

**Theory, Measurement, and Methods in  
The Study of Family Influences on Adolescent Smoking**

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**Forthcoming in Addiction.**

### **Abstract**

This paper discusses three key issues facing researchers interested in family influences in substance use: the transitional nature of adolescent smoking, the complexity and multi-dimensionality of family forms and influences, and the interrelationship of family influences with other key developmental contexts. Methodological and conceptual issues stemming from these dilemmas are discussed with regards to understanding why previous reviews have found the correlations between family predictors and adolescent smoking to be relatively low. In particular, the importance of understanding time, the transitional nature of the phenomenon, and within- and between- family processes are emphasized. More appropriate conceptual and statistical models for analyzing family influences are suggested, including growth curve analyses, use of techniques that take the nested nature of within-family processes into account, typological approaches. It is argued that stronger links between the sophisticated theoretical discussions in the growing literature on adolescents tobacco use trajectories and the methodological techniques used to model those processes will move the field towards a clearer understanding of developmental process.

## **Theory, Measurement, and Methods in The Study of Family Influences on Adolescent Smoking**

Although researchers interested in the development of adolescent smoking have long been interested in family influences, the literature has been less than clear about the strength of relationships (described as ‘unexpectedly low’ by Conrad (1992)) or the key processes through which they operate. Researchers interested in studying family influences face three key dilemmas. The first is the nature of adolescent smoking. Most individuals enter adolescence as non-smokers. Many begin smoking during their adolescent years. Some of those who begin to smoke quit, never to smoke again, while others go on to become committed, long-term smokers. In other words, smoking during adolescence is best characterized by change (Petraitis, Flay, & Miller, 1995). On the other hand, many of the family characteristics used to predict adolescent tobacco use (e.g. family bonding, parent smoking, parent attitudes towards adolescent smoking, parental monitoring) are relatively stable characteristics. Thus the dilemma: how does one conceptualize the processes that relate stability to change?

The second dilemma researchers interested in family influences on adolescent smoking must grapple with is the nature of the family itself. Although we commonly speak of ‘the family unit’, within-family influences cannot accurately be conceptualized as singular. Instead, mothers, fathers, siblings, and other family members each influence adolescents in different ways. Systemic properties of the family operate as well (Whitchurch & Constantine, 1993). For example, it is possible that an adolescent might have a greater tendency to begin smoking in a household where her mother, father, and only sibling smoke than would be predicted from the simple additive influences of each family

member. The confluence (Darling & Koehle, 2000) of influences may make conformity to family norms more salient (Bronfenbrenner & Morris, 1998). Alternatively, a threshold effect may operate, such that a single smoking family member increases adolescent risk to the same extent as three. In other words, modeling family influences on adolescent smoking is complex both because of the number of potential sources of influence within the family and because families have systemic properties over and above the influence of the individuals that compose them. Modeling family influences is further complicated by two additional characteristics of families. First, families come in many diverse forms. Obviously we would not want modeling maternal and paternal smoking as separate variables to result in all adolescents living in single parent families eliminated from the analyses because of missing data. How should this problem best be addressed? The second problem is more subtle. Family member characteristics are inherently interdependent, posing problems for traditional statistical techniques. For example, if we assume that parent and offspring tobacco use are correlated, how appropriate is it to model sibling influence on adolescent smoking by controlling parent tobacco use? Each of these latter two concerns make use of traditional statistical techniques problematic.

The third dilemma researchers interested in the influence of the family on adolescent smoking must grapple with is the nature of the family *during adolescence*. Although we have moved beyond primarily thinking of the family as a place for adolescents to move out of (Steinberg, 1990), it is still true that a key characteristic of adolescence is the expansion of the social world. Adolescents spend more time in the company of peers and less time with family members than do children (Larson & Richards, 1991; Larson, Richards, Moneta, Holmbeck, & Duckett, 1996). In addition, although parental influence remains quite strong, especially in areas involving values and long-term goals (Steinberg,

1990), peer influence peaks during mid-adolescence, especially in day-to-day activities (Berndt, 1979). Thus the relationship between the family and other key contexts should be of special interest to researchers interested in adolescent tobacco use. How do families influence the nature of other contexts to which adolescents are exposed? How do they influence the processes that occur in those other contexts? How are they influenced by outside contexts? And how, given the complex nature of the family, can such interrelationships be modeled? Similarly, normative changes in both contexts and behavioral expectations allow greater expression of individual differences in temperament, genetic predispositions, and learned attitudes and behaviors in adolescence than in childhood (Scarr & McCartney, 1983). How do family characteristics inhibit or facilitate the expression of such individual differences?

This paper has two goals: to examine each of these issues as it relates to developmental patterns of adolescent smoking trajectories and to discuss potential strategies for modeling family processes.

#### Status, stage, transition, and trajectory.

Recent reviews of the literature have highlighted the distinction between examining adolescent smoking *status* and examining the development of smoking *trajectories* (Clayton & Rountree, 2000; Mayhew, Flay, & Mott, 2000; Petraitis et al., 1995). Such distinctions are critical in understanding and accurately modeling the relationship between family characteristics and adolescent tobacco use. Status refers to the current categorization of an individual according to the variable of interest: in this case, tobacco use. Such statuses may be as simple as 'current smoker' v. 'current non-smoker' or they may include an explicit time element, for example 'never tried tobacco' v. 'tried tobacco'. Other status categorization schemes include an implicit time element. For example, Mayhew, Flay, & Mott (2000)

explicate four 'stages' of tobacco use. Individuals are labeled 'triers', 'experimenters', 'regular users', and 'dependent users'. Implicit in the stage model is the idea that a snapshot of an individual at any given time tells us something about their historical tobacco use. Just as we assume that the middle-aged individual pictured in a photograph was once a child, the explicated stages imply that a person who is captured in the status of 'regular user' has gone through the stages of 'trier' and 'experimenter' (Petraitis et al., 1995)<sup>1</sup>.

Current tobacco use status is limited in what it tells us about time, however, because it only captures a snapshot of a particular temporal moment. In contrast, the concept of 'transition' incorporates time explicitly, but incompletely. A transition is defined by change over time, for example, by a move from Status 1 (e.g. 'never tried') to Status 2 ('experimenter'). Transitions are not identical to time, however, because the unit of analysis is *change* rather than *time*. For example, a person who is a non-smoker at both Time 1 and Time 2 cannot be said to have made a transition, even though time has passed. Similarly, two people, both of whom have moved from Status 1 to Status 2, may have existed in the statuses for different periods of time. For example, Person 1 may have been in Status 1 at measurement points 1, 2, and 3, and moved to Status 2 at measurement point 4, while Person 2 may have been at Status 1 at measurement point 1, but Status 2 at measurement point 2. Although we can

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<sup>1</sup> A 'never used' category is not included in these stages. Also neglected are statuses that capture current levels that are lower than past use. For example, an individual who had been a heavy smoker but now smokes only occasionally would presumably be at a different stage of tobacco use than someone who currently smokes occasionally but had never shown any other pattern. This distinction highlights the limited way in which time is reflected in categorization schemes based on current status. Most stage models of substance use appear to be based on 'strong stage' assumptions, including unidirectionality and irreversibility (Wohlwill, 1973). Tobacco use histories, however, are not consistent with these assumptions.

look at the predictors of a transition without regard to time (for example, we can try to differentiate people who never smoke from those who make the transition, however fast that transition occurs), the comparison group of people who haven't made the transition always implies the element *within a given time frame*. Individuals included in the non-smoking status may make a transition to smoking at some time in the future.

Transitions, then, are quite different from *trajectories*, which are defined by *time* rather than by *change*<sup>2</sup>. Because the unit is time, change can take a value of 0, so stability is one potential trajectory. The minimum number of time-points needed to capture a trajectory is two<sup>3</sup>, thus the difference between smoking statuses at adjacent time points is change over time (i.e. speed of transition). With more than two points of measurement, trajectories also can include both measures of acceleration (changes in the speed of transition), if change is smooth, and measures of deflection, where comparisons in trajectories are made before and after the temporal occurrence of a particular predictor (divorce or the cessation of parental smoking, for example). The concept of deflection also implies that change can either be towards higher levels of smoking or mark a change to lower levels.

Before going on to discuss trajectories, two additional points should be made about the interface of time with transitions and trajectories. First, like transitions, trajectories implicitly assume 'within a given time frame'. Take the example where an individual is measured at Time 1, Time 2, and

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<sup>2</sup> Methodologically, the terms 'transition' and 'trajectory' are used, respectively, in latent transition analysis (LTA) to describe qualitative shifts in status and in growth curve models to describe the quantitative shifts evident in the time component of growth models, however it is not the intent of this paper to imply a distinction between qualitative and quantitative shifts by this usage.

<sup>3</sup> however, see Collins & Sayers (in press) for an excellent discussion of why more and more frequent collection of longitudinal data provide better estimates of developmental trajectories.

Time 3 and during that time moves from 'experimenter' to 'regular user' to 'dependent user'. We can calculate a trajectory for this individual of a movement of 2 stages within the time frame of Time 1 to Time 3. A second individual may be observed at Time 1 and Time 2 as an 'experimenter' and Time 3 as a 'regular user'. Within the time frame from Time 1 to Time 3, the second individual's trajectory appears show a slower progression. This is not necessarily the case however. For example, the first individual may have been an experimenter at Time -1 (i.e. at a hypothetical measurement point prior to the start of observation), but was not observed. The second individual may move to 'dependent user' at Time 4. In other words, both individuals may have identical trajectories of tobacco use, but be observed at different points in their trajectories. This observation introduces additional problems (and error) into the modeling of tobacco use trajectories, a point to be returned to in the discussion of sibling influences on tobacco use.

Second, tobacco use trajectories, which are defined by historical or objective time, interface with life course time - i.e. with age (Elder, 1998). For example, one would predict a different distribution of normative trajectories of tobacco use at different ages. During the pre-adolescent years, one might expect that the normative trajectory would be a flat pattern of non-use, with a secondary pattern of non-use with a singular status change to 'ever-tried'. One would also expect a small group of individuals at this age to make a rapid transition from non-user into dependence. For example, Jessor & Jessor (1977), Moffitt (1993), Patterson, DeBaryshe, & Ramsey (1989), and Pulkkinen (1990) all suggest that a certain subset of individuals evince a strong and consistent pattern of highly intercorrelated problem behaviors that appear early in their lives but take somewhat different forms depending on the developmental stage of the individual. Based upon their work, one might expect that



individuals who, *during late childhood or early adolescence*, show a trajectory of rapid movement from tobacco non-use to use would also be more prone towards sensation-seeking and impulse control problems, be more likely to experience dysfunction within the family system, be associated with a deviant peer group, be socially rejected by normal peers, and be engaged in a wide variety of other deviant behaviors<sup>4</sup>. However, there is no theoretical or empirical basis from which to predict that the same trajectory of rapid change would be associated with the same set of predictors at a different developmental period - during late adolescence, for example (Moffitt, 1993). For late adolescents, one might hypothesize that particular social processes and context (entrance into the military, for example) might predict a steep trajectory from non-use to use (see, for example, Schei & Sogaard, 1994). Thus at different points in the life course, we might predict different distributions of tobacco use trajectories and we might also expect to see different correlates of trajectory types. These two different issues of the interface of time and trajectory (implicit time frame and age) taken together, might help to bring order to the sometimes divergent findings of studies relating family predictors with adolescent tobacco use.

The nature of adolescent smoking: Predicting change from stability.

Family characteristics have been used to predict adolescents' tobacco use statuses, transitions, and trajectories. Demographically, adolescents from single-parent and lower SES families, whose

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<sup>4</sup> This hypothesis about differences in the predictors of similar trajectories (and, implicitly, of the processes underlying these trajectories) at different points in the life course is consistent with Graham et. al's (1991)'s finding that adolescents who begin the transition to substance use with tobacco showed a more rapid trajectory to high levels of use than those who began with alcohol as well and with Brook, Whiteman, Czeiler, Shapiro, & Cohen's (1996) report that only predelinquency predicted smoking among younger adolescents, but that a wider range of contextual variables predicted smoking among older adolescents.

families grow tobacco, and adolescents whose parents are less educated are more likely to smoke than their peers (Tyas & Pederson, 1998). At the proximal level, strong, positive parent-child bonds, authoritative parenting, higher levels of parental monitoring and parent-child communication, parent disapproval of smoking, and parent and sibling non-smoking have all been shown to decrease risk of tobacco use (for reviews, see Avenevoli & Merikangas, 2000; Centers for Disease Control and Prevention, 1994; Hawkins, Catalano, & Miller, 1992; Moncher, Holden, & Schinke, 1991).

As in most areas of developmental research, the majority of studies present cross-sectional findings and demonstrate associations between family characteristics and adolescent tobacco use status. Longitudinal research has provided researchers with the opportunity to examine both transitions and trajectories. Contrasting the two types of studies has provided some interesting insight into the importance of the distinction between statuses, transitions, and trajectories. Longitudinal research has also highlighted the differences in processes (or at least differences in predictors) that are involved in moving from being a non-user to an experimenter, and those involved in moving from experimentation into regular use. For example, Flay, Hu, & Richardson (Flay, Hu, & Richardson, 1998) found that peer factors were more important in moving adolescents from trial to experimental stages, but that family processes - specifically parental smoking and family conflicts - predicted transitions from experimental to regular use. In contrast, Chassin, Presson, & Sherman (1984) found that parents' smoking specific socialization predicted smoking cessation among younger adolescents, but that peer processes predicted cessation among older adolescents. Sibling smoking has been found to predict smoking status (Avenevoli & Merikangas, 2000), but not transitions or changes in smoking (Ary & Biglan, 1988; Hanson, Collins, Johnson, & Graham, 1985; Spielbecker, Jacobs, Crane, & Russell,

1983).

Because much of the longitudinal work has focused on the prediction of smoking status from family characteristics, it has obscured the fact that such studies are attempting to predict change from characteristics that are stable. Although such analyses are common, a more careful examination of their underlying assumptions is in order. When a stable family characteristic, such as parent smoking, is used to predict smoking status, the dependent variable is either the end point of a trajectory (for example, when parent smoking is used to predict smoking status in late adolescence) or it is capturing adolescents 'mid-flight' - i.e. at a particular time point within a trajectory. Because all smoking trajectories start at the same status (non-smoker), the ability to detect differences in adolescents' trajectories based on estimates at a particular point depends upon where you are in the diverging trajectories. If we start sufficiently early enough, statuses of future smokers and non-smokers will be identical. Thus the ability of a stable predictor to differentiate adolescent trajectories based on smoking status depends upon how appropriate the age of the participants and the time frame of the study is as well as on statistical power and measurement error.

In addition, adolescence is a time when long-term smoking patterns are in flux. Because most individuals enter adolescence as non-smokers, but most people who become smokers start smoking during adolescence, studies of adolescent smoking are inherently studies of change, even when such change is captured as smoking status. Although stable family characteristics may be predictors of change, they cannot be said to be the proximal *cause* of change. To use an analogy, when a rock rolls down a hillside, it's movement is not initiated by the hill, but by the person who kicked it. Taking the analogy one step further, one might predict that a rock on a hill will tumble down at some point in the

future, but its position on the hill neither tells you when that will happen nor what the particular event that will trigger the change will be. Knowing the rock is on a hillside, however, does allow you to predict that the effect of a kick on it may be different from the effect of a kick on a rock in a field. Focusing on proximal processes operating at points of transition, stable characteristics (such as parental smoking) can predict change only in the presence of a triggering event (such as the offer of a cigarette by a peer).

Triggering events can be internal to the child or they can be environmental. Stable characteristics of the family can make it more likely that a triggering event occurs, they can change the likelihood that a triggering event will be sufficient to cause change, or both. For example, social cognitive theory (Bandura, 1989) postulates that the knowledge and ability to enact a behavior is a necessary, but not sufficient, condition for the behavior to become manifest. With regard to smoking, growing up in families where parents are observed smoking provides the opportunity for children to learn the rudiments of smoking - how to light a cigarette, how to inhale, what to do with ashes, etc. - and virtually guarantees that smoking becomes part of the repertoire of behaviors that the child is capable of enacting. It also provides knowledge of where and when it is appropriate to smoke - while talking after a meal, drinking alcohol, driving, or relaxing, for example. Note that the family is not the only context in which knowledge of smoking behaviors can be acquired (peers and the media are obvious other sources), however it is possible that the length and breadth of exposure to smoking in the family make knowledge of smoking acquired in this setting both quantitatively and qualitatively different from that acquired through other sources.

The likelihood that the acquired behavior will be enacted depends upon many other factors,

however. For example, observers are more likely to enact learned behaviors modeled by attractive others who are similar to the observer and behaviors that are observed to have positive consequences. One would expect, then, that smoking by same-gender parents would increase the likelihood that children smoke more than smoking by cross-gender parents, and that parents who are positive about the smoking experience are more likely to be imitated than those who are negative. There is evidence to support each of these hypotheses, although tests have been relatively infrequent and results have been somewhat mixed (Avenevoli & Merikangas, 2000). Learned behaviors are also more likely to be enacted when models are attractive. With regards to smoking, then, one would expect to see the link between parent and child smoking to be strongest in the presence of a positive parent-child bond. Few researchers have investigated this prediction<sup>5</sup>. Interestingly, the preponderance of evidence suggests that poor relationships within the family and low levels of perceived parental support are associated with increased risk for tobacco use (for review, see Avenevoli & Merikangas, 2000) and greater likelihood of moving from experimental to established smoking (Distefan, Gilipin, Choi, & Pierce, 1998). Several theorists (Jessor & Jessor, 1977; Patterson et al., 1989) have suggested that adolescents who have poor relationships with parents are at increased risk for tobacco use because such relationships increase the likelihood that they will associate with deviant peers, and there is strong

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<sup>5</sup> Exceptions to this general trend is the finding by Bauman, Fisher, Bryan, & Chenoweth (1984) that maternal disapproval of smoking is only associated with lower levels of cigarette use when the adolescent is close to the mother (though no such association was found with regard to fathers) and by Andrews (1997) that modeling of parent alcohol and marijuana was highest when parents had relatively good relationships with their parents. In contrast, Doherty & Allen (1994) found that parent smoking combined with *low* family cohesion was the best predictor of smoking. Although inconsistent with what would be predicted from social cognitive theory, these findings are consistent with the contradictory processes that often operate within families, discussed in the next section of the paper.

evidence to support this contention (Biglan, Duncan, Ary, & Smolkowski, 1995; Chassin, Peterson, Todd, Rose, & Sherman, 1998; Cohen & Rice, 1997; Flay, Hu, Siddiqui, Day, & et al., 1994; Frauenglass, Routh, Pantin, & Mason, 1997; Melby, Conger, Conger, & Lorenz, 1993). Taken together, these theories suggest that (a) parental smoking will be most influential when adolescents enjoy a positive relationship with their parents and (b) that adolescents are more likely to be part of a peer group that encourages smoking when they experience poor relationships with parents. In other words, good relationships with parents who smoke may make adolescents more vulnerable to a triggering event such as being offered a cigarette, but less likely that they will be in a setting where that situation is likely to occur. It is possible that the inconsistency in the association between parent and child tobacco use (described as 'unexpectedly low' by Conrad, Flay, & Hill (1992, p. 1711)) may be partially accounted for by characteristics of the parent-child relationship or observed consequences of parental smoking that moderate the relationship between parent and adolescent smoking. For example, it seems counterintuitive that observing a parent struggle to quit smoking or suffer from a smoking-related illness would increase the likelihood of tobacco use.

In addition to illustrating the importance of examining moderating effects in understanding family processes (a point brought out again later in this essay), the previous discussion of social cognitive theory also illustrates three mechanisms through which stable family characteristics can predict change in behavior: directly through child characteristics that (a) increase their exposure, (2) increase their vulnerability to triggering events, or (3) change the child's environment in such a way that it increases the likelihood that the child will be exposed to triggering events. Each is discussed in turn.

Stable family characteristics can have a direct effect on child characteristics that change the

likelihood that children will be exposed to triggering events. Researchers from the Oregon Social Learning Center have presented compelling evidence that coercive parenting practices experienced in early childhood lead to a sequence of events, mediated through child behavior, that increases the likelihood that individuals will be exposed to deviant peer groups where tobacco use is common and delinquent acts are reinforced (see, for example, Dishion, Patterson, Stoolmiller, & Skinner, 1991; Dishion, Spracklen, Andrews, & Patterson, 1996; Patterson et al., 1989). Although these researchers focus on family reinforcement of aversive child behaviors and children's failure to acquire prosocial skills, other mechanisms are possible as well. For example, genetic characteristics or prenatal exposure to alcohol are biological mechanisms through which families can influence child sensation seeking or decrease impulse control, each of which may increase the likelihood that children are exposed to triggering events (Rutter, Champion, Quinton, Maugham, & Pickles, 1995). Girls whose mothers smoked during pregnancy are more likely to smoke during adolescence (Kandel, Wu, & Davies, 1994). Although part of this effect appears to be mediated through girls' child behavior problems (a result consistent with Patterson, DeBaryshe & Ramsey's (1989) model of the etiology of deviance), prenatal tobacco exposure appears to have a direct effect as well (Griesler, Kandel, & Davies, 1998). It is possible that such exposure increases girls' preferences for or responsiveness to tobacco, a point developed in the next section.

Stable family characteristics can have a direct effect on child characteristics that increase the likelihood that triggering events will cause a change in behavior. One way of conceptualizing family characteristics as risk factors is by using the analogy of action potential in nerves. Nerves have a particular action potential that they must reach before firing. Repeated stimulation of the nerve

increases its excitation state. The greater the excitation state, the less additional stimulation the nerve needs before it gets above a critical level and the nerve fires. Familial risk factors can be thought of as raising the excitation state of the system. Peer processes are the triggering events that bring the system over the critical level. With higher excitation states, less stimulation is needed to trigger the release of the action potential. For example, exposure to positive smoking models (such as parents) may increase the likelihood that adolescents will accept a cigarette when it is offered. Jessor & Jessor (1977) describe adolescents who are easily influenced to engage in deviant behaviors as 'transition prone' and hypothesize that rejection of mainstream values and rejection of parents increases adolescents' transition proneness by making them more vulnerable to negative peer influences. Although Jessor & Jessor focus on family socialization of dominant norms and the impact of family processes on child personality characteristics, biological processes may be seen to increase transition proneness as well. To the extent that susceptibility to the effects of nicotine or to tobacco addiction or to the extent that personality characteristics such as openness to peer influence have a genetic component, family characteristics may be said to predict susceptibility to triggering events through biological mechanisms. In addition, family characteristics can change biological predisposition to smoke if exposure to nicotine or tobacco smoke (either prenatally or postnatally) increases preferences for or susceptibility to smoking. For example, prenatal exposure to tobacco predicts adolescent girls' current smoking status, but not their lifetime smoking history, once current maternal smoking is controlled (Griesler et al., 1998). Lifetime smoking history is predicted by childhood problem behaviors, but current smoking status is not. These results are consistent with the hypothesis that prenatal tobacco exposure creates a 'latent addiction' in girls that is activated by tobacco exposure (Griesler et al., 1998). The likelihood



that postnatal tobacco exposure occurs varies depending upon characteristics of the girls' proximal environment (including her peer group), which, in turn, is partially dependent upon her own characteristics, including childhood problem behavior.

Stable family characteristics can have a direct effect on the likelihood that children will be exposed to triggering events. It is likely that stable family characteristics will influence children's exposure to triggering events through their influence on children's social network (for example, through choice of neighborhood or friends). Regional, neighborhood, and social class variations in the prevalence of smoking result in variability in the likelihood that children will be exposed to smoking models and offers. In one study of substance use (excluding tobacco), it was found that living in neighborhoods where adolescents are more involved in substance use increases the likelihood that adolescents themselves will become involved, even controlling for parent characteristics (Darling & Steinberg, 1997). Residential location is normally chosen by parents and is influenced by numerous family characteristics (see Furstenberg, Cook, Eccles, Elder, & Sameroff (1999) for in-depth treatment of this topic). In addition, Darling & Steinberg also report that the relationship between substance use among neighborhood peers and individual substance use varied with the extent to which families were integrated into the neighborhood. Adolescents whose families were integrated into their neighborhoods were more vulnerable to the negative influence of high levels of peer substance use. In this study, families had both a direct influence on adolescents' exposure to substance using peers through neighborhood selection and, within neighborhood, influenced their adolescents' vulnerability to neighborhood influences through their social integration.

Family processes influence exposure to risk factors in other ways as well. One process through

which parental monitoring, parenting style, and parental supportiveness may influence adolescent smoking is by changing the likelihood that adolescents associate with deviant peers (Patterson et al., 1989; Steinberg, Darling, & Fletcher, 1995). In addition to changing the exposure of adolescents to substance using peers, family characteristics may also increase the likelihood that adolescents are exposed to triggering events such as stressors that may move adolescents more quickly along the trajectory to dependent tobacco use. Childhood exposure to family-related stressors (including marital disruption, divorce, physical, sexual, or emotional abuse, growing up with substance-abusing, mentally ill, or incarcerated family members or an abused mother) is related to earlier initiation of smoking, greater likelihood of ever-time smoking, current smoking status and current smoking level during adolescence and adulthood (Anda et al., 1999). Anda et al. argue that exposure to stressful events increases the salience of the stress-reduction properties of nicotine, increasing the benefit of tobacco to users during early stages and making it more difficult to quit at later stages. Thus family stressors may both increase adolescents' exposure to triggering events through impact on the peer group, and also increase adolescents' vulnerability to triggering events.

Note that each of these three potential classes of processes linking stable family characteristics with change in adolescent smoking is mediated through triggering events, such as exposure to tobacco-using peers. The interrelationship of these processes can be seen in a study of contextual influences on substance use (Caldwell & Darling, 1999). Low parental monitoring and greater amount of time spent in unsupervised peer settings predicted more time spent in settings where it was likely that adolescents would be exposed to substance use ('partying'). However, unsupervised time spent with peers was only associated with time partying when the peers with whom adolescents associated thought partying

was important. In addition, although time spent partying was associated with higher levels of substance use (excluding tobacco), this was only true for adolescents with low resistance to peer pressure. In other words, the link between low parental monitoring and substance use could be interrupted at several points, both by characteristics of adolescents' peer groups and by characteristics of the adolescents themselves. This complexity is almost certainly one underlying reason for the weak association observed between stable family processes and changes in adolescent tobacco use.

One final point that is important in thinking about the issue of predicting change in behaviors from stability comes back to the issue of age. As several authors have noted, the same parent behaviors may take on different characteristics when the child is at different ages as these behaviors become more or less developmentally appropriate (e.g. Darling & Steinberg, 1993b; Dishion & McMahon, 1998). For example, strict curfews and parental supervision that are developmentally appropriate for a younger child might be met with hostility and rebellion by an adolescent. Poor parental monitoring, which might have had only modest negative effects during middle childhood, may become increasingly problematic as deviant behaviors become more normative and adolescents spend more time in unsupervised settings. In other words, stability in parent behavior, coupled with change in the developing child, may combine to form a triggering event for change. It is exactly this type of lag between changes in parent behavior and child expectations that Collins (1990; 1994) and Smetana (1994) credit with the increase in conflict observed in early adolescence.

Similarly, if parents communicate that smoking is an unacceptable behavior *for children*, the older adolescent may not perceive parent disapproval as applying to them. As adolescents grow older, they increasingly differentiate between their belief that parents have a right to set rules and their belief

that they are not obligated to obey parental rules that they do not agree with (Smetana, 1994).

Although alcohol, drug, and tobacco use are defined as 'prudential' (i.e. safety-related) issues that adolescents expect parents to set rules about and believe parents have a right to set rules about, they are also the issues on which adolescents are most likely to differentiate between parents' right to set rules and their own obligation to obey (Nucci, Guerra, & Lee, 1991). Again, here the change from which a behavioral transition might be predicted is not a characteristic of the parents, which remains constant, but of adolescents' thinking about the issues involved.

The nature of the family: The family as a complex system.

In their 1957 study of the influence of mothers on infant development, Sears, Maccoby, and Levin (1957, 1976) summarized the relationships between hundreds of maternal characteristics and dozens of child outcomes. Their main conclusion was that families are complicated systems and that it is impossible to fully disentangle the influence of the many different processes that operate within them. Similar conclusions had been reached by the Child Study Association in 1936 (Greenberger, quote by Symonds, 1939). It is this inherent complexity that has motivated much of the research on parenting style (Darling & Steinberg, 1993a). Although Sears, Maccoby, and Levin were writing about the influence of mothers on young children, and despite the decades that have passed and the striking advances in statistical modeling, the same conclusions might be drawn about the influence of the family on adolescent smoking.

Multiple processes: the case of style. There are three major difficulties in modeling family influences. First, individuals within families engage in many different exchanges and interactions across a broad range of issues. As was seen in the discussion of social cognitive theory, these exchanges may

push the adolescent in contradictory directions, as when having a good relationship with a mother who smokes may predispose an adolescent to look at smoking positively, but make it less likely that he spend time with friends who smoke. Although the influence of different processes may be additive, it is also possible that they will moderate each other - either acting together synergistically or buffering one another. For example, authoritative parenting, a parenting style that combines strictness and warmth, is associated with lower levels of tobacco use (Baumrind, 1991; Cohen & Rice, 1997; Radziszewska, Richardson, Dent, & Flay, 1996). Darling & Steinberg (1993a) have argued that parenting style might best be thought of as a context that moderates the influence of other parenting behaviors by increasing the effectiveness of those behaviors and by changing adolescents' openness to socialization.

Consistent with this model, Bauman, Fisher, Bryan, & Chenoweth (1984) report that maternal disapproval of smoking is only associated with lower levels of cigarette use when the adolescent is close to the mother (though no moderating effect was found with regard to fathers) and Andrews, Hops, & Duncan (1997) report that modeling of parent alcohol and marijuana was highest when parents had relatively good relationships with their parents <sup>6</sup>.

A further complication is that processes within families operate over a long period of time and their influence may differ depending upon the age of the child. For example, several researchers have reported that parents' former cigarette use is associated with adolescent smoking (Bailey et al., 1993;

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<sup>6</sup> It should be noted that Bailey, Ennett, & Ringwalt (1993) concluded in a study of 6<sup>th</sup> and 7<sup>th</sup> graders that parent smoking and family contextual variables (monitoring, time spent with child, disapproval of smoking, family conflict, and family disunion) that an additive, rather than interactive, model best fit the data. However, the young age and high functioning of this sample limits its ability to inform this issue in that, as previously discussed, different processes may be involved in taking up smoking at different development stages.

Bauman, Foshee, Linzer, & Koch, 1990; Farkas, Distefan, Choi, Gilpin, & Pierce, 1999; Jackson & Henriksen, 1997). Farkas (1999) and his colleagues found that parental smoking reduction is most beneficial if it occurs before the child reaches age 9, i.e. before most children encounter frequent cigarette offers. Nonetheless, children whose parents quit when they were relatively young were only one third less likely to smoke than those whose parents were currently smoking. These results suggest that children absorb messages about tobacco use across their lifetime, not just during the period when they are likely to begin to smoke. Thus families are unique in the breadth of areas they touch upon, in the length of time they interact, and in the fact that they touch the lives of the children with them at all developmental stages.

Reciprocal processes: The case of monitoring. The second major difficulty posed by the complexity of family systems is that patterns of family interactions and influence develop reciprocally over time and are mutually interdependent. Parental monitoring is a case in point. Effective monitoring of adolescent behavior is consistently associated with lower levels of substance use (see, for example Ary, Duncan, Biglan et al., 1999; Ary, Duncan, Duncan, & Hops, 1999; Darling & Koehle, 2000; Dishion et al., 1991; Duncan, Duncan, Biglan, & Ary, 1998; Metzler, Biglan, Ary, & Li, 1998; Metzler, Noell, Biglan, Ary, & et al., 1994; Mott, Crowe, Richardson, & Flay, 1999). Although monitoring has often been interpreted as a parenting practice involving active attempts on the part of parents to watch over children as a means of control (for reviews, see Kerr & Stattin, 2000; Stattin & Kerr, 2000), recent theoretical and empirical work has undermined this interpretation (Darling, Cumsille, & Dowdy, 1998; Darling, Hames, & Cumsille, 2000; Dishion & McMahon, 1998; Kerr & Stattin, 2000; Stattin & Kerr, 2000). For example, although parental monitoring predicted a wide range of positive adolescent

outcomes, most of this relationship was explained by adolescents' spontaneous disclosure of information to parents, and not by parents' attempts to secure information (Kerr & Stattin, 2000).

Both adolescents' decisions about the extent of information they disclose to parents and their motivations for doing so depend upon many factors, including their perception that the issue can be successfully kept from parents, their belief that their parent has a legitimate right to set rules about the behavior in question, and their perception that the issue is important (Darling et al., 2000). Adolescents are more likely to disclose disagreement with parents when they think the issue is important than when they did not, which suggests that most adolescents are interested in maintaining open communication with parents, even when so doing might have negative consequences for themselves<sup>7</sup>. The critical factor in determining both disclosure strategy and motivations appears to be adolescents' legitimacy beliefs (Darling et al., 2000). Stattin & Kerr interpret non-disclosure as a sign of dysfunction within the family system (Kerr & Stattin, 2000; Stattin & Kerr, 2000). In contrast, Elkind (1980) suggests that increasing privacy concerns and decisions not to share some kinds of information with parents represent a normative shift in parent-adolescent relationships that is part of the healthy development of autonomy, an interpretation more consistent with literature on strategic communications and interactions (see, for example, Buhrmester & Prager, 1995, and other chapters in the same volume). It is possible, however, that although normative shifts in disclosure patterns are a healthy part of the evolution of the parent-

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<sup>7</sup> On average, high school students in this dataset ranked smoking, drinking, and drug use as among the least important to them of 36 potentially conflictual issues (31<sup>th</sup>, 32<sup>th</sup>, and 36<sup>th</sup>, respectively). Smoking had a mean importance score of 2.17, with 1 representing 'not important' and 4 'important', although 50 of 121 students rated smoking as either 'very important' or important'. Virtually equal numbers of adolescents agreed and disagreed with parents about smoking and agreement with parents did not differentiate between those who reporting smoking was 'very important' or 'important' to them from those who reported that it was 'a little' or 'not' important.

adolescent relationship, premature shifts to non-disclosure may represent problematic developmental trajectories (Darling, 2001). If true, this pattern would be parallel both to Jessor & Jessor's (Jessor & Jessor, 1977) work on problem behavior syndrome and Steinberg & Silverberg's research on the development of adolescent autonomy (Steinberg & Silverberg, 1987). In both those studies, early evidence of pseudoadult behavior was indicative of developmental problems. This newly developing literature on the adolescents' role in parental knowledge of adolescent activities makes it clear that what has been called parental monitoring is a function of both parent and child characteristics and reflects current characteristics of the relationship as well as past history.

As children enter adolescence, they spend increasing time in unsupervised settings outside of the home. In addition to increasing parents' reliance on adolescents for information about their activities, this shift also means that the effectiveness of parental socialization efforts depends upon adolescents' willingness to obey rules when adolescents are away from direct parental supervision. Chyung & Darling, (1998) report that adolescents' beliefs in the legitimacy of their parents' authority buffers them from the negative influence of substance using peers and that monitoring only predicts adolescent substance use when adolescents do not believe that their parents have the right to set rules. Taken together, these findings underscore the reciprocity of parent-child influence and the reliance of adolescents' parents on their children's willingness to be socialized (Darling & Steinberg, 1993a) as well as the importance of understanding both adolescents' and parents' roles in processes underlying constructs such as monitoring (Darling et al., 1998; Darling et al., 2000; Kerr, Stattin, & Trost, 1999; Stattin & Kerr, 2000).

Diverse family forms. Finally, the third major difficulty posed by the complexity of family



systems is that 'the' family is not a singular source of influence, but is usually made up of several different sources, each of whom may influence (and be influenced) by the developing individual in many different ways. Traditional techniques for modeling multiple sources of influence run into several problems. First, families take on many forms. In a study of a small, rural town in upstate New York, it was necessary to code thirty-four different basic categories of family types, including a 'joint custody' coding that did not specify who was living in each household the child spent significant time in (1987). In this category alone we found families in which children were spending time with two now divorced parents in separate homes, a family in which both parents and their new spouses lived with the children of the first marriage in one large home, a family in which the child moved between living with her biological father and a stepmother and her mother and her lesbian partner, etc. More diverse communities expand the number of observed living situations. For example, 'Woodlawn', a poor, predominantly African-American neighborhood in Chicago was described as having over 80 different family types (Pearson, Hunter, Ensminger, & Kellam, 1990). This diversity poses a challenge for researchers. If current smoking status of mothers, fathers, and siblings are coded separately, decisions must be made about how to code adolescents who live only with a mother or only with a father. Is residential status important, or is smoking by non-residential parents important as well? Should adolescents without complete sets of data (i.e. those living in non-intact families) be dropped from the analysis? What of stepparents and other adults living in the home? Sensitivity to the definition of 'family' is especially important in understanding social influences on adolescent smoking among immigrant and ethnic minority groups whose kinship networks include larger numbers of kin who may have neither biological nor legal ties to the adolescent (Spencer & Dornbusch, 1990). Substantial

numbers of adolescents change their residential mobility depending upon opportunities for schooling, recreation, and the availability of supervising adults. In a country where more than one third of children are born to unwed mothers and more than one quarter of adolescents spend five or more years living with a single parent, this issue will become increasingly important.

Siblings add additional complexity. First, number, type, and residential status of siblings varies even more widely than number, type, and residential status of parent figures. Relative age and gender are important considerations in sibling research (Dunn & Plomin, 1990). If one collapses sibling smoking information by coding number of smoking siblings, should adolescents who have no siblings, an only sibling who is still a toddler, and three older, non-smoking siblings all be coded the same way? Obviously, the answers to these questions should vary depending upon theory-driven hypotheses about developmental processes. To date, many of the analyses have been simplistic, only rarely examining the differential impact of mothers and fathers on their same and cross-gender offspring. Research on sibling smoking could especially benefit from careful, theory-driven research, in that it is both complicated and appears to have powerful effects on adolescent smoking status (Avenevoli & Merikangas, 2000).

The standard way of modeling multiple family influences is to use techniques such as multiple regression, entering mother, father, and sibling smoking as separate variables that are statistically independent of one another. Potential moderating effects are modeled as statistical interactions using multiplicative terms. Several problems with this standard practice are worth discussing, however. These problems are usually classed under the categories of collinearity and power. If we assume that the smoking behaviors of family members are associated with adolescent smoking (this is the reason for testing the model, after all), we have to assume that smoking behaviors of other family members are

correlated as well. This problem of colinearity makes it difficult to disentangle the separate influence of each variable (i.e. it reduces the power of the tests associated with each individual variable) and makes differences in variability an important determinant of the results of the analyses. For example, take the case where mother and father smoking are more highly correlated with one another than they are with sibling smoking. When mother, father, and sibling smoking are entered into a regression equation simultaneously, colinearity may eliminate the independent effects of mother and father smoking as individual variables, even though, *treated as a block*, these variables may still predict adolescent smoking. In addition, parent smoking probably has a very different distribution than does sibling smoking. If most adults either smoke regularly or don't smoke at all, but adolescents exhibit a wider range of smoking patterns (experimenting, smoking regularly, etc.), then the variability of sibling smoking will be much greater than the variability in parent smoking. This would enhance the power of sibling smoking as a predictor. In this situation, modeling interactions between variables may be particularly problematic, not only because the predictors are not independent, but also because the distribution of the component variables will not approximate normal, exacerbating the problem of outliers (Wilcox, 1997).

Traditional techniques for modeling family influence: The example of sibling smoking. Although the colinearity issue inherent to modeling family processes is a methodological problem, it has a strong conceptual component as well. If we believe that family smoking-related behaviors are interrelated, does it make sense to examine the influence of sibling smoking on target adolescent smoking, for example, but control for the effect of parents? Several researchers have reported that when parent and sibling smoking are entered into a regression equation simultaneously, the parent effect is diminished

(Avenevoli & Merikangas, 2000). Normally, this would be interpreted as a mediational effect: the association between parent characteristic and adolescent outcome is caused by the parents' effect on the sibling, which in turn, directly influences the target adolescent. This is consistent with empirical research suggesting that adolescents sometimes begin smoking in response to offers by older siblings (Presti, Ary, & Lichtenstein, 1992). Logically, however, this explanation lacks substance. One cannot posit that parents influence one sibling directly, but the other only indirectly.

A second model consistent with this pattern of findings is that both siblings are influenced by a third (unmeasured) process that influences both of their smoking behaviors. In this model, parent behavior is only associated with adolescent smoking because it is correlated with this third factor - i.e. parent behavior can be treated as a confound. For example, if the family lives in a neighborhood that has been heavily targeted by cigarette advertising aimed at children, one can imagine that parent smoking behaviors might be correlated with amount of neighborhood advertising, but both siblings might be more strongly influenced by the advertising because they were part of the targeted population. Once you controlled for sibling smoking behavior, the parent effect would drop out of the model but the sibling variable would not because it captured the advertising effect. In other words, predicting the behavior of one sibling from that of another taps the shared environment experienced by the dyad.

A third model consistent with a measured sibling variable diminishing the relationship between a measured parent variable and adolescent smoking is similar, but builds upon the idea that parent behavior is much more complex than measured parent variables. Measured sibling smoking has the potential to capture all of the processes operating in the family that would influence smoking. These

are, presumably, the same processes affecting the target adolescent<sup>8</sup>. If parental smoking were the measured parent variable, its effect on the target adolescent, plus all other unmeasured characteristics of the family, neighborhood, school, and shared environment that influence smoking, would be captured in the measure of sibling smoking. When sibling smoking was controlled, the relationship between parent smoking and adolescent smoking would be diminished.

Within and between family differences. A better strategy for modeling family influences on smoking is to acknowledge the nested structure of the data and use analytic methods that take this structure into account. Such methods can be modeled using structural equation models or through specialized programs like PROC MIXED (SAS) or HLM (hierarchical linear modeling) (Bryk & Raudenbush, 1992). Taking a simple case, data could be collected on smoking status of two adolescent siblings and two parent predictors in a sample of families. In this example, adolescent smoking could be predicted by the parent predictors, sibling characteristics (smoking status, for example), and individual characteristics (age and birth order, for example). In a standard HLM analysis, the first step would be to estimate the intraclass correlation between sibling smoking. This is an estimate of the amount of variance in the smoking outcome that can be attributed to being a member of a particular family (i.e. the similarity of siblings on smoking). In the second step of the analysis, predictors would be used to predict both between-family and within-family variance. This latter distinction between between-family and within-family models is critical. Parent smoking is common to both siblings but differs between families, and can be used to predict between-family differences in

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<sup>8</sup> Obviously, sibling smoking would also include non-shared environmental effects as well as individual differences in the effects of these processes on adolescent smoking that might not be common to the sibling, plus random error (Rowe & Plomin, 1981).

adolescent smoking. Within-family differences would be predicted by the differential experiences of the two siblings. For example, in a family in which one sibling smokes and the other doesn't, having a smoking sibling differentiates between the experience of the two siblings. Note that in these two models, the parameter of the relationship between shared family characteristic such as parent smoking and adolescent smoking is estimated between families, but the parameter of the relationship between non-shared family characteristics such as sibling smoking is estimated within-families.

Models that use two siblings from the same family to estimate sibling influence have several advantages over standard techniques. One is the differentiation of between- and within-family parameter estimates. By modeling sibling effects within families, common sources of between family variance are removed from the sibling estimate. In addition, individual differences in siblings characteristics can be used to further specify the model - for example, age. This is particularly important in trying to understand sibling influences. Most researchers interested in sibling influence on tobacco use have estimated current tobacco use status. However, because exposure to contexts in which smoking is likely to be initiated is often age graded, the age differences between siblings becomes quite problematic. For example, would having a 16 year old sibling who began smoking at 15 better predict the smoking status of a 13 year old, the age at which the 13 year old would make the transition to smoking, or the trajectory of smoking? In other words, adolescents' developmental trajectories might be more similar than their statuses at different ages. In addition, it may be that having an older sibling already smoking may speed the younger sibling along their own trajectory. Within-family growth curve analysis, in which sibling trajectories are compared with one another, may be the most promising method of understanding sibling influences (for a discussion of such models in the context of modeling

reciprocal influences in marital dyads, see Maguire, 1999). Differential influence of family characteristics on siblings with different characteristics can be modeled as well. Rose, Chassin, Presson & Sherman (1999) used HLM to model family and peer influences on adolescent smoking using a sample of sibling dyads and found quite strong between family effects. Unfortunately, sibling influence was not modeled. This paper was particularly interesting in that it noted strong shared environmental effects within the family (both in that the intraclass correlation between siblings was quite high and the effects of parent smoking were relatively powerful), as well as strong non-shared environmental influences from peers.

Contexts, communities, and niches. An alternative way of conceptualizing the family as a context for adolescent smoking is to take the word 'context' literally, rather than simply using it as a synonym for the word 'influence'. Person-context interaction and ecological systems theories (Bronfenbrenner & Morris, 1998; Magnusson & Stattin, 1998) both emphasize the interrelated nature of the processes and characteristics of naturally occurring systems, such as families, and the potential for distorting our understanding of how these systems work when we ignore their systemic nature. One way of respecting the systemic properties of families is to apply an ecological or community systems approach to its study. In the biological science of ecology, the concept of *community* is used to describe a set of interrelated species that commonly co-occur (Wilson & Bossert, 1971). For example, a high desert supports a community that is quite different from a bog community. Although the individual species found in each community type vary in different parts of the world, species occupying a community share common characteristics due to the processes underlying community formation. Species in communities co-occur because they share overlapping niches. A *niche*, in this

technical sense of the word, is the set of environmental conditions necessary for species survival (Wilson & Bossert, 1971). For example, temperature range, rainfall, sun exposure, and soil pH are characteristics that help to differentiate niches and thus separate species into different plant communities. Species within communities share a suite of correlated features due to the selection and adaptation processes that operate in their shared environmental conditions. Although different community types vary across the environmental features that define them (soil pH, for example, differentiates high desert and bog environments), it is important to note that the differences between bog and high desert communities are not captured along those single dimensions.

Applying this kind of community systems perspective to the family provides an alternative strategy for studying adolescent tobacco use and opens several lines of investigation not previously explored. For example, this model suggests that particular constellations of interrelated characteristics arise in response to particular ecological processes (Ricklefs, 1976). Cataloging and describing community types leads to greater understanding of the prevalence and operation of etiological processes. Applied to adolescent tobacco use, this suggests that the within-family patterning of tobacco use and a careful study of the conditions under which particular patterns arise may prove helpful in gaining insight into how tobacco use begins and is maintained. For example, if families in which only fathers smoke and both parents smoke are common, but it is less common to find families in which only the mother smokes, what are the processes underlying this 'hole' in the distribution? How common is it for the adolescents in a family to smoke when neither parent does and under what conditions does this pattern occur? Although data collected to answer questions about the predictors of individual smoking can be analyzed in such a way as to answer these questions, framing questions



from a community systems perspective that focuses on the patterning of features changes the emphasis and generates a different set of hypotheses (see Magnusson & Stattin, 1998, for a discussion of this point).

Grouping families according to patterning and predicting group membership also implies very different methodological approaches than individually centered techniques. Focusing on individuals in particular roles (e.g. oldest child) within an ecological community framework embeds the child in a particular constellation of processes. Because typological analyses capture a great deal of information about environmental conditions through the classification, they increase the power of the analyses markedly. For example, in an analysis of the relationship of parental monitoring, sibling substance use (excluding tobacco), peer substance use and adolescent substance use, Darling & Koehle (2000) classified sibling dyads according to the similarity of their peer groups and their perception of parental monitoring. Based on hypotheses about buffering processes, they predicted that parental monitoring would be most powerful and peer substance use least powerful as predictors in the condition where siblings experienced similar levels of parental monitoring, but had quite different types of peers. Their hypotheses were confirmed. A more traditional, non-system based analysis would have required testing these hypotheses using two three-way interaction terms. A daunting task! Two things about this example are important. First, is the issue of power. Complex interactions require large samples to model adequately. Second is that dyads were classified, not according to the patterning of their values on monitoring and peer substance use, but on the *confluence* of influences operating within the family. In other words, families were not grouped according to whether they had high or low monitoring and on whether peers were high or low on substance use. The study's major hypotheses concerned the way

that parent, sibling, and peer processes operated when family, sibling, and peer processes were all were working together compared to how they operated when family and peer influences were working at cross-purposes. Because of this, dyads were grouped according to the confluence or disjunction of influences (maintaining the full range of variance in each group). Using this strategy, direct comparison of the relationship between variables across dyad types yields information on the full range of adolescent outcomes in very different circumstances. Other hypotheses might lead to different systemic properties becoming more important in determining group membership.

Systemic approaches may be especially useful when examining longitudinal data. For example, comparing the smoking trajectories of adolescents who have similar characteristics but who are embedded in different family types yields information about the influence of multiple factors (including moderating effects) with only limited loss of power.

The nature of the family during adolescence: The interface of family and non-family processes.

The changing nature of adolescent social relationships and the previous discussion of processes linking stable family characteristics with changes in smoking behavior both highlight the importance of examining the interface between family processes and processes operating in other contexts. For example, how do peer processes influence adolescent smoking trajectories in families that differ in parent smoking? One approach to modeling moderating effects is using multiplicative interaction terms in standard regression models. However, this method has limitations, many of which have already been discussed. Going back to the analogy of the plant communities, a drought will have a very different effect on a high desert community than on a bog community. These differences are only captured in a limited extent by examining the statistical interaction of observed and average rainfall. In a small

sample, they would probably not be captured in tests of the interaction of observed rainfall and soil pH at all. This example illustrates two related points. First, and most broadly, the ability of an interaction term to capture differences in process depends upon the ability to measure the processes accurately. In this particular example, soil pH can be measured quite accurately, but measuring rainfall is problematic in both settings. The infrequent torrential rains typical of high deserts can overwhelm measuring instruments, while measurement of rainfall in bogs does not capture constant, low-level precipitation and dew well, and may not reflect deposition of watershed drainage that results from distant rainfall. Although measurement error is always problematic, poor measurement is especially problematic in modeling interactions, where error is compounded and deviations from normality can have strong and unexpected effects on the results (Wilcox, 1997). Second, the differences between the high desert and bog communities are not well captured by any single dimension along which they vary. Despite this limitation, average rainfall probably captures the differences between the environments better *in this situation*, because it is more strongly tied to the process of interest: drought. In situations characterized by highly correlated features, such as families, single indicators may best be thought of as marker variables - i.e. variables that do not measure the construct of interest, but rather are standing in as proxies for them. In this situation, the more highly correlated the marker variable is with the latent, unmeasured construct, the more successful it will be in capturing those differences in an interaction term.

Structural equation models are designed to capture latent processes more fully and have the additional advantage of enabling modeling of error terms. Unfortunately, most current applications are limited in that they do not lend themselves to testing interactions between linear measures. Because the

most important effects of families on adolescent smoking may be specifically in their ability to moderate the influence of other contexts, this limits SEM models' applicability to studying family influences in this domain. One promising strategy may be to combine the typological approach discussed in the previous section with an SEM approach to modeling process. For example, one might classify families according to a patterning of potential processes. Comparison of SEM models of non-familial processes across family types would test hypotheses about the differential influence of non-familial processes on adolescent smoking in different family contexts.

### Conclusion

The goal of this paper was to discuss how the nature of adolescent smoking, the nature of the family, and the nature of the family during adolescence present serious conceptual and methodological challenges to researchers interested in studying the family as a context for the development of adolescent smoking. First, although the study of smoking during adolescence is fundamentally the study of change, smoking is often predicted from relatively stable family characteristics, such as demographics, parent smoking status, or relationship quality. Focusing on adolescent smoking 'status' rather than on trajectories introduces considerable error into models of family process. In addition, it is likely that the influence of families on smoking trajectories is indirect, through changing adolescents' exposure and vulnerability to triggering events. Greater sensitivity to the transitional nature of adolescent smoking may help bring this sometimes contradictory literature into clearer focus. Second, the complexity of the family system, including multiple simultaneous processes, the reciprocal nature of processes, and the diversity of family forms, makes it imperative that research be theoretically grounded. Approaches that recognize the nested nature of family data or take a typological/community

systems approach to modeling family influences offer several advantages over more commonly employed statistical techniques in capturing this complexity. These techniques also offer promise in modeling the interface of family processes with processes operating in other social contexts. Because adolescents spend increasing time outside of the family, the connections between the family and the larger social world may be a critical area of research.

Although the many excellent prospective studies currently in the literature provide a wealth of data about the correlates of adolescent tobacco use, our understanding of the developmental processes underlying the initiation of tobacco use remains limited. One factor contributing to this problem may be disciplinary, stemming from interest in predicting risk. Although traditional statistical techniques provide excellent means of identifying risk factors that increase the likelihood of the development of a particular behavior (smoking, for example), they are more limited in modeling developmental processes in complex, interrelated systems. These limitations become especially apparent when many questions of major theoretical interest center around how the functioning of these complex systems varies in different circumstances as well as across time. Several less traditional approaches to modeling adolescent smoking trajectories, including growth curve analyses, use of techniques that take the nested nature of within-family processes into account, typological approaches, and the combination of these techniques were discussed. Stronger links between the sophisticated theoretical discussions in the growing literature on adolescents tobacco use trajectories with the methodological techniques used to test and model those processes will move the field towards a clearer understanding of developmental processes.

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