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The Moderating Role of Context:

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ABSTRACT

A social context can be viewed as an entity or unit around which a group of individuals organize their activities and interactions. Social contexts take such diverse forms as families, dwelling places, neighborhoods, classrooms, schools, workplaces, voluntary organizations, and sociocultural events or milieus. Understanding social contexts is essential for the study of individual behaviors, social networks, and the relationships between the two. Contexts shape individual behaviors by providing an avenue for non-dyadic conformity and socialization processes. The co-participation within a context affects personal relationships by acting as a focus for tie formation. Where participation in particular contexts confers status, this effect may also lead to differences in popularity within interpersonal networks. Social contexts may further play a moderating role in within-network influence and selection processes, providing circumstances that either amplify or suppress these effects. In this paper we investigate the joint role of co-participation via social contexts and dyadic interaction in shaping and being shaped by individual behaviors with the context of a US high school. Implications for future study of social contexts are suggested.

Keywords

contexts, foci, homophily, assimilation, affiliation networks

The Moderating Role of Context:

Relationships between Individual Behaviors and Social Networks

Homophily, or the tendency for individuals to have friendships with those like themselves in traits, attitudes, and behaviors,[1] has long been considered as a key feature of social structure (Lazardfeld and Merton 1954). In this foundational work, Lazarsfeld and Merton (1954) went one step further by advancing the concept of a "context for homophily" (p. 64). A context in this sense can be seen as a *focus* – "a social, psychological, legal, or physical entity around which joint activities are organized (e.g., workplaces, voluntary organizations, hangouts, families, etc.)" (Feld 1981, p. 1016), or a social unit "within which individuals and groups of individuals are contained" (Entwisle et al. 2007; p. 1496). Individuals who share a focus or setting are more likely to form interpersonal relationships than those who do not, and the interaction within a context is expected to be stronger than those across contexts (Homans 1950; Feld 1981; Eccles and Barber 1999; McPherson et al. 2001; Pattison and Robins 2002; Schweinberger and Snijders 2003; Goodreau et al. 2009); ecologically, the density of foci within a population has been argued to be a primary driver of network density (Butts 2019). Moreover, individuals embedded in certain contexts have higher social status and may become popular in friendship networks (Coleman 1961, 1965; Spady 1970; Rodkin et al. 2006). However, an individual can be affiliated with many different contexts in the real world, and sociological ambivalence (Merton and Barber 1976) and status conflict can develop from these competing affiliations due to

[1] Homophily is also referred to as a homophilous selection effect in the adolescent/peer influence literature, especially among those utilizing the Exponential Random Graph Modeling strategy (Goodreau et al. 2009; Schaefer et al. 2011) and the Stochastic Actor-Based modeling strategy (Rambaran, Dijkstra, and Stark, 2013; Schaefer, adams, and Hass 2013; Lomi and Stadtfeld 2014; Lakon et al. 2015; Laninga-Wijnen et al. 2017; Fujimoto, Snijders, and Valente 2018). While homophily (in the correlative sense) and homophilous selection are in fact distinct concepts, this distinction is not always articulated in the literature.

ecological differences in functions, interests, norms and rules, role behaviors and expectations, and cultures or subcultures (e.g., values and beliefs) across contexts (Lazardfeld and Merton 1954; Merton 1957; Bronfenbrenner 1979; Stryker and Statham 1985; Rubin, Bukowski, and Parker 2006). These same differences can lead to unequal pressures towards homophily within different parts of a social system, and across different individual attributes.

Relatedly, human behaviors are learned in dynamic interaction with other individuals, and it is common for individuals in a modern society to encounter competing ideologies, conflicting cultures, and multiple standards and modes of behaviors both within and between contexts (Sutherland 1947). Some behaviors can be salient to individuals in one context but lack meaning and impact in another (Coleman 1961; Bronfenbrenner 1979). Therefore, while individual behaviors are learned from associates in general, an oscillation of behaviors or even counteracting influence can be observed when contexts are incompatible or in conflict with one another (Sutherland 1947; Merton and Barber 1976). Assimilation[2] of behavioral influences is hence *contextual*, and degrees of assimilation can vary across contexts just like degrees of homophily.

Figure 1 illustrates the possible relations among contexts, individual behaviors, and social networks. Contexts not only directly shape individual behaviors through a conformity process (Homans 1950; Asch 1955; Allen 1965), but contribute to social network formation via shared foci (Feld 1981; also referred to as affiliation-based closure in Lomi and Stadtfeld 2014 and context-based selection in Fujimoto, Snijders, and Valente 2018) and status/popularity acquisition (Coleman 1961, 1965; Spady 1970; Rodkin et al. 2006). Contexts may also moderate

[2] Assimilation is also referred to as a peer influence effect in the adolescent/peer influence literature, especially among those utilizing the Stochastic Actor-Based modeling strategy (Rambaran, Dijkstra, and Stark, 2013; Schaefer, adams, and Hass 2013; Lomi and Stadtfeld 2014; Lakon et al. 2015; Laninga-Wijnen et al. 2017; Fujimoto, Snijders, and Valente 2018).

the relationship between individual behaviors and social networks, yielding different degrees of homophily (Lazardfeld and Merton 1954) and assimilations (Ellis and Zarbatany 1997). Contexts therefore play an essential role in Figure 1. According to Feld (1981), "Without such contextual information, conclusions about networks and their consequences are likely to be incomplete and even misleading" (p. 1016). This point was echoed in Doreian and Conti (2012): "studies of social networks that ignore the contexts of these networks are fraught with hazard" (p. 45) and "counterproductive" (p. 32).

<<<Figure 1 about here>>>

In another body of literature, contexts and individuals embedded in them are regarded as two-mode bipartite networks (Breiger 1974; McPherson 1982), which are often studied via their projection into one-mode, individual-by-individual networks (Wasserman and Faust 1994).[3] In this way contexts exert informational influence (Deutsch and Gerard 1955) by serving as assimilation channels of individual behaviors just like dyadic networks in Figure 1, which are different from normative influence (Deutsch and Gerard 1955) under conformity pressure. For example, as indicated in Friedkin and Johnsen (2011), social groups as influential networks "are the ubiquitous context in which persons' expressed positions on issues are modified" (p. 17); and unlike the "standard contextual effect" (p. 20) via conformity which enables the production of consensus or near consensus, the assimilation process of behaviors among individuals embedded in a context allows for "interpersonal disagreement" as "an emergent group-level characteristic (an equilibrium faction structure)" (p. 23) and may "transform heterogeneous distributions of

[3] A network is defined by the relationships (or ties) among the elements (or nodes) (Wasserman and Faust 1994). One-mode networks include only one set of elements, e.g. students in a classroom or scientists in a community, who are connected through communications, collaborations, and other types of interactions. Two-mode bipartite networks include two sets of elements, e.g. students and clubs or scientists and papers, with the latter being connected through the former and the former being connected through the latter. Two-mode bipartite networks are also referred to as affiliation networks.

initial positions on an issue into bimodal or multimodal distributions consisting of emergent within-group factions that have distinct perspectives on an issue" (p. 23).

So far we have differentiated four mechanisms initiated from contexts in Figure 1 in addition to a fifth when contexts are treated as affiliation networks. However, to our knowledge these classic mechanisms have not been investigated simultaneously under a single analytical framework. The current study aims to fill this gap in the existing literature.

This study links the classic concepts of conformity, homophily, and assimilation within contexts. From a theoretical perspective, we differentiate five mechanisms initiated from contexts and try to explain how contexts directly and indirectly shape individual behavior and social networks via these five mechanisms. Moreover, this study demonstrates that these five mechanisms should be understood holistically rather than separately. From a methodological perspective, we apply the Stochastic Actor-Based (SAB) modeling strategy, a state-of-the-art model on co-evolution of individual behavior and social networks, to study the five mechanisms in a unified modeling framework. As far as we know, this has not been done before, observing further that mechanism 5 of assimilation through co-participation in contexts has not been implemented in extant SAB software tools (notably the RSiena software package). Therefore, we make contributions not only to network science but to the sociological understanding of the roles that contexts play in defining the micro-level decision-making processes, i.e., changes in behavior levels and network ties of a focal actor.

The remainder of this paper is organized as follows. In the next section we review the literature on the mechanisms through which contexts impact individual behaviors and social networks, and their relationship. In the third section we empirically examine these mechanisms

in our analytical framework. We conclude the paper with a discussion on the general usefulness, applicability, and the modeling process that might be related to contextual research in the future.

Contexts, Individual Behaviors, and Social Networks

Social contexts can take a variety of forms, such as a physical location where people may interact (e.g. families, dwelling places, neighborhoods); an institutionalized group or organization whose regular activities form a setting for interaction (e.g. classrooms, schools, workplaces); a noninstitutionalized (de facto) group or organization whose activities form a setting for interaction (e.g. voluntary organizations); and a transient social environment generated by a confluence of actors, either as part of an institutionalized event or an ad hoc event (e.g. Olympics, FIFA world cup). While the term "social context" has been given many distinct meanings in the social science literature, all widely used notions share the common characteristic of describing an entity or setting around which a group of individuals organize their activities and interactions.

Mechanism 1: Contexts and Individual Behaviors

Powerful normative influence occurs when individuals conform to the norms of a context in which they are affiliated (Asch 1940, 1948). Norms arise from repeated and shared behaviors of individuals embedded in this context and are accepted standards for judging one another's behaviors regarding what they should do and are expected to do under given circumstances in the form of verbal or written statements as well as unwritten latent rules (Homans 1950; Burgess and Akers 1966). Individuals are motivated to comply with normative expectations in order to accrue rewards (e.g. material needs, information, popularity, companionship and affection, praise, respect, self-esteem, emotional support, and social inclusion, approval, and status) and avoid

punishments (e.g. financial loss, physical torture, victimization, ridicule, disdain, discouragement, disrespect, cognitive dissonance, and social degradation, exclusion, and rejection) (Sutherland 1947; Coleman 1961; Homans 1961; Stryker and Statham 1985; Bukowski and Sippola 2001; Price, Nir, and Cappella 2006; Rubin, Bukowski, and Parker 2006; Veenstra, Dijkstra, and Kreager 2018). For example, an institutionalized group or organization is expected to have weakened control over its members when its norms are not held in common or specified clearly (Homans 1950).

Norms manifest in a variety of ways. Homans (1950) pointed out that "some norms are much more important than others, and that a group may hold some much more explicitly than others. Some are stated outright; others the observer must infer, accepting all the risks of inference" (p. 283). For example, Suh, Brashears, and Genkin (2016) found that gang members not only possessed delinquent norms and behaviors but drank more often. In this case the former norms are explicit and outright ones. The latter norms are more likely to be more observed and inferred unless those gang members were subject to a variety of rituals for coordinating and regulating alcohol consumption.

The interplay of norms from multiple contexts can have complicated effects on individual behaviors. For example, Merton and Barber (1976) hypothesized that incompatible normative expectations from multiple contexts could result in these norms being expressed as compromised behaviors or an oscillation of behaviors. However, these hypotheses have received mixed support from empirical research. In one study, congruent norms of multiple contexts magnified the norm-consistent behaviors, while competing norms of multiple contexts reduced normative behaviors (Verkooijen, de Vries, and Nielsen 2007). In another study, while conventional school club memberships were not associated with frequent drinking and binge drinking, gang members

attending more conventional school clubs had higher levels of alcohol use than exclusive members of gangs (Suh, Brashears, and Genkin 2016).

Mechanism 2: Contexts and Social Networks

Shared relations in a context are a common source of weak ties (Granovetter 1973) via three mutually dependent elements – activities, interactions, and sentiments (Homans 1950; Feld 1981; McPherson et al. 2001; Goodreau et al. 2009). Schaefer et al. (2011) elaborated this theory in the case of extracurricular activity settings and adolescent friendships:

> "First, Focus Theory posits that regular, sustained contact centered around an activity increases the likelihood that friendships will develop (Feld, 1981). The consistency of extracurricular activities provides the basic environment for adolescents to spend time with each other. Second, extracurricular activities afford experiences that build relationships among co-participants, such as teamwork and emotion regulation. These skills learned during activities can help adolescents maintain current friendships and develop new ones. Third, extracurricular activities tend to bring together adolescents with similar interests who are, hence, appealing to one another as friends" (p. 1142).

While contexts contribute to social network formation in general, the same context can have disparate effects on multiple cohorts of individuals. For example, Anderson, Wasserman, and Crouch (1999) found that friendship network processes were different for children randomly assigned to classrooms. In a similar vein, different contexts can have disparate effects on a group of individuals; for instance, mother-father-infant interaction was different in home and laboratory settings (Bronfenbrenner 1979). In another study, Schaefer et al. (2011) found that while adolescents who participated in the same extracurricular activity were more likely to be

friends than adolescents who did not, the association between shared extracurricular activities and friendships was weakest for sports team co-participation and strongest for performing art club co-participation, with academic club co-participation indistinguishable from either. The effect of shared foci/focus on network tie formation has been examined in recent research using the state-of-the-art network modeling strategies of exponential random graph models (Brennecke and Rank 2017), multilevel exponential random graph models (Zappa and Lomi 2015; Meredith et al. 2017), and Stochastics Actor-Based models (Lomi and Stadtfeld 2014; Hollway et al. 2017; Fujimoto, Snijders, and Valente 2018; Lewis and Kaufman 2018; Friemel 2020).

Individuals can acquire status and popularity by being members of specific contexts. For example, Coleman (1961, 1965) found that athletes, especially the boys in football and basketball teams, and girls as cheerleaders, had higher status and thus were more popular and likely to be in the leading crowds in high schools of the 1960s, though Spady (1970) supplemented this finding and observed that being perceived as peer leaders, athletes tended to have exaggerated aspirations but low fulfillment if athletics were not combined with service or actual leadership experience. Individuals with certain traits, attitudes, and behaviors may also have higher status and popularity in some contexts but not the others, e.g., bullies were found to enjoy power and preference in aggressive groups while model students were nominated by their peers in nonaggressive groups (Rodkin et al. 2006).

Mechanisms 3 & 4: Moderating Effects of Contexts on Individual Behaviors and Social Networks

The co-evolution of individual behaviors and social networks has been a compelling topic among researchers in social science and public health in recent years. These researchers attempt to differentiate a homophily effect and an assimilation effect, with the former indicating the

tendency of individuals to form ties with others having similar characteristics and the latter indicating the tendency of individuals to adopt the characteristics of their associates.

Contexts can moderate the magnitudes of homophily effects and assimilation effects during the co-evolution of individual behaviors and social networks. For example, Mounts and Steinberg (1995) found that while adolescents' grade point average (GPA) and drug use were influenced by their friends, the assimilation effect on GPA was stronger and that on drug use was weaker for those coming from families where parents were relatively more authoritative. Another study found that the assimilation effect on risk attitudes was stronger in classes where students' risk attitudes were positively correlated with in-degree popularity at the beginning of the study than in classes where risk attitudes were not or less correlated with popularity (Rambaran, Dijkstra, and Stark, 2013). In a third study, adolescents tended to select their friends based on similarity in aggression and adopt the aggressive behavior of their friends only when they were in classes where the association between aggression and perceived popularity[4] was high at the beginning of the study (Laninga-Wijnen et al. 2017).

Mechanism 5: Contexts as Affiliation Networks

The strategy of treating contexts as affiliation networks follows a probabilistic approach to network analysis and is likely to capture weaker ties like casual contacts which are typically not included on conventional network inventories (Granovetter 1973; Suh, Brashears, and Genkin 2016; Genkin et al. 2018). Therefore, contexts as affiliation networks can behave either similar to or different from conventional social networks.

[4] Laninga-Wijnen et al. (2017) differentiated two types of popularity, one measured as in-degree popularity or how many times an individual is nominated a friend, and the other as perceived popularity or the extent to which an individual is seen as popular by his or her peers. We use in-degree popularity in our empirical analysis.

In empirical studies the assimilation effect is sometimes compared between randomly-paired roommates and mutually-selected roommates, with the former representing shared context and the latter representing personal relationships in addition to shared context. For example, Rozin, Riklis, and Margolis (2003) picked 38 randomly-paired roommates along with 10 mutually-selected roommates but neither type of room partners became similar on food or music preferences after seven months (or an academic year) of mutual exposure. In another study Wood et al. (2007) found that in one sample randomly-paired roommates became similar in music preferences and social activities after one semester of mutual exposure while mutually-selected roommates became more similar in personality traits, religiosity, and political preferences; and in a second sample randomly-paired roommates became more similar in social activities and dorm room behaviors while mutually-selected roommates maintained their similarity in social activities but became less similar in general attitudes and personality traits over time.

From Previous Research to the Current Study

The previous research underscores the importance of context in studies of social behavior and relational structure. Each of the five aforementioned mechanisms initiated from contexts have been studied extensively, but not simultaneously under a single modeling framework. The current study aims to address this gap and is guided by the following research questions: (1) For mechanism 1, do various contexts have similar or different conformity process to individual behaviors? (2) For mechanism 2, while shared focus/foci contribute to social network formation, is this effect universal or only found for certain contexts? How about status/popularity acquisition process? (3) For mechanisms 3 and 4, is the moderating role of contexts over individual behaviors and social networks a standalone effect, or a leakage from conformity

and/or status/popularity acquisition process? And (4) For mechanism 5, is the assimilation effect from affiliation networks weaker than that from conventional social networks as suggested by Granovetter (1973), Suh, Brashears, and Genkin (2016), and Genkin et al. (2018)? To answer these research questions, in the next section we introduce the data and methods used in this study.

Data and Methods

Data

The data utilized in this study come from early waves of the National Longitudinal Study of Adolescent to Adult Health (Add Health; Harris et al. 2019). The Add Health project provides a unique glimpse into a nationally representative sample of schools at a particular moment in time, with a rich collection of data including club affiliations, individual behaviors, and friendship networks of US adolescents. In previous research, a rural Midwest public high school (n = 1,024), often referred to as "Jefferson High" (Bearman, Moody, and Stovel 2004), has been widely used to examine the co-evolution of smoking behavior and friendship networks in which both homophily and assimilation effects were confirmed (Schaefer adams, and Hass 2013; Lakon et al. 2015). The information of students at Jefferson High was collected across three waves, the first one conducted via a self-administrated questionnaire at school on November 1994, and the second and third waves conducted via face-to-face interview at home from May to November 1995 and from April to August 1996, respectively.[5]

Variables

Two dependent variables are included in this study. The *dependent behavior* variable is the smoking level of each student in Jefferson High. The questions with regard to smoking behavior

[5] The Add Health project includes another suburban Northeast public high school (n = 2,104) referred to as "Sunshine High" (Shoham et al. 2012). In this study we do not estimate the models for this bigger school due to its large sample size and computational power issues.

were a little bit different across the three waves. At wave 1 students were asked "During the past twelve months, how often did you smoke cigarettes", while at wave 2 and wave 3 they were asked "During the past 30 days, on how many did you smoke cigarettes". We use the same response categories as in Lakon et al. (2015), Wang et al. (2016), and Wang et al. (2018) that recode the smoking behavior into 4 levels on a 30-day basis with 0 = "never", 1 = "1-3 days", 2 = "4-21 days", and 3 = "22 or more days" such that they have the same category framing across the three waves. The *dependent network* variable is built upon the nomination of up to five male and female best friends from each student over the three waves. It is a sociometric matrix with a dimension of 1,024 by 1,024 indicating the presence or absence of friendship ties between each pair of students (i.e. 0 = "no", 1 = "yes") at each wave.

The *independent* variable of the most interest measures the contexts – the club affiliation information. In the survey of wave 1, the students were provided with a list of clubs (and organizations and teams)[6] and asked to mark which one they participated or planned to participate in 1994. Following Schaefer et al. (2011), 30 clubs are classified into three categories, i.e., 14 in academic clubs including French club, German club, Latin club, Spanish club, book club, computer club, debate team, history club, math club, science club, newspaper, honor society, student council, and yearbook, 12 in sport clubs including cheerleading/dancing team, baseball/softball, basketball, filed hockey, football, ice hockey, soccer, swimming, tennis, track, volleyball, and wrestling, and 4 in performing art clubs including drama club, band, chorus/choir, and orchestra. This strategy of aggregating specific clubs into club types was found to be theoretically and practically appropriate (Brashears et al. 2017). The club affiliation information helps construct three measures, the first one indicating the affiliation to a club type or specific

[6] For convenience the organizations and teams are labeled as clubs as well in the current study.

club (0 = "no", 1 = "yes"), the second one as a 1,024 by 1,024 matrix indicating how many clubs each pair of students co-participated in, and the third one also as a 1,024 by 1,024 matrix indicating the binary status of co-participation in any clubs (or any categories of clubs, or any specific club) for each pair of students with 0 = "no" and 1 = "Yes". For mechanism 1 (conformity) the key measure is the first one – affiliation to a club type or specific club (0 = "no", 1 = "yes") – and we want to know whether it is related to higher or lower levels of smoking behavior. For mechanism 2, the key measure for network formation is the second one – how many clubs each pair of students shared in common (ranging from 0 to 30) – and we want to know whether it contributes to tie formation, and the key measure for status/popularity acquisition is still the first one – affiliation to a club type or specific club (0 = "no", 1 = "yes") – and we want to know whether it is related to high in-degree of a student in the friendship networks. For mechanisms 3 and 4, the key measure is again the first one – the affiliation to a club type or specific club (0 = "no", 1 = "yes") – and we want to know whether it moderates the homophily and assimilation effects between smoking behavior and friendship networks. For mechanism 5 – assimilation through affiliation networks, the key measure is the third one – the co-membership in a club type or specific club for each pair of students (0 = "no", 1 = "yes") – and we want to know whether a student is influenced to adopt the smoking levels of his or her co-members in the club type or specific club.

We control for covariates[7] such as *gender* (0 = "male", 1 = "female"), *grade* (from 9 to 12), and *parents' highest education level* (1 = "less than high school", 2 = "high school graduate", 3 = "some college or trade school", 4 = "graduate of college or university") from the survey of wave 1. *Depressive symptom* is generated as a factor score (Cronbach's α = 0.87) of 19

[7] Jefferson High was a racially homogenous schools with 93.4% white students at the time the surveys were conducted, and thus race is not included as a covariate.

ordinal items adapted from the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff 1977) included in the survey of wave 2. *Parental support* and *parental monitoring* are standardized factors scores generated through confirmatory factor analysis with Root Mean Squared Error of Approximation (RMSEA) below .06 and Comparative Fit Index (CFI) above .95, both of which suggest a good fit. Parental support is based on 6 items from the survey of wave 2, including 5 ordinal ones on to what extent the students felt their parents care about them, felt their parents were warm and loving toward them, felt close to their parents, were satisfied with the way their parents and they communicated with each other, and were satisfied with the relationship with their parents, as well as a binary one indicating whether the students had a talk about personal problems they were having with their parents in the past four weeks. Parental monitoring is based on nine items from the survey of wave 2, including four ordinal ones on how often the students' parents were at home when they left for school, returned from school, ate their evening meals, and went to bed, as well as five binary ones indicating whether the students' parents let them make their own decisions about the time they must be home on weekend nights, the people they hung around with, how much television they watched, which television programs they watched, and what time they went to bed on week nights. *Home smoking environment* is a summation of whether the students' parents smoked at least once a month (0 = "none", 0.5 = "one parent", 1 = "both parents") and cigarettes ware easily available to the students at home (0 = "no" and 1 = "Yes") at wave 2.

Due to an administrative error, 4.8% and 0.4% of students at Jefferson High were only allowed to nominate one male and female best friend at wave 2 and wave 3, respectively. To account for this survey discrepancy, on the one hand, we code the outgoing ties of the limited nomination students as NAs at wave 2 and wave 3 and let the RSiena software package handle

these missing network values internally (Ripley et al. 2021); on the other hand, we include the students' limited nomination status as a control variable measured as -1 = "changed from full to limited nominations", 0 = "no change", and 1 = "changed from limited to full nominations". These same strategies were utilized in Lakon et al. (2015), Wang et al. (2016), and Wang et al. (2018).

Analytical Method

The stochastic actor-based (SAB) modeling strategy (Snijders, van de Bunt, and Steglich 2010; Snijders 2011) is applied to investigate how club participation and co-participation affects the evolution of smoking behavior as well as that of friendship networks implemented in RSiena software package (Ripley et al. 2021). RSiena estimates the opportunities for a student *i* to change his/her smoking behavior and his/her friendship network between two consecutive waves, referred to as the rate functions λ_i. It also estimates whether the student will change in mini-steps his or her smoking behavior (+1 level, no change, or -1 level) and friendship network (+1 tie, no change, or -1 tie) based on his or her current behavior-network status, referred to as the objective function $f_i = \sum_k \beta_k s_{ik}(x)$, where β_k represents the log-probability for the *k*th behavior-network status $s_{ik}(x)$. For example, a student has a current state of $s_{ik}(x_a)$ and an opportunity to change it to $s_{ik}(x_b)$ at the next wave. The focal student will evaluate the objective function before and after making the change (i.e., $f_{ia} = \sum_k \beta_k s_{ik}(x_a)$ vs. $f_{ib} = \sum_k \beta_k s_{ik}(x_b)$) and select the one with higher value to maximize utility. RSiena uses an iterative approximate algorithm of changing the parameter (i.e., the log-probability) for each joint behavior-network variable included in the SAB model until the deviations between the average statistics of many (1,000 by default)

simulated networks and behaviors and the observed target values are small enough.[8] Therefore, RSiena simultaneously estimates two equations, one for the dependent behavior variable and the other for the dependent network variable, with two rate functions and two objective functions (i.e., from wave 1 to wave 2 and from wave 2 to wave 3) specified in each equation.

In the behavior equation that models changes in cigarette smoking *z*, the first mechanism of concern is the conformity process via club participation – whether the number of clubs in a category a student *i* joined $\#c_i$ affected his or her smoking level z_i. A positive parameter indicates that the students joined many clubs in this category smoked more frequently over time and a negative parameter suggests the opposite. To account for a curvilinear effect, its squared term $\#c_i^2$ is also included. Next, the affiliation network mechanism focuses on the assimilation effect via club co-participation – whether the smoking behavior of a club member was learned from that of other club members. Given a student *i* with a smoking level z_i participated in any of the 30 clubs with other students *j*, this assimilation effect has a functional form of $-\sum_j c_{ij}|z_i - z_j|/\sum_j c_{ij}$, where c_{ij} represents the club co-participation status of the student *i* and other students *j*. This two-mode club co-participation effect is measured as the Sum Of the Negative Absolute Difference in behavior between ego and all his or her co-participants Averaged by ego's co-participants, or briefly, SONADA two-mode effect.[9] A positive parameter indicates that a club member in Jefferson High tended to adopt the smoking levels of his or her co-participants and a negative parameter suggests the opposite. The third mechanism of interest is the moderation process between club participation and assimilation effect from friends. We

[8] In Ripley et al. (2021), good convergence of a SAB model is indicated by the overall maximum convergence ratio below .25 and the absolute value of the t statistics for deviations from observed targets below .1.
[9] RSiena allows researchers to write their own codes and add new effects (Ripley et al. 2021: chapters 15-18). This effect can be specified as "sonada2m" of club co-participation in the augmented RSiena software package publicly available at https://github.com/socnetfan/RSiena.

measure this effect as $c_i \times \left(-\sum_j x_{ij} \left| z_i - z_j \right| / \sum_j x_{ij}\right)$ with x_{ij} indicating the states of friendship ties between the student *i* and his or her peers *j*. A positive parameter indicates that a club member was more likely to assimilate the smoking behavior of his or her friends and a negative parameter suggests the opposite.[10]

In the network equation that predicted friendship ties *x*, the shared focus/foci mechanism examines whether the number of clubs a pair of students shared in common $\sum c_{ij}$ affected the odds that the student *i* nominated the other student *j* as a best friend. A positive parameter indicates club co-participation drove friendship ties and a negative parameter suggests the opposite. Next, the status/popularity acquisition mechanism investigates whether the student *i* was more likely to nominate other students *j* who joined a club or a category of clubs. A positive parameter indicates he or she was inclined to do so and a negative parameter suggests that opposite. The last mechanism explores the moderation process between club participation and the homophily effect in smoking behavior.[11] A positive parameter indicates that a club member was more likely to form friendships with those having similar smoking behavior and a negative parameter suggests the opposite.[12]

The goodness-of-fit of our SAB models are assessed by computing the Mahalanobis distance test of key network statistics (including out-degree distribution, in-degree distribution, geodesic distance distribution, and triad census as suggested in Lospinoso and Snijders 2019) and behavior statistics (including behavior distribution, behavior transition, edgewise homophily,

[10] We set center option as "False" for all constant actor covariates (coCovar), constant dyadic covariates (coDyadCovar) and time-varying dyadic covariates (varDyadCovar) in our model specification. Moreover, we remove the centering function of dependent behavior variable by its overall mean in the augmented RSiena software package available at https://github.com/socnetfan/RSiena.

[11] This effect can be specified as the interaction term between "egoX" of club participation and "simX" of smoking behavior in either the original or augmented RSiena software package.

[12] The R scripts that can be used to replicate the SAB models in this study are available from https://github.com/socnetfan/context.

and Moran's *I* as suggested in Wang et al. 2020) for wave 2 and wave 3 separately. The *p*-value in each test is greater than 0.05, suggesting the compatibility of our models with the observed network and behavior data.

Forward Stepwise Modeling Approach

There were 30 clubs in Jefferson High. Unfortunately, due to both computational cost and model convergence considerations, it is not practical to estimate effects for all of them simultaneously. Therefore, we adopt a forward stepwise modeling approach by gradually building up the model as suggested in Ripley et al. (2021, chapter 10). As shown in Figure 2, we begin with a single measure that is a count of all clubs; if any mechanisms of concern, i.e., conformity and affiliation network mechanisms in the behavior equation and shared focus/foci and status/popularity acquisition mechanisms in the network equation, is statistically significant we move on to the three categories of clubs; in the new model if the foregoing mechanisms related to any three categories of clubs are statistically significant we move on to each specific club in that category; finally, in the new model if the membership of a specific club affects smoking behavior and social networks we move on to include the moderation mechanism on assimilation via social networks in the behavior equation as well as the moderation mechanism on behavioral homophily in the network equation. Score-type tests (Schweinberger 2012; Ripley et al. 2021, p. 96-97) are applied as a tool when moving through the sub-models.

<<<Figure 2 about here>>>

Findings

Descriptive Statistics

The descriptive statistics of time-invariant covariates in Jefferson High are summarized in Table 1. The genders were about equally distributed among the 1,024 students. There were relatively

more students enrolled in the 9th and 10th grades than in the 11th and 12th grades. Most students' parents were high school graduates or had some college or trade school experience. 77% of students joined at least one of the 30 clubs, and a majority of them were sport club members. More than 1/3 of students participated in academic clubs. Among the four performing art clubs that recruited approximately 30% of the student body, the drama club and band each attracted 15% students, followed by chorus with 13% students, and orchestra had the fewest members. The mean of home smoking environment is above 1, suggesting the average student in Jefferson High either had both parents who were smokers, or cigarettes were easily available at home.

<<<Table 1 about here>>>

Table 2 provides the information on dynamics in smoking behavior and friendship networks. Substance use was relatively prevalent in Jefferson High, and this school ranked among the top five in smoking prevalence out of 108 participating schools in the Add Health study. Across the three waves, about 45% of students were non-smokers and 28% were heavy smokers. The friendship ties decreased over time due to limited nomination restrictions, graduation, moving, dropping out, and sample attrition/non-response/missing network data.[13] About 35% of friendship ties were reciprocal. The tendency toward triadic closure slightly increased over time. As a measure of stability in friendship networks, the Jaccard indices were above .2, satisfying the threshold described in Snijders, van de Bunt, and Steglich (2010).

<<<Table 2 about here>>>

Results from SAB Models

[13] We code the out-going ties for those students having limited nomination, non-responses, and missing network data to be NAs at wave 2 and wave 3 and allow the RSiena software package to handle the missing network values internally. We code the out-going ties for students who graduated, moved, and dropped out at wave 2 and wave 3 as structural zeros (10s) so the RSiena software package will not simulate out-going and incoming ties for those students.

We generate two tables to present the results from SAB models, with Table 3 focusing on the five mechanisms initiated from contexts and Table 4 displaying the remaining effects included in the models.[14] The behavior equation in Model 1 of Table 3 shows no sign of conformity (mechanism 1) or affiliation network (mechanism 5) effects when summing all 30 clubs as one measure. In the rest of the behavior equation shown in Table 4, we find that while a Jefferson High student tended to smoke less over time (as indicated by the linear shape effect), a non-smoker was more likely to stay as a non-smoker and a heavy smoker was more likely to remain a heavy smoker (as indicated by the quadratic shape effect); a student's smoking level was definitely influenced by that of his or her friends (as indicated by the assimilation via friendship network effect); and a student had higher smoking level when he or she had high depression value or a home environment which favored smoking.

<<<Table 3 about here>>>

<<<Table 4 about here>>>

The network equation in Model 1 of Table 3 suggests that two students were more likely to be friends in the next time point if they shared one more club in common (as indicated by the club co-participation effect; shared foci/focus in mechanism 2). The number of clubs a student belonged to did not make him or her receive more friendships nominations (as indicated by the alter's number of club participation effect; status/popularity acquisition in mechanism 2). With regard to endogenous network effects shown in Table 4, we find that at the dyad level a student preferred mutual friendship ties (as indicated by the reciprocity effect); at the triad level a student

[14] There was no evidence of multicollinearity in our models. We estimated each model 30 times in RSiena and the parameters and their statistical significance patterns were very robust with no large standard errors. Inspection of the covariance matrix of the parameters showed no evidence of problems. There is no evidence that using our uncentered versions of measures in the RSiena package rather than the centered versions cause any multicollinearity, which is unsurprising given the discussion of Aiken and West (1991) that uncentered main effects in interactions provide identical results to interactions using centered main effects.

tended to end in closed triads, no matter they were transitive or cyclic ones, while the interaction between transitive triplets effect and reciprocity is controlled as suggested by Block (2015); and at higher network level a student was inclined to befriend popular peers with higher in-degrees instead of those with similar in-degrees. In terms of controlled covariates, we detect the presence of homophily (similarity) effects in gender, grade, parent education, and smoking behavior; a student receiving more parent support nominated more friends; and a smoking student received more friendship nomination (as indicated by the alter's smoking behavior effect).

Given a shared foci/focus in mechanism 2 is detected in Model 1, we move on to Model 2 by replacing the overall club effects with three categories of clubs specified in Schaefer et al. (2011). In the behavior equation, we find a conformity effect (mechanism 1) which is not present in Model 1 – a student was less likely to increase his or her smoking level one unit at the next time point than stay the same smoking level if he or she was in one performing art club. We also detect the presence of a negative assimilation effect via co-participation in performing art clubs (mechanism 5) which is not found in Model 1 either. Consider a scenario that a student was a non-smoker surrounded by other performing art club members who were all light smokers. With regard to the odds of change, he or she was more likely to stay as a non-smoker than increase one unit to be a light smoker as his or her co-participants. In the network equation, we find that the shared foci/focus (in mechanism 2) only existed in one category of clubs – two students were more likely to be friends in the next time point if they shared membership of one more performing art club in common. Also, a student tended to befriend others joining a similar number of sport clubs, as shown in Model 2 of Table 4. The significance pattern of the remaining effects in Model 2 is the same as that in Model 1 and thus we do not repeat it here.

We apply the forward stepwise modeling approach again by replacing the overall performing art club measure with that of the four specific art clubs in both the behavior and network equations of Model 3. In the behavior equation, we found both conformity and affiliation network assimilation mechanisms initiated from Chorus. A non-chorus member was more likely to increase his or her smoking level one unit at the next time point than stay at the same smoking level, compared to chorus members (mechanism 1). And a chorus member was less likely to assimilate the smoking behavior of other members (mechanism 5). Here again, given a student who was a non-smoker surrounded by other chorus members who were all light smokers, he or she was more likely to stay as a non-smoker than increase one unit to adopt the smoking level of his or her co-participants. In the network equation, we find the shared focus and status/popularity acquisition (mechanism 2) existed in two out of four performing art clubs – two students were more likely to be friends in the next time point if they were both members of drama club or band, respectively; and a student who was a member of band and chorus received more friendship nominations than those who were not. And chorus members tended to nominate more friends, as shown in Model 3 of Table 4. The results of the remaining effects are consistent across Model 2 and Model 3.

Finally, since chorus membership affected smoking behavior via conformity and affiliation network assimilation mechanisms, we move on to examine whether it moderated the relationships between smoking behavior and friendship networks in Model 4. In the behavior equation, the degree of assimilation in smoking behavior was not found to be influenced by chorus participation (mechanism 4). However, in the network equation we find that the degree of homophily in smoking behavior was lower for chorus members than for non-members

(mechanism 3). The significance pattern of the remaining effects in Model 4 is the same as that in Model 3.

One slight concern is with the magnitude of negative assimilation effect of smoking behavior among chorus members – it has a parameter of -.02 in Model 3 and Model 4, which at first blush seems to be tiny when compared with that of the assimilation effect via friendship networks. To test the substantive importance of this specific effect, we change its parameter from -.02 to 0 and leave parameters of all the other effects as estimated in Model 4 and then simulate the friendship network and smoking behavior 1000 times.[15] Since this assimilation effect through affiliation network of chorus is negative, we expect that when it is turned off we should see a *higher* autocorrelation coefficient between chorus co-participation and smoking behavior. Figure 3 shows the boxplots of Moran's *I* values before and after the parameters is changed at wave 3. Its left panel suggests that the estimated Model 4 adequately reproduce the observed value of Moran's *I* as -.00, and its right panel satisfies our expectation that the value of Moran's I goes up when the negative assimilation effect of chorus is off. Therefore, while this specific effect does have a seemingly small magnitude, it is definitely present and its impact on the social system is in fact quite substantial.

<<<Figure 3 about here>>>

Moreover, as shown in Table 5, while the proportion of heavy smokers (i.e., 22 or more days in the past 30 days) among chorus members stayed stable, the percentage of non-smokers (i.e., never in the past 30 days) increased and that of light smokers (i.e., 1 to 3 days in the past 30 days) decreased across the three waves. This means the chorus membership had an impact on

[15] In fact, for our final models, we estimated each model 30 times in RSiena to guarantee robustness of the standard errors. Furthermore, it often required four to five rounds of estimation to achieve a satisfactory result that appropriately minimizes the difference between observed the network/behavior and the simulated ones. As a consequence, the cumulative iterations in Phase 3 typically exceed 120,000.

those whose smoking levels were less than regular, but not on heavy smokers. Chorus members smoked less than expected due to dynamics such as conformity against cigarette use, negative assimilation effect via affiliation social networks,[16] and negative moderation effect on the degree of homophily in smoking levels.

<<<Table 5 about here>>>

Discussion

This paper systematically reviewed multiple mechanisms emanating from contexts: the conformity process from contexts to individual behaviors, the shared foci/focus and status/popularity acquisition processes from contexts to social networks, the moderation processes of contexts upon the relationships between individual behaviors and social networks, and the affiliation network assimilation process of context on individual behaviors. Our study investigated these mechanisms in a single analytical framework. With regard to the conformity process (mechanism 1), out of 30 clubs being surveyed in Jefferson High, only chorus members tended to smoke less. Our results showed that while heavy smokers did not change their smoking behavior, many chorus members who smoked less regularly decreased their smoking levels or maintained their smoking levels over the three waves. Smoking can affect the health of mouth, nose, throat, and lungs, which in turn impact chorus members' vocal performance. This norm was more likely to be an observed and inferred one (Homan 1950) but its effect was

[16] Theoretically, a negative assimilation effect could mean that when a majority of peers did not smoke (or smoked less regularly than the focal student), the focal student would be more likely to smoke. This mechanism should be understood along with other key factors in this study. First, chorus was among the two clubs in Jefferson High whose members could acquire high status and became popular in their social networks. Second, for some reason chorus members held a conformity norm, either explicit or inferred, against smoking. Third, while chorus members also tended to befriend others based on homophily on smoking levels, this tendency was weaker when compared with non-chorus members. Taken together, given the rarity of resources in status/popularity, chorus members, especially those who smoked less regularly, tended to decrease their smoking levels instead of the opposite.

evident. Therefore, circling back to our first research question, not all contexts have the same conformity process for their members' behavior.

Turning to our second research question, the shared foci/focus and status/popularity acquisition processes (mechanism 2) are not universal but rather occur only for certain contexts: the co-participation in drama club and band increased the likelihood of friendship formation, and band and chorus members received more friendship nominations in Jefferson High. Athletes were not found to receive more friendship nominations in this high school. Therefore, while shared relations in a context is a common source of weak ties (Granovetter 1973), friendships and strong ties need more investment and this is only available in a few settings rather than everywhere. And in-degree popularity is not universal but a rare resource and only a couple of entities can provide it. It supplies additional reasons that drive conformity among chorus members.

Next, only the moderation effect from chorus membership on the homophily effect (mechanism 4) was detected: chorus members in Jefferson High also tended to nominate others with similar smoking levels as their best friends, but this degree of homophily was lower when compared with non-members. Chorus was among the two clubs in Jefferson High that could provide the rare resources of in-degree popularity (mechanism 2), its members therefore chose to decrease smoking levels which made non-smokers gradually become the majority by the end of the study. This specific contextual effect decreased the extent to which the homophily effect was at play. Returning to our third research question, status/popularity acquisition (mechanism 2) is a key driver of this moderation effect along with the norm against smoking behavior (mechanism 1) among chorus members.

As for our last research question on assimilation via co-participation of affiliation networks (mechanism 5), the chorus members again appeared distinct – they showed a negative tendency to assimilate the smoking levels of other chorus members. The magnitude of this mechanism is small, especially when compared with that of the smoking behavior assimilation effect via friendship networks, which corroborates the finding that the assimilation effect from affiliation networks is weaker than that from conventional social networks as in Granovetter (1973), Suh, Brashears, and Genkin (2016), and Genkin et al. (2018). This type of effect is uncommon. But when it exists it makes a difference – when this specific effect is turned off we see in simulation that autocorrelation between chorus co-participation and smoking behavior significantly increases. At the same time, this mechanism could be more or less related to the leakage from the conformity (mechanism 1) and status/popularity acquisition (mechanism 2), because chorus participation in Jefferson High prevented its members from smoking and represented high social status. To sustain their statuses chorus members followed the norm on smoking and resisted mimicking fellow members who smoked, and this is an independent effect from the conformity and status/popularity mechanisms.

There is one additional mechanism regarding social contexts – the competition between foci (McPherson 1983; Brashears et al. 2017). Multiple clubs will compete with one another for their potential members because each individual has limited time and energy to participate in club activities (McPherson 1983; Brashears et al. 2017). We do not include this in this study for several reasons. First, this study focuses on how social contexts shape individual behaviors and social networks and moderate the relationship between them. Social contexts are taken for granted and treated as the key independent variable. Second, the club membership was only measured at the first wave in Add Health study. We therefore cannot utilize it as a dependent

affiliation network variable to investigate the dynamics of ecological competition among these clubs. Third, our models are already complicated, and therefore this question is outside the scope of this study. Therefore, we focus on clarifying the five mechanisms distinguished in this study. Examining this additional mechanism with other datasets containing social networks, individual behaviors, and club membership collected at the same time over multiple waves is a useful direction for future research.

The key takeaway from the Jefferson High case is not that there is something generally distinct about chorus membership *per se* that is expected to be found in every school setting, but rather that status/popularity is a rare resource and only a few contexts can provide it (with those contexts varying from one setting to another): those were football, basketball, and cheerleader teams in Coleman (1961, 1965), Spady (1970), and Rodkin et al. (2006), and they happen to be band and chorus out of 30 clubs in Jefferson High. We emphasize that the status/popularity acquisition (mechanism 2) is a key driver of micro-level decision-making processes, including whether a member chooses to follow the norm of the context on a behavior (mechanism 1) or not, whether a member is more or less likely to adopt his or her friends' behavior that is favored or disfavored by the contexts s/he is in (mechanism 3) and befriend others with the similar level of behavior that is favored or disfavored by the contexts s/he is in (mechanism 4), and adopt the co-members' behavior that is favored or disfavored by the contexts s/he is in (mechanism 5). Therefore, these five mechanisms initiated from contexts must be understood holistically.

This study has some limitations. Although the Add Health data is quite rich, it is older and therefore may not capture any recent changes in social structure patterns. Second, the club participation information was only collected at the very first wave, so we do not have dynamic information on this membership (though students typically do not change membership during the

year). Third, the club participation information did not differentiate actual participation from intended participation. When future studies collect similar data, they should solicit both statuses to tell to what extent the results are driven by aspirational responses. Fourth, the Add Health data provide little information about non-school network ties. Future studies need to collect this type of information. Fifth, we studied a single school's network, and therefore caution needs to be exhibited when generalizing the results to other contexts.

We conclude by highlighting three key findings from our study. First, the negative assimilation effect from chorus co-participation to smoking behavior is notable given that prior research often treats the assimilation effect as a binary construct – it either exists positively or does not exist. We found evidence that the assimilation effect can be negative. We explained earlier that it could result from the normative influence of a specific context and the loss of social status if a member left this context and it eventually turned to be an independent effect. Future studies will want to explore these possible mechanisms.

Second, our results highlighted that whereas researchers might have information on many contexts, there nonetheless might be only one or a few of them that are disproportionately salient to the individual behaviors and social networks of concern. Most of the contexts we measured showed no influence effect. Therefore, there is a risk of failing to detect an effect if too many contexts are aggregated together into a single measure. For example, the conformity and affiliation network assimilation mechanisms in the behavior equation and the status/popularity acquisition mechanism in the network equation were not detected at all until we disaggregated clubs into three categories.

Finally, related to the second point, researchers in social science, public health, and other areas may need a way to quickly pick the one or few salient contexts out of many choices when

estimating dynamic network models. For example, estimating a single model on our school took multiple weeks of computing time, necessitating a systematic technique for model estimation and selection. We adopted a forward stepwise modeling approach in which we systematically disaggregated measures. There is nonetheless a trade-off of such an approach in which one must make certain assumptions to minimize the number of models needed to explore. For example, if one was willing to assume that conformity and status/popularity acquisition are more dominant than other mechanisms, researchers might choose to estimate simple statistical analysis like group mean *t*-test or logistic regression to identify the salient context(s) before constructing a comprehensive analytical framework. Alternately, L1 (i.e., LASSO) regularized estimation would provide a more efficient way of identifying predictively relevant contexts within large models; although not currently implemented for SAB models (and computationally non-trivial), our findings certainly motivate further technical work in this area. Despite these challenges, we conclude that estimating the distinct impacts of different social contexts is of importance to researchers.

Disclosure Statement

No potential conflict of interest was reported by the authors.

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Table 1. Descriptive Statistics of Time-Constant Variables in Jefferson High (n = 1,024)

Variable	
Female (%)	48.46
Grade level (%)	
9th grade	28.79
10th grade	28.48
11th grade	21.72
12th grade	21.00
Parent education level (%)	
Less than high school	5.23
High school graduate	38.32
Some college or trade school	36.48
Graduate of college/university	19.98
Club participation (%)	
Any clubs	77.05
Academic clubs	34.02
Sport clubs	63.52
Art clubs	29.51
Drama club	15.06
Band	15.06
Chorus	13.42
Orchestra	6.25
Depressive symptom, mean (SD)	0.00(0.53)
Parental support, mean (SD)	-0.04(0.29)
Parental monitoring, mean (SD)	-0.04(0.10)
Home smoking environment, mean (SD)	1.42(0.73)

Table 2. Descriptive Statistics of Time-Varying Variables in Jefferson High (*n* = 1,024)

	Wave 1	Wave 2	Wave 3
Smoking (past 30 days, %)			
0 = never	42.01	53.17	45.39
1 = 1-3days	21.31	9.12	11.68
2 = 4-21 days	9.02	11.58	10.55
3 = 22 or more days	27.66	26.13	32.38
Network statistics			
Out-going ties	6,063	3,713	2,484
Reciprocity index[a]	0.34	0.35	0.35
Transitivity index[b]	0.18	0.19	0.20
Jaccard index[c]		0.22	0.21
Limited nominations (%)	0	4.82	0.41

[a] The reciprocity index is the proportion of ties that were reciprocal.
[b] The transitivity index is the proportion of 2-paths (ties existing between AB and BC) that were transitive (ties existing between AB, BC, and AC, which represent the dyadic relations among three students A, B, and C).
[c] The Jaccard index measures the network stability between consecutive waves.

Table 3. Five Mechanisms Initiated from Club Affiliation Status in Jefferson High (*n* = 1,024)

Effect name	Model 1		Model 2		Model 3		Model 4	
Behavior equation	beta	s.e.	beta	s.e.	beta	s.e.	beta	s.e.
Effect from number of clubs (M1: Conformity)	-0.01	0.03						
Effect from number of sport teams			0.04	0.04	0.04	0.03	0.04	0.05
Effect from number of performing art clubs			-0.22*	0.10				
Effect from drama club participation					0.10	0.14	0.09	0.19
Effect from band participation					-0.07	0.20	-0.08	0.22
Effect from chorus participation					-0.63*	0.30	-0.78*	0.38
Effect from orchestra participation					-0.19	0.15	-0.19	0.20
Effect from number of academic clubs			-0.02	0.04	-0.02	0.04	-0.01	0.05
Behavior equation								
Smoking behavior assimilation via club co-participation (M5: Assimilation via affiliation networks)	0.00	0.00						
Smoking behavior assimilation via sport team co-participation			0.00	0.00	0.00	0.00	0.00	0.00
Smoking behavior assimilation via performing art club co-participation			-0.01*	0.00				
Smoking behavior assimilation via drama club co-participation					0.00	0.00	0.00	0.00
Smoking behavior assimilation via band co-participation					0.00	0.00	0.00	0.01
Smoking behavior assimilation via chorus co-participation					-0.02*	0.01	-0.02*	0.01
Smoking behavior assimilation via orchestra co-participation					0.00	0.02	0.00	0.02
Smoking behavior assimilation via academic club co-participation			0.00	0.00	0.00	0.00	0.00	0.00
Network equation								
Number of club co-participation (M2: Tie formation from shared focus/foci)	0.04*	0.02						
Number of sport team co-participation			0.05	0.03	0.05	0.03	0.05	0.04
Number of performing art club co-participation			0.27**	0.07				
Drama club co-participation					0.18***	0.05	0.18***	0.04
Band co-participation					0.12*	0.05	0.12*	0.05
Chorus co-participation					0.08	0.05	0.08	0.05
Orchestra co-participation					-0.12	0.19	-0.12	0.11
Number of academic club co-participation			-0.05	0.05	-0.03	0.06	-0.03	0.09
Alter's number of club participation (M2: Status/popularity acquisition)	0.00	0.01						
Alter's number of sport team participation			0.02	0.01	0.02	0.01	0.02	0.02

Alter's number of performing art club participation	-0.05	0.03				
Alter in drama club			0.00	0.05	0.00	0.06
Alter in band			0.17***	0.05	0.17**	0.07
Alter in chorus			0.11*	0.06	0.12*	0.05
Alter in orchestra			-0.09	0.12	-0.09	0.12
Alter's number of academic club participation	-0.01	0.02	-0.01	0.02	-0.01	0.03
Network equation						
Ego in chorus × Similarity in smoking behavior (M3: Moderation on degree of homophily)					-0.18*	0.07
Behavior equation						
Effect from chorus participation × Smoking behavior assimilation via friendship networks (M4: Moderation on degree of assimilation)					-0.66	0.86

Notes: * Two-sided $p < 0.05$; ** Two-sided $p < 0.01$; *** Two-sided $p < 0.001$; M1 – Mechanism 1; M2 – Mechanism 2; M3 – Mechanism 3; M4 – Mechanism 4; M5 – Mechanism 5

Table 4. Other parameter estimated for the SAB models (n = 1,024)

Effect name	Model 1		Model 2		Model 3		Model 4	
Behavior equation	beta	s.e.	beta	s.e.	beta	s.e.	beta	s.e.
Rate smoking behavior (period 1)	9.21***	1.48	9.12***	1.19	9.09***	0.85	8.96***	1.79
Rate smoking behavior (period 2)	14.86***	1.62	15.13***	3.39	15.12***	1.67	14.95***	1.99
Smoking behavior linear shape	-2.01***	0.24	-2.00***	0.22	-2.01***	0.25	-1.98***	0.30
Smoking behavior quadratic shape	0.68***	0.02	0.68***	0.02	0.69***	0.03	0.68***	0.03
Smoking behavior in-degree	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Effect from number of clubs squared	0.00	0.00						
Effect from number of sport teams squared			0.00	0.00	0.00	0.00	0.00	0.00
Effect from number of performing art clubs squared			0.02	0.02				
Effect from number of academic clubs squared			0.00	0.00	0.00	0.00	0.00	0.00
Effect from gender (female=1)	-0.01	0.04	0.00	0.04	0.00	0.04	0.00	0.05
Effect from grade	-0.02	0.02	-0.02	0.02	-0.02	0.02	-0.03	0.03
Effect from depressive symptoms	0.13**	0.04	0.14***	0.04	0.13**	0.05	0.13**	0.05
Effect from parental home smoking environment	0.12***	0.03	0.12***	0.03	0.13***	0.05	0.13***	0.03
Effect from parental support	-0.02	0.08	-0.02	0.07	-0.01	0.09	-0.01	0.08
Effect from parental monitoring	-0.20	0.19	-0.21	0.19	-0.23	0.22	-0.21	0.23
Smoking behavior assimilation via friendship networks	0.76***	0.10	0.75***	0.12	0.77***	0.10	0.84***	0.21
Network equation								
Constant friendship rate (period 1)	21.66***	1.89	21.58***	1.04	21.50***	1.70	21.44***	1.68
Constant friendship rate (period 2)	15.31***	0.57	15.25***	0.55	15.23***	0.73	15.17***	0.86
Out-degree (density)	-2.53***	0.07	-2.51***	0.07	-2.54***	0.07	-2.52***	0.08
Reciprocity	2.75***	0.12	2.75***	0.08	2.75***	0.11	2.76***	0.08
Transitive triplets	0.69***	0.04	0.69***	0.03	0.69***	0.03	0.69***	0.03
Transitive reciprocated triplets	-0.79***	0.05	-0.79***	0.07	-0.80***	0.05	-0.80***	0.05
3-cycles	0.18***	0.04	0.18**	0.06	0.19*	0.07	0.19***	0.04
In-degree popularity	0.06**	0.02	0.06***	0.01	0.06**	0.02	0.06***	0.01
In-in degree^(1/2) assortativity	-0.11**	0.04	-0.11***	0.02	-0.11**	0.04	-0.12***	0.03
Ego's number of club participation	-0.01	0.01						
Ego's number of sport team participation			0.02	0.02	0.02	0.01	0.02	0.02
Ego's number of performing art club participation			-0.06	0.04				

Ego in drama club					0.09	0.05	0.09	0.08
Ego in band					0.06	0.07	0.06	0.07
Ego in chorus					0.10*	0.05	0.00	0.09
Ego in orchestra					-0.12	0.22	-0.11	0.11
Ego's number of academic club participation			-0.03	0.02	-0.03	0.02	-0.03	0.03
Similarity in number of club participation	0.00	0.01						
Similarity in number of sport team participation			0.03*	0.01	0.03*	0.01	0.03*	0.01
Similarity in number of performing art club participation			-0.03	0.04				
Similarity in number of academic club participation			-0.02	0.02	-0.02	0.02	-0.02	0.03
Gender similarity	0.20***	0.02	0.20***	0.02	0.20***	0.02	0.20***	0.03
Grade similarity	0.39***	0.02	0.40***	0.02	0.40***	0.02	0.40***	0.02
Similarity in parental education	0.05**	0.02	0.05**	0.02	0.05**	0.02	0.05**	0.02
Ego's parental home smoking environment	-0.03	0.02	-0.02	0.02	-0.02	0.02	-0.02	0.02
Ego's parental support	0.09*	0.05	0.09*	0.05	0.09*	0.05	0.10*	0.05
Ego's parental monitoring	0.10	0.17	0.07	0.12	0.06	0.16	0.07	0.13
Alter's smoking behavior	0.07***	0.02	0.08***	0.02	0.08*	0.04	0.08*	0.03
Ego's smoking behavior	0.00	0.02	0.00	0.02	0.00	0.03	0.00	0.02
Similarity in smoking behavior	0.26***	0.04	0.26***	0.02	0.26***	0.04	0.28***	0.05
Ego's limited nomination status	-0.67***	0.07	-0.67***	0.06	-0.67***	0.06	-0.67***	0.07

Note: * Two-sided $p < 0.05$; ** Two-sided $p < 0.01$; *** Two-sided $p < 0.001$

Table 5. Smoking Behavior Statistics of Chorus Members in Jefferson High (*n* = 1,024)

Smoking (past 30 days, %)	Chorus members		
	wave1	wave2	wave3
0 = never	39.69	54.96	51.15
1 = 1-3days	19.08	7.63	10.69
2 = 4-21 days	8.40	9.16	6.87
3 = 22 or more days	32.82	28.24	31.30

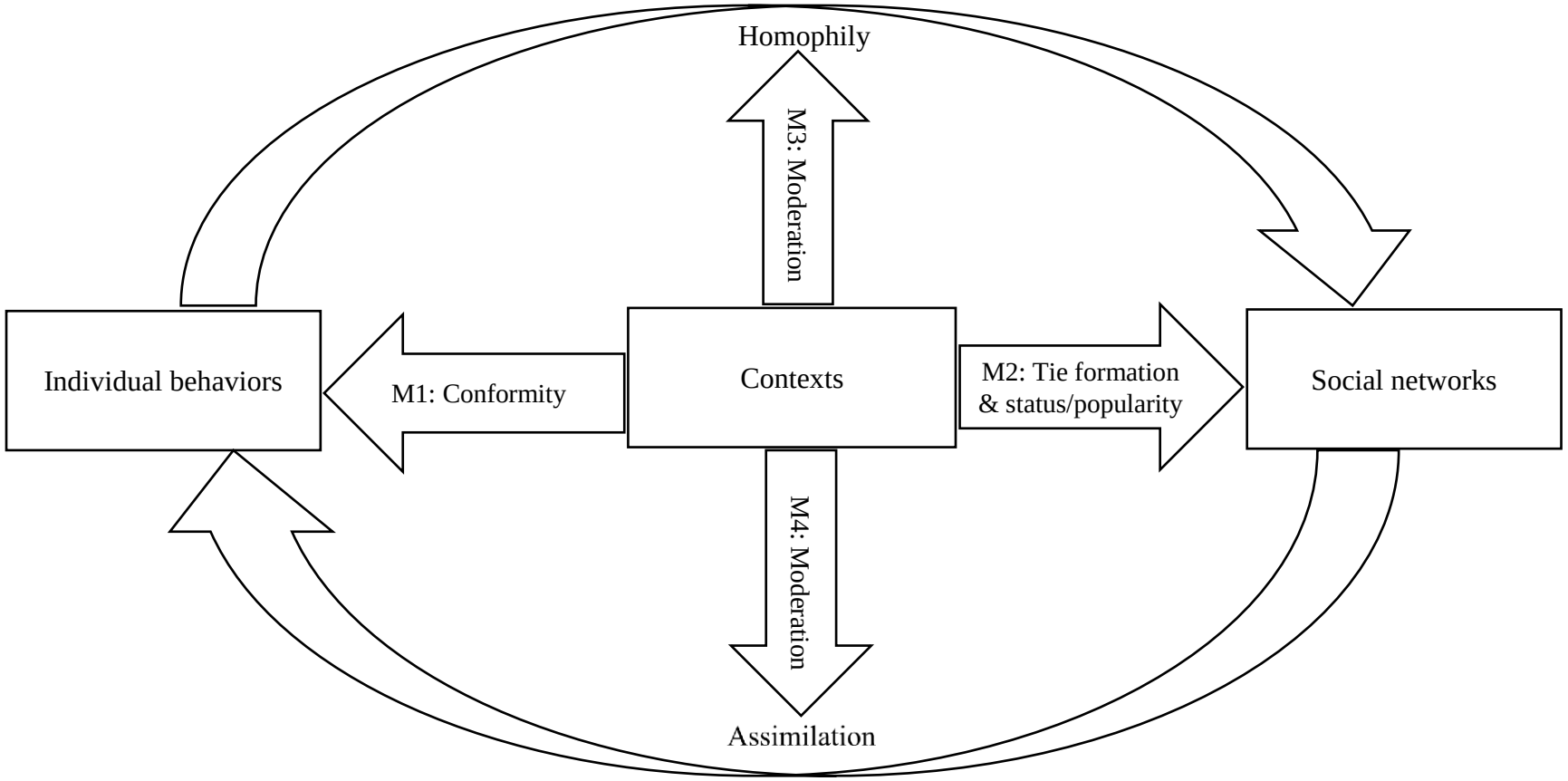

Figure 1. Relations among Contexts, Individual Behaviors, and Social Networks

Notes: M1 – Mechanism 1; M2 – Mechanism 2; M3 – Mechanism 3; M4 – Mechanism 4

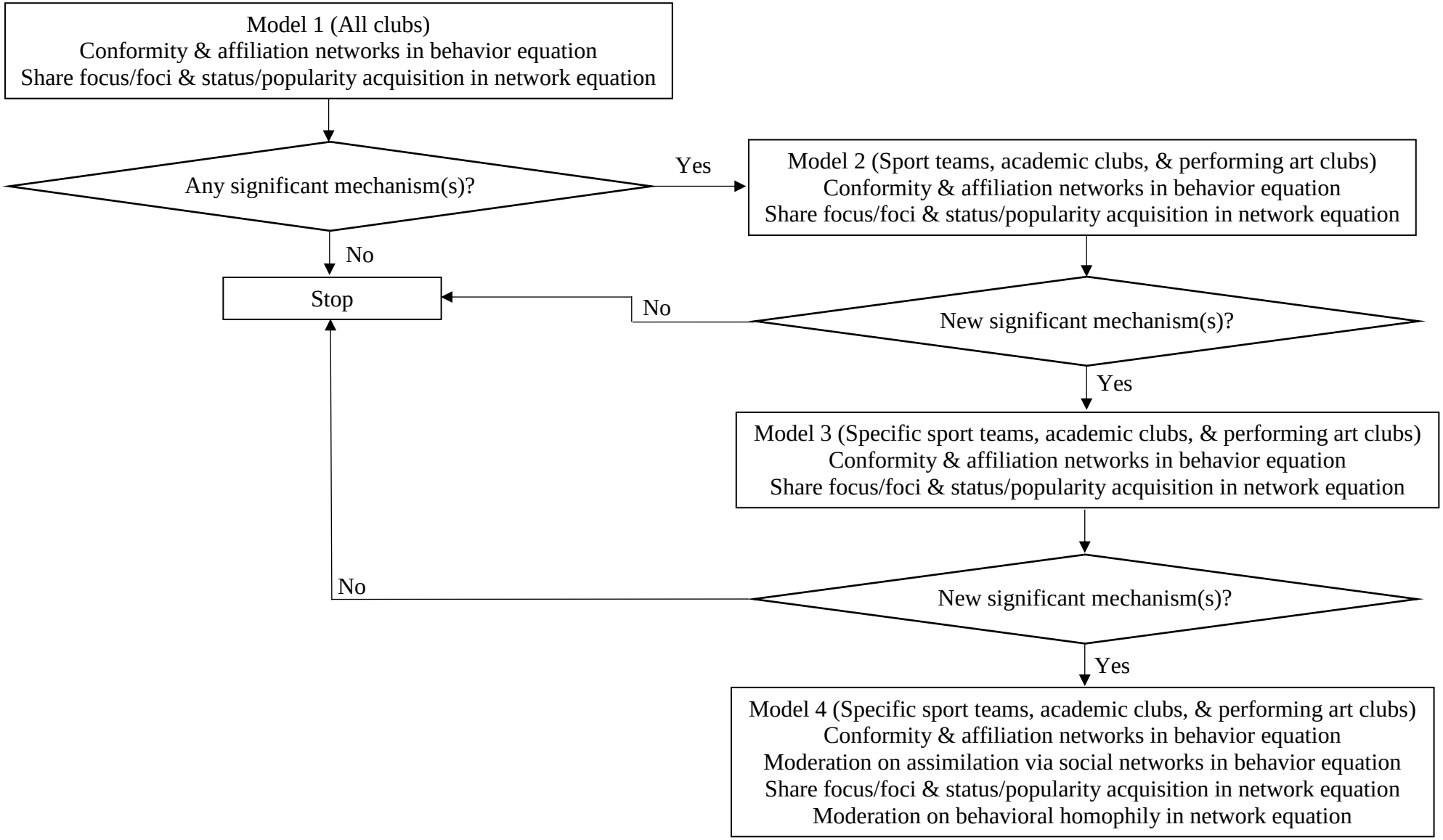

Figure 2. Flow Chart of Forwarding Stepwise Modeling Approach

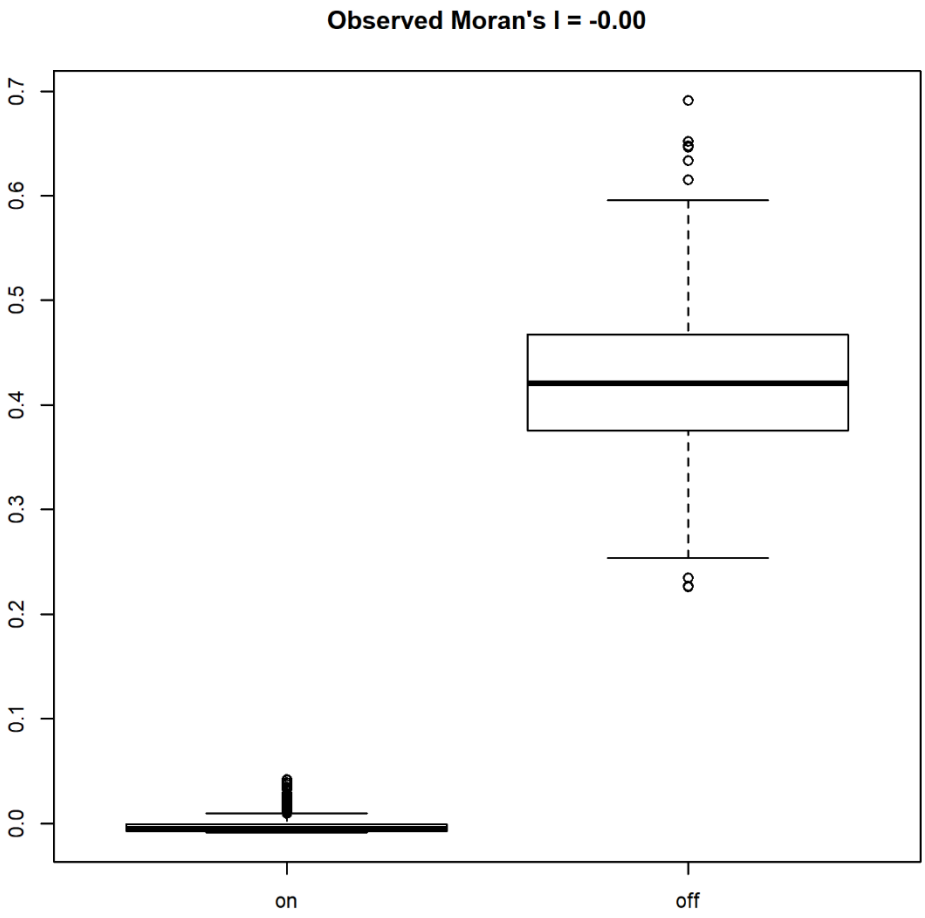

Figure 3. Autocorrelation Coefficients between Chorus Co-Participation and Smoking Behavior at Wave 3 before and after the Negative Assimilation Effect of Smoking Behavior among Chorus Members is Turned off