*, 15, 608–616.

BROOK, J. S., WHITEMAN, M., GORDON, A. S. & BROOK, D. W. (1985) Father's influence on his daughter's marijuana use viewed in a mother and peer context, *Advances in Alcohol and Substance Abuse*, 4, 165–190.

BROOK, J. S., WHITEMAN, M., NOMURA, C., GORDON, A. S. & COHEN, P. (1988) Personality, family, and ecological influences on adolescent drug use: a developmental analysis, *Journal of Chemical Dependency Treatment*, 1, 123–161.

BRYK, A. S. & RAUDENBUSH, S. W. (1987) Application of hierarchical linear models to assessing change, *Psychological Bulletin*, 101, 147–158.

CHASSIN, L., PRESSON, C. C., SHERMAN, S. J., MONTELLO, D. & MCGREW, J. (1986) Changes in peer and parent influence during adolescence: longitudinal versus cross-sectional perspectives on smoking initiation, *Developmental Psychology*, 22, 327–334.

CRONBACH, L. J. (1951) Coefficient alpha and the internal structure of tests, *Psychometrika*, 16, 297–334.

DISHION, T. J. & LOEBER, R. (1985) Adolescent marijuana and alcohol use: the role of parents and peers revisited, *American Journal of Drug and Alcohol Abuse*, 11, 11–25.

DONOVAN, J. E. & JESSOR, R. (1985) Structure of problem behavior in adolescence and young adulthood, *Journal of Consulting and Clinical Psychology*, 53, 890–904.

DOUVAN, E. & ADELSON, J. (1966) *The Adolescent Experience* (New York, Wiley).

DUNCAN, S. C. & DUNCAN, T. E. (1994) Modeling incomplete longitudinal substance use data using latent variable growth curve methodology, *Multivariate Behavioral Research*, 29, 313–338.

DUNCAN, T. E. & DUNCAN, S. C. (1995). Modeling the processes of development via latent variable growth curve methodology, *Structural Equation Modeling*, 2, 187–213.

DUNCAN, T. E. & STOOLMILLER, M. (1993) Modeling social and psychological determinants of exercise behaviors via structural equation systems, *Research Quarterly for Exercise and Sport*, 64, 1–16.

DUNCAN, T. E., DUNCAN, S. C. & HOPS, H. (1994) The effect of family cohesiveness and peer encouragement on the development of adolescent alcohol use: a cohort-sequential approach to the analysis of longitudinal data, *Journal of Studies on Alcohol*, 55, 588–599.

FISHER, L. A. & BAUMAN, K. E. (1988) Influence and selection in the friend–adolescent relationship: findings from studies of adolescent smoking and drinking, *Journal of Applied Social Psychology*, 18, 289–314.

FRANCIS, D. J., FLETCHER, J. M., STUEBING, K. K., DAVIDSON, K. C. & THOMPSON, N. M. (1991) Analysis of change: modeling individual growth, *Journal of Consulting and Clinical Psychology*, 59, 27–37.

HANSEN, W. B., GRAHAM, J. W., SOBEL, J. L., SHELTON, D. R., FLAY, B. R. & JOHNSON, C. A. (1987) The consistency of peer and parent influences on tobacco, alcohol, and marijuana use among young adolescents, *Journal of Behavioral Medicine*, 10, 559–579.

HOPS, H., TILDESLEY, E., LICHTENSTEIN, E., ARY, D. & SHERMAN, L. (1990) Parent–adolescent problem-solving interactions and drug use, *American Journal of Drug and Alcohol Abuse*, 16, 239–258.

HUBA, G. J., WINGARD, J. A. & BENTLER, P. M. (1979) Beginning adolescent drug use and peer and adult interaction patterns, *Journal of Consulting and Clinical Psychology*, 47, 265–276.

JACOB, T. & TENNENBAUM, D. L. (1988) *Family Assessment: Rationale, Methods, and Future Dimensions* (New York, Plenum Press).

JESSOR, R. & JESSOR, S. L. (1977) *Problem Behavior and Psychosocial Development* (New York, Academic Press).

JESSOR, R. & JESSOR, S. L. (1984) Adolescence to young adulthood: a 12-year prospective study of problem behavior and psychosocial development, in: MEDNICK, S. A., HARWAY, M. & FINELLO, K. M. (Eds) *Handbook of Longitudinal Research, Teenage and Adult Cohorts*, vol. 2, pp. 34–61 (New York, Praeger).

KANDEL, D. B. (1985) On processes of peer influences in adolescent drug use: a developmental perspective, in: BROOK, J. S., LETTIERI, D. J., BROOK, D. W. & STIMMEL, B. (Eds) *Alcohol and Substance Abuse in Adolescence*, pp. 139–163 (New York, Haworth Press).

KANDEL, D. B. & ANDREWS, K. (1987) Processes of adolescent socialization by parents and peers, *International Journal of the Addictions*, 22, 319–342.

KANDEL, D. B. & FAUST, R. (1975) Sequence and stages in patterns of adolescent drug use, *Archives of General Psychiatry*, 32, 923–932.

KROSNICK, J. A. & JUDD, C. M. (1982) Transitions in social influence at adolescence: who induces cigarette smoking? *Developmental Psychology*, 18, 359–368.

MCARDLE, J. J. (1988) Dynamic but structural equation modeling of repeated measures data, in: CATTELL, R. B. & NESSELROADE, J. R. (Eds) *The Handbook of Multivariate Experimental Psychology*, 2nd edn, pp. 561–614 (New York, Plenum Press).

MCARDLE, J. J. & EPSTEIN, D. (1987) Latent growth curves within developmental structural equation models, *Child Development*, 58, 110–133.

MCARDLE, J. J. & HAMAGAMI, F. (1991) Modeling incomplete longitudinal and cross-sectional data using latent growth structural models, in: COLLINS, L. M. & HORN, J. C. (Eds) *Best Methods for the Analysis of Change*, pp. 276–304 (Washington, DC, American Psychological Association).

MEREDITH, W. & TISAK, J. (1990) Latent curve analysis, *Psychometrika*, 55, 107–122.

MOOS, R. (1974) *Family Environment Scale and Preliminary Manual* (Palo Alto, CA, Consulting Psychologists Press).

MURRAY, D. M., O'CONNELL, C. M., SCHMID, L. A. & PERRY, C. L. (1987) The validity of smoking self-reports by adolescents: a reexamination of the bogus pipeline procedure, *Addictive Behaviors*, 12, 7–15.

NAM, C. B. & TERRIE, W. (1988) *1980-based Nam-Powers Occupational Status Scores* (Working Paper Series 88–48, Center for the Study of Population, Florida State University).

NESSELROADE, J. R. & BALTES, P. B. (1979) *Longitudinal Research in the Study of Behavior and Development* (New York, Academic Press).

NEWCOMB, M. D., MADDAHIAN, E. & BENTLER, P. M. (1986) Risk factors for drug use among adolescents: concurrent and longitudinal analyses, *American Journal of Public Health*, 76, 525–531.

PARKE, R. D., MACDONALD, K. B., BEITEL, A. & BHAVNAGRI, N. (1988) The role of the family in the development of peer relationships, in: PETERS, R. DE V. & MCMAHON, R. J. (Eds) *Social Learning and Systems Approaches to Marriage and the Family*, pp. 17–44 (New York, Brunner-Mazel).

PATTERSON, G. R., REID, J. B. & DISHION, T. J. (1992) *Antisocial Boys* (Eugene, OR, Castalia).

RAO, C. R. (1958) Some statistical methods for comparison of growth curves, *Biometrics*, 14, 1–17.

RAUDENBUSH, S. W. & CHAN, W. (1992) Growth curve analysis in accelerated longitudinal designs, *Journal of Research in Crime and Delinquency*, 29, 387–411.

STEIN, J. A., NEWCOMB, M. D. & BENTLER, P. M. (1987) An 8-year study of multiple influences on drug use and drug use consequences, *Journal of Personality and Social Psychology*, 53, 1094–1105.

STEINBERG, L. & SILVERBERG, S. (1986) The vicissitudes of autonomy in adolescence, *Child Development*, 57, 841–851.

STOOLMILLER, M., DUNCAN, T. E., BANK, L. & PATTERSON, G. (1993) Some problems and solutions in the study of change: significant patterns in client resistance, *Journal of Clinical and Consulting Psychology*, 61, 920–928.

TUCKER, L. R. (1958) Determination of parameters of a functional relation by factor analysis, *Psychometrika*, 23, 19–23.

WILLET, J. B., AYOUB, C. C. & ROBINSON, D. (1991) Using growth modeling to examine systematic differences in growth: an example of change in the function of families at risk of maladaptive parenting, child abuse, or neglect, *Journal of Consulting and Clinical Psychology*, 59, 38–47.