Simulation Modeling of a College Drinking Event

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Introduction

Excessive drinking among college students represents a dangerous public health problem for academic institutions across the country. It is estimated that each year 1,825 college students die from alcohol-related injuries and that roughly 600,000 students are unintentionally injured (Hingson et al., 2009). The phenomenon of college drinking is pervasive; more than 80% of college students drink alcohol, and nearly 50% admit to heavy episodic or "binge" drinking. Due to the seemingly preventable nature of this health issue and the accompanying negative consequences including academic problems, risky sexual behavior, and injury to self and others, college drinking represents a critical target for effective intervention (Hingson et al., 2009; Rinker and Neighbors, 2013; Wechsler et al., 1994).

Social Norms Marketing

Social Norms Theory, which asserts that misperceptions of the actions (or beliefs) of the typical college student have a direct effect on individual behavior (Perkins, 2002a), offers potential for intervention and prevention. College students have incorrect perceptions of normative drinking, with 71% overestimating peers drinking (Perkins et al., 2005). Drinking rates correlate positively with these misperceptions (Lewis and Neighbors, 2004; Neighbors et al., 2006a; Neighbors et al., 2006b; Perkins, 2002b), and perceived norms are considered to be the strongest predictors of excessive alcohol consumption among college students (LaBrie et al., 2010; Borsari and Carey, 2003; Neighbors et al., 2007).
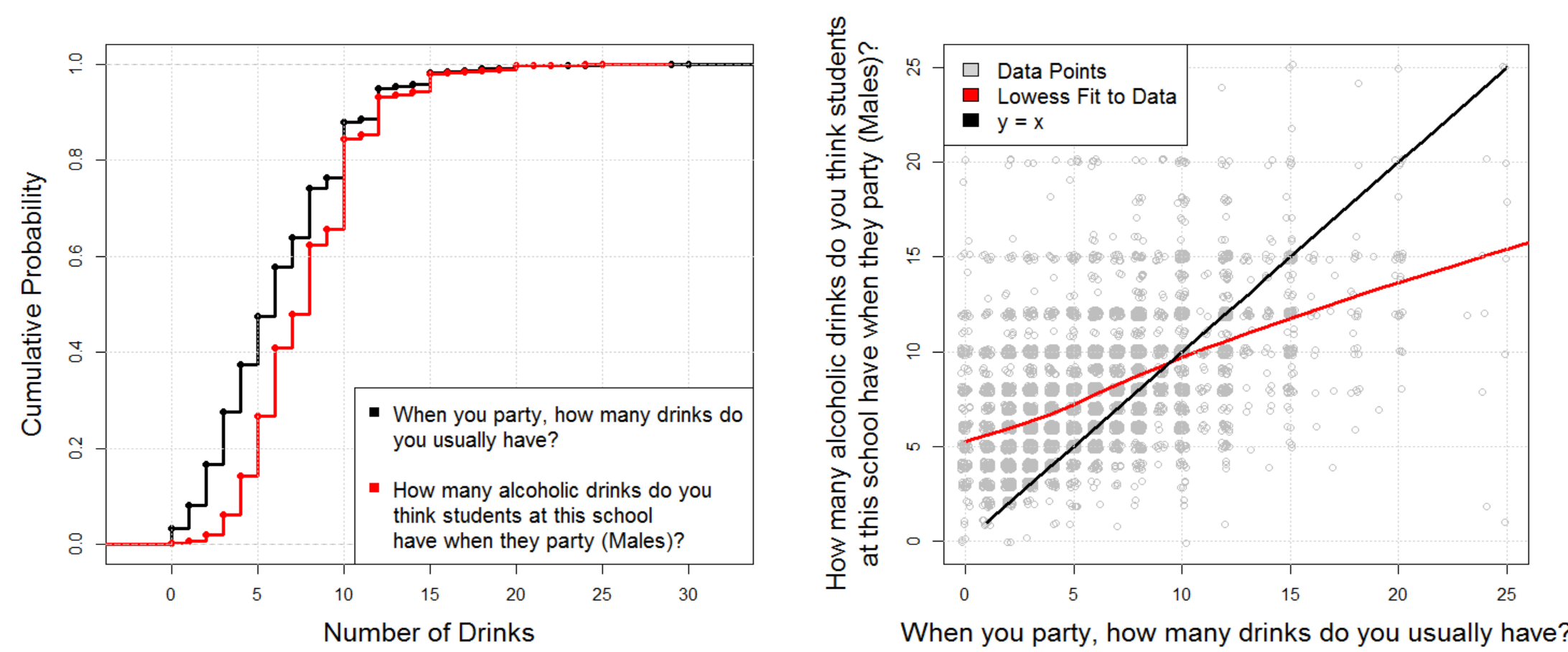

Figure 1. ECDF (left) and scatterplot (right) of the "number of drinks when you party" and "How many drinks do you think students at this school have when they party?"

Many investigations of Social Norms Marketing (SNM) interventions have been conducted, with varying degrees of success. Wechsler and colleagues (2003) examined the Harvard College Alcohol Study (CAS) data, comparing 37 colleges with SNM campaigns to 61 without, finding no differences in drinking. The Social Norms Marketing Research Project (SNMRP, DeJong et al., 2006; Scribner et at, 2011) examined 32 universities that had not previously implemented an SNM campaign, pairing similar institutions, and randomly assigning one to treatment and the other to control. The SNM intervention implemented at the treatment institutions was carefully overseen by the investigators, in contrast to the Wechsler study, which asked administrators if an SNM campaign had been conducted. A significant interaction between treatment effect and outlet density was found for drinking data.

Other studies have focused on interactions and peer influences within drinking contexts to understand social norms (Borsari and Carey, 2001; Borsari and Carey, 2003; Crawford and Novak, 2007; van der Ven, 2011). Different types of peer influence, from direct offers of drinks to modeling peer behavior to perceived norms, impact individual drinking behavior. Crawford and Novak (2007) note that peer appraisals may present risks for drinking behavior.

Here we develop an agent-based simulation model to investigate the social processes that may underlie social norms effects.

Agent Based Modeling

We have developed an agent-based simulation model of a college drinking event. Our model was developed in the Matlab programming environment to simulate individual student drinking and group interactions at a college party over a fixed time period (Fitzpatrick et al., 2015).

Previous models (Gorman et al., 2006; Garrison and Babcock, 2009) consider a much simpler event structure, focusing instead on the longer term evolution of the population with respect to drinking. Here we concentrate on the details of interactions at a single event in order to investigate the interplay between misperception, identity, and peer behavior.

The party progresses at discrete time steps with a number of agents (students) who arrive, congregate into groups, interact, and drink. At each step students assess their situation and make decisions based on their observations and interactions. The actions the students take are (1) consuming alcohol based on their identity, appraisals, and observations of other partiers and (2) leaving a group to join or form another. Figure 2 illustrates these two dynamic processes.

We consider three primary processes as influencers of drinking: identity verification, peer influence, and self-monitoring. The following paragraphs describe these processes.
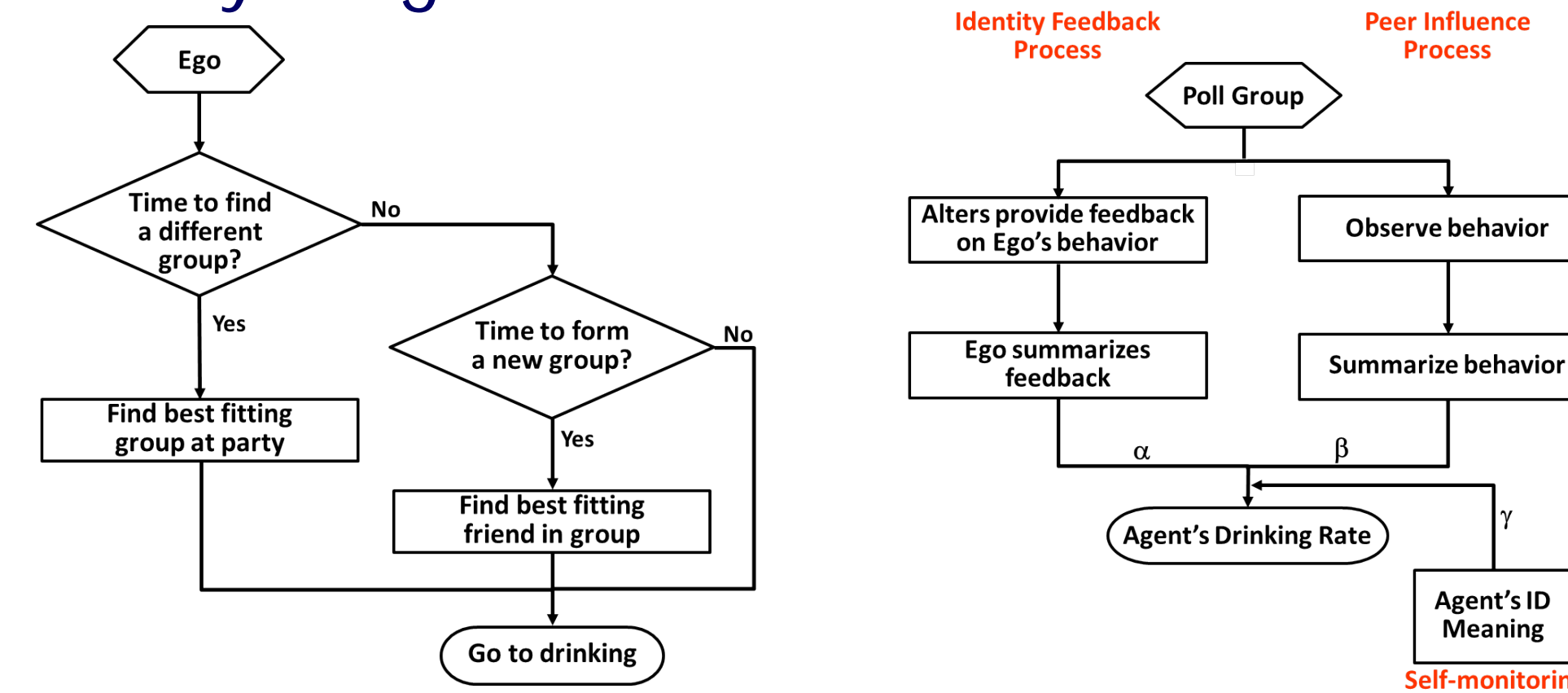
Party Activity Diagrams

Figure 2. Diagrams of grouping (left) and drinking (right) dynamics.

Identity Verification (IV)

Identity Control Theory (ICT) states that identities are formed by a set of meanings that serve as a reference or standard for defining who one is (Burke 1991; Stets & Burke 2000; Burke & Stets 2009). When an identity becomes salient in a social situation, the individual or agent perceives appraisals from others. If the appraisals are not in line with the agent's meanings, the agent experiences distress. This distress may lead to behavioral changes in the agent. Burke and Stets (2009) use the analogy of engineering feedback control systems that monitor inputs from their environments and apply control signals to bring the system outputs into agreement with a reference signal. Inputs are generally meant as direct or indirect social cues that are referred to as appraisals from agents in the social environment (Burke 1991), and the controls are an agent's behavior.

Peer Influence (PI)

Peer influence provides a second form of feedback control of drinking behavior. The distinction from IV is that PI models a behavioral change in which individuals seek approval by adopting the behavior of others. Peer influence can encompass a number of control actions (Borsari & Carey 2001). Within the college drinking context, peer influence can range from direct offers of drinks to indirect modeling of others' behaviors to that of identity control. Indeed, ICT is a form of direct peer influence, as peers provide appraisals that an individual processes. Thus, we use PI in the indirect sense of an individual attempting to model the behavior of peers, much like attitude and opinion dynamics of Abelson (1964). Experiments (Dericco and Garlington 1977; Derrico 1978) have tended to corroborate the notion that agents are influenced by indirect PI within a drinking context. Osgood and colleagues (2013) also observe not only significant relationships between individual and peer behavior in alcohol use but also strong tendencies for friendship selection based on similar drinking behavior.

Self-Monitoring (SM)

A potential moderator for these social pressures is self-monitoring (SM), in which individuals exert expressive control over behavior. High self-monitors are highly responsive to interactions and social cues, while low self-monitors tend to behave in ways that reflect their inner attitudes (Gangestad and Snyder, 2000; Crawford and Novak, 2007). Individuals who are low self-monitors would appear to be more resistant to the pull of misperceptions about social norms than would higher self-monitors.

Friendships and Grouping in Parties

College drinking is a fundamentally social phenomenon, and party gatherings form an important social forum for drinking activity (Harford, Wechsler, & Muthén, 2003; Wechsler et al., 2000). Generally speaking, party events do not involve a single large group of individuals who are simultaneously interacting with everyone else, nor do they involve singletons behaving as if alone. Rather, parties and social events tend to involve smaller clusters of interaction partners within the larger event (Bakeman & Beck 1974; Ingram & Morris 2007).

Our short-time model of an individual drinking event involves a group formation dynamic based on a friendship network and trait similarity which may or may not be correlated with drinking rates. Osgood et al (2013) demonstrates correlations between drinking rates and interaction partners.

Parameterization

(1) Agents have (and can make more) friends: each agent has a list of friends
  -- a single trait variable is used to model similarity, and this value may be correlated with identity
(2) Agents have drinking identities: 1-5 represent Abstainer, Infrequent, Light, Moderate, and Heavy
(3) Agents have a drinking rate that depends on identity
(4) Agents have drinking rate appraisal values for each of the five identities:
  -- these are used in interactions to provide feedback to interaction partners
(5) Agents have 3 susceptibilities (that add up to one)
  (a) susceptibility to identity verification pressure
  (b) susceptibility to peer influence
  (c) susceptibility to self-monitoring
(6) Agents have a misperception level, a single number added to appraisal drinking rates
  -- these numbers model the misperception that SNM seeks to influence

Comparing Simulations to Survey Data

We used CAS survey questions concerning how much students typically drink and how they self-identity to parameterize the identity component.

We parameterize a "Light Drinking School" and a "Heavy Drinking School" by stratifying the CAS data into below median fraction HED and above median fraction HED groups.

We used SNMRP misperception data to parameterize misperception in the model

We generate uniform random numbers (and normalize them to sum to 1) for the susceptibilities 10000 independent 20 person, 4 hour parties were simulated

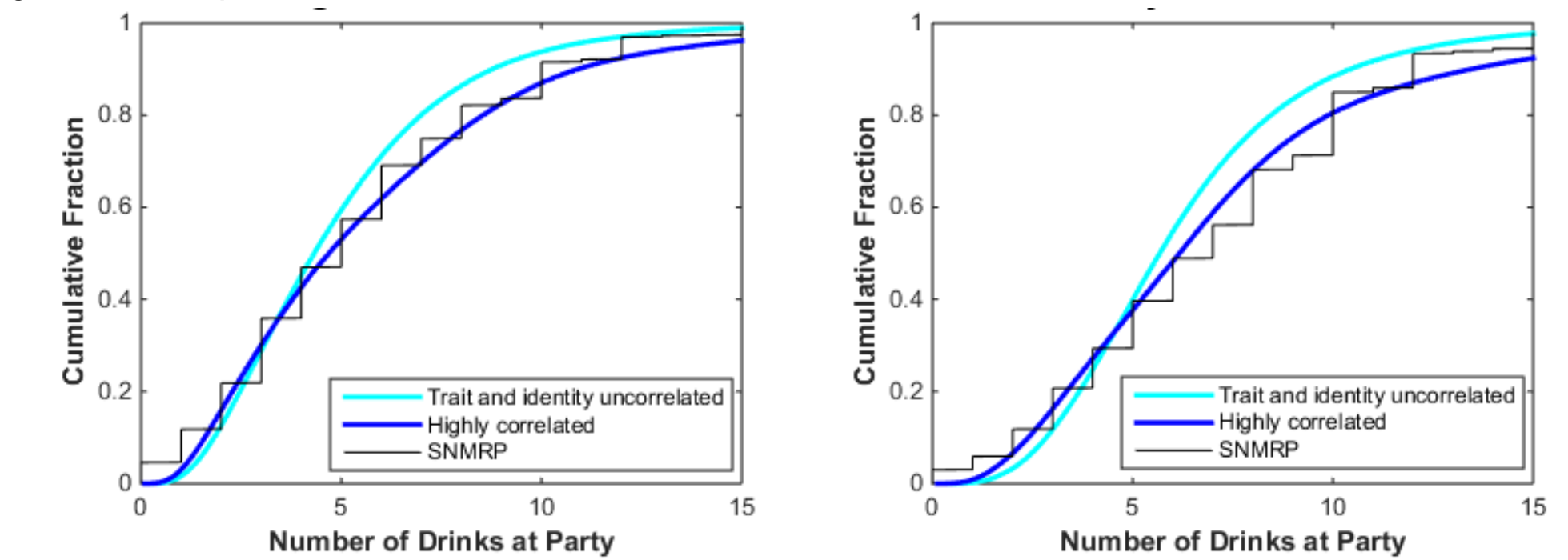Figure 4 compares SNMRP data to the simulation:

Figure 4. ECDFs of drinking activity at Light (left) and Heavy (right) Drinking Schools

Simulation of Social Norms Marketing Interventions:

Social Norms Interventions attempt to remove misperception by informing students of actual drinking behavior at their schools.

This will affect the appraisals students provide others and students' interpretation of the appraisals they receive. We optimistically model the intervention as reducing misperception to 0 and removing all susceptibility to identity verification appraisals. Students who respond to the intervention provide accurate feedback, and their drinking is governed by self-monitoring and peer influence.

For Light Drinking Schools (the lower 3 curves) and for Heavy Drinking Schools (the upper three curves), we set three susceptibility configurations, whose ratios of IV to PI to SM parameters are noted in the legend. Each data point corresponds to 10000 simulated parties of 20 students over 4 hours.

We consider the fraction of students who respond to the intervention as a parameter in Figures 5 and 6.
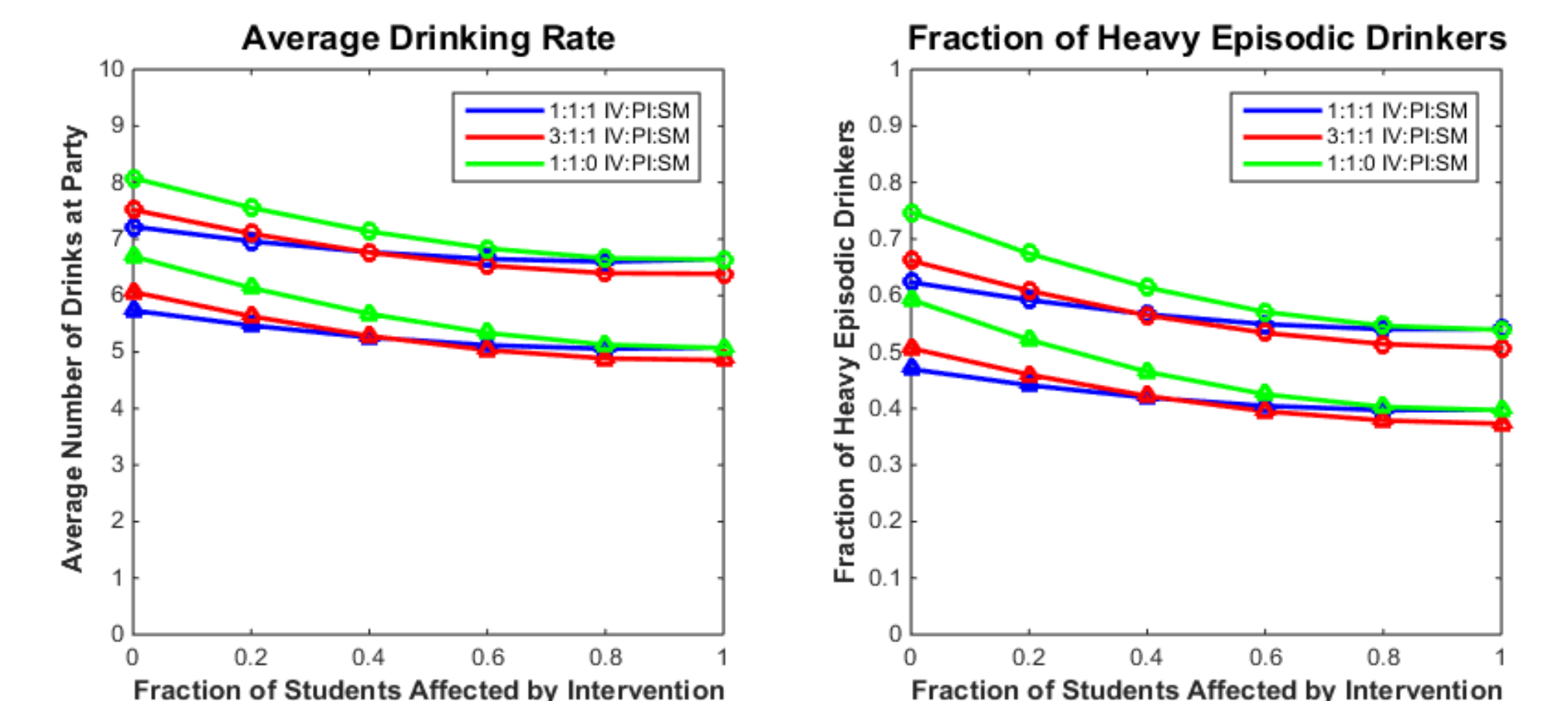

Figure 5. Average drinks at the party (left) and fraction of HEDs at the party. For this simulation traits are highly correlated with drinking identity.
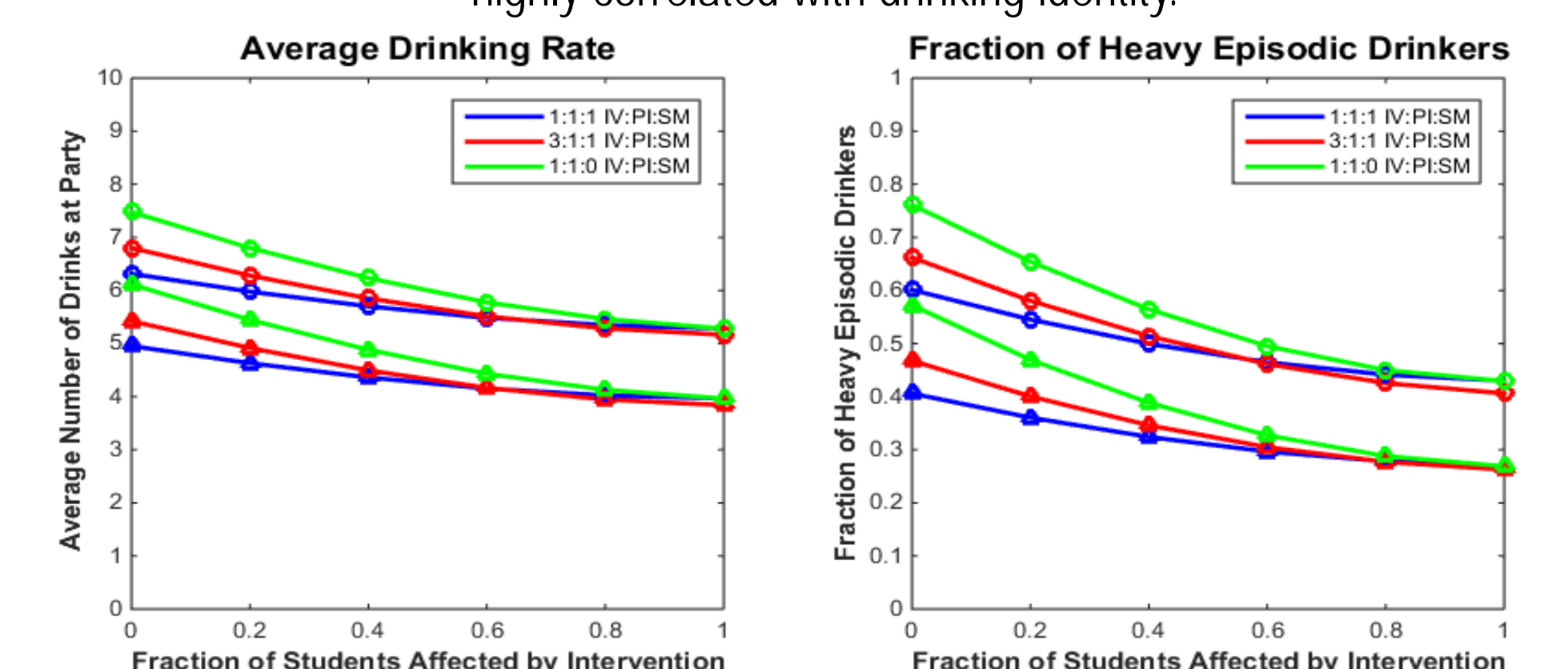

Figure 6. Average drinks at the party (left) and fraction of HEDs at the party. For this simulation traits are not correlated with drinking identity.

Remarks

It is crucial that we improve our understanding of the circumstances that might impact the effectiveness of SNM campaigns. One approach to developing insights is through agent-based modeling built on social science theories. In this work we have translated identity theory, peer influence, and self-monitoring into a model of college drinking. Informed by survey data, this simulation provides results that compare favorably to observation.

Our results show that when friendships correlate with drinking behaviors, the impact of an SNM is reduced and in some situations even reversed, suggesting a social network effect. Scribner et al (2011) observed an increase in drinking from control to treatment schools with high outlet densities. Might this be a result of a drinking-dependent social network in high availability schools? More research is needed!