Published in final edited form as:
Psychol Addict Behav. 2011 March ; 25(1): 80–89. doi:10.1037/a0021874.

Accuracy and Bias in Adolescents' Perceptions of Friends' Substance Use

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Abstract

This study tested competing hypotheses related to the false consensus effect and pluralistic ignorance by examining the accuracy and bias of adolescents' perceptions of peer substance use, and the effects of their own substance use, gender, and age on perceptions of peer behavior. Two samples (*N*s = 163 and 2,194) that collected data on peer nominations, perceptions of peer substance use, and self-reports of substance use were used in analyses. Results from both samples provided evidence supporting the false consensus effect, that is, adolescents' reports of their friends' substance use were biased in the direction of their own use. Users and non-users did not differ in accuracy of perceptions; however, across all substances and samples, they differed significantly in bias. Substance users displayed nearly perfect liberal bias, assuming their friends also used substances. Non-users displayed an opposite, conservative bias, assuming their friends did not use substances. Gender and age differences in bias also were observed, with older adolescents and females having more liberal biases than younger adolescents and males. Results suggest the importance of differentiating the effects of actual and perceived peer substance use.

Key Phrases

Adolescence; Substance Use; Peer Relationships; Accuracy and Bias; False Consensus Effect

Peers are a major source of influence on adolescent substance use (Kobus, 2003), moderating even genetic predispositions (Guo, Elder, Cai, & Hamilton, 2009). Perceptions of peer substance use affect individual adolescent substance use (D'Amico & McCarthy, 2006; D'Amico, et al., 2001) as does actual peer substance use (Bauman & Ennett, 1996; Ennett, et al., 2006; Henry & Kobus, 2007), but studies simultaneously examining perceptions and peer self-reports obtain differing effects (Ellickson, Bird, Orlando, Klein, & McCaffrey, 2003; Kobus & Henry, 2010). The validity of research that relies on adolescents' perceptions of their friends' substance use behavior has been called into question due to the potential for rater bias, whereby respondents misperceive the behavior of their peers as a function of their own behavior. Biased estimates of peer substance use may be due to statistical factors such as common method variance (i.e., the tendency to respond similarly to similar questions on a survey) or measurement error (Norton, Lindrooth, & Ennett, 2003), but there are other possibilities. Half a century of research has documented evidence for what Murstein and Pryer (1959) termed "attributive projection," that is, perceiving a trait in others that one is aware of in the self (Holmes, 1968). Social

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psychologists refer to this as a “false consensus effect,” in which people perceive others to believe or behave as they do, when in fact, they may not (Ross, Greene, & House, 1977).

The false consensus effect, also termed “normative fallacy,” has been observed in adolescent substance users’ overestimation of use among their peers and non-users’ underestimations of peer use. Segrist and colleagues (2007) found that adolescent males who either never drank or drank only with parents were unlikely to perceive their peers as drinking, but adolescents who drank with friends almost universally perceived their peers as drinking. Gillmore and colleagues (2002) found that smokers and nonsmokers differed significantly in their perceptions of peer, parent, and teacher approval of smoking. Smokers perceived others to be less disapproving, whereas non-smokers perceived greater disapproval, suggesting a bias in the direction of one’s own behavior. Cunningham and Selby (2007) found that almost three fourths of young adult smokers overestimated the prevalence of smoking among their peers by more than 20%. A false consensus effect is also consistent with findings of weaker correlations between friend and respondent substance use behaviors when friends report their own behavior than when respondents’ perceptions of friend behavior are used (Bauman & Fisher, 1986; Fisher & Bauman, 1988; Norton, et al., 2003), and with findings that perceived friend substance use is a better predictor of an individual’s own use than is the actual behavior of friends (Ianotti & Bush, 1992; Prinstein & Wang, 2005).

In contrast, researchers have long observed a tendency for individuals to inaccurately perceive that certain behavior is socially normative, a phenomenon termed “pluralistic ignorance” by Katz and Allport (1931, p. 348). Applied to substance use, this notion leads to the prediction that non-users and users alike would overestimate substance use among their peers. Evidence consistent with this tendency, also known as the “majority fallacy,” has been observed in overestimations of peer engagement in risk behaviors, such as alcohol consumption (Bourgeois & Bowen, 2001; Mäkelä, 1997; Prentice & Miller, 1993; Segrist, et al., 2007) and high-risk sex (Cohen & Shotland, 1996). Pluralistic ignorance is part of the theoretical foundation for normative feedback interventions that seek to address substance use and other risk behaviors by correcting inaccurate perceptions of peer attitudes and behavior (Cunningham & Selby, 2007). It provides one possible explanation for occasional findings of unintended negative consequences from normative feedback interventions (Grabosky, 1996). That is, although normative feedback interventions have shown strong effects in reducing alcohol use (DeJong, 2002; Mattern & Neighbors, 2004), some findings reveal varying effects for users and abstainers -- specifically, reducing alcohol consumption among heavy drinkers, but increasing it among those who consume little (Grabosky, 1996; Lintonen & Konu, 2004).

Other findings also provide evidence consistent with pluralistic ignorance. Prinstein and Wang (2005) found that adolescent’s own health risk behavior (smoking, drinking, and marijuana use) correlated with the degree of incorrect estimation. That is, overestimation of friends’ health risk behaviors was greater if the individual engaged in the health risk behaviors themselves. Prentice and Miller (Prentice & Miller, 1993) found evidence for pluralistic ignorance in college students of both genders, but found that males tended to adjust their own behavior to approximate the perceived norm whereas females did not. Other findings, however, suggest a more general tendency for youth to overestimate peer substance use. Lai, Ho, and Lam (2004) reported that Hong Kong youth overestimated the prevalence of adolescent smoking, regardless of their own smoking status, but that current smokers and particularly male smokers tended to overestimate to a greater extent than others.

Evidence consistent with the cognitive biases of a false consensus effect and pluralistic ignorance highlight the need to better understand the accuracy and bias of adolescents’

perceptions of peer substance use. To what extent are adolescents' perceptions of peer substance use free of error, i.e., accurate? To what extent are their perceptions dependent on their own substance use behaviors, i.e., biased? Understanding issues of accuracy and bias are especially important, given the common research practice of assessing peer substance use via respondents' perceptions, rather than by direct assessment of peers (Kobus, 2003).

The literature also suggests that estimates of peer behaviors may vary depending on the specific substance in question. For example, Kobus and Henry (2010) found significant peer effects on alcohol use when measured by perceptions, but only marginal effects when measured by peer self-reports. They also found significant effects for tobacco use when measured by peer self-reports but not when measured by perceptions of peer behavior. Because of this variation by substance, in the present study we test accuracy and bias separately for tobacco, alcohol, and marijuana.

In addition, bias may vary systematically by gender and age. Gender and age differences have been found in the composition of peer networks (Poulin & Pedersen, 2007) and in the relation between network position and smoking (Fang, Li, Stanton, & Dong, 2003). Gender differences have been found for prevalence of marijuana use (Henry & Kobus, 2007), the influence of peers norms on sexual risk (Henry, Schoeny, Deptula, & Slavick, 2007), and in conformity to behavior that is perceived to be normative (Prentice & Miller, 1993). Age differences have been found on substance use prevalence and the influence of school norms on substance use (Kumar, O'Malley, Johnston, Schulenberg, & Bachman, 2002). Moreover, Keefe (1994) found age differences in alcohol use prevalence and in perceived normative peer pressures not to use alcohol. The literature leads us to no specific predictions about the directions of gender and age differences, but we believe it important, nonetheless, to explore gender and age differences in the accuracy and biases of adolescents' perceptions of their peers' substance use.

Although research findings suggest that adolescent estimates of peer substance use may be biased by the adolescent's own substance use, no study to date has attempted to measure the degree of such accuracy and bias. The purpose of the present study is to assess the degree of accuracy and bias in perceptions of peer use of tobacco, alcohol, and marijuana; and the extent to which accuracy and bias differ as a function of age, gender, and one's own use or non-use of substances.

Believing that similar results from two independent and methodologically distinct samples would provide stronger inference than data from any single sample, in this study, we used two datasets that shared three important characteristics. First, both assessed friendship networks using peer nominations, allowing us to assess substance use within ego-centric friendship networks (i.e., networks defined by individual reports of friendships). Second, respondents' own alcohol, tobacco, and marijuana use were assessed, and third, respondents' perceptions of substance use among friends were assessed. These characteristics made it possible to compare respondents' perceptions of their friends' substance use with the self-reported substance use of nominated friends. Due to differences in the measurement between the two samples and between assessments of respondent use and perceptions of peer use, we chose scaling that would represent the least common denominator among all measures, namely, dichotomization. Despite the potential loss of information involved, dichotomization also had the advantage of allowing signal detection theory analysis, thus enabling us to quantify accuracy and response bias.

The National Longitudinal Study of Adolescent Health (Add Health) provides a social network data set that makes it possible to study the discrepancy between adolescents' reports of peer substance use and peers' own reports. Add Health has been the basis for studies of

race and friendship (Mouw & Entwisle, 2006; Wang, Kao, & Joyner, 2006), characteristics of peer networks and sexual behavior (Adamczyk & Felson, 2006; Henry, et al., 2007), and peer effects on substance use (Guo, et al., 2009; Wen, Van Duker, & Olson, 2009). The breadth of the assessments collected by Add Health makes it ideal for studying inconsistencies in reports from different sources. For example, Griesler and colleagues (Griesler, Kandel, Schaffran, Hu, & Davies, 2008) used the Add Health data to study discrepancies in reports of smoking collected from the same adolescents in household and in school surveys. They found that age, ethnicity, absence of involvement in deviant activities, and non-substance-using parents all contributed to inconsistency between home and school reports. In this study, we use the Add Health data to study the association between substance use as reported by peers and by adolescents' estimates of their peers' use.

The Teen Survey data set provides a methodologically similar but distinct sample of early adolescents. Although it has a smaller sample than the Add Health study, including it in the present study offers the possibility of a conceptual replication of the findings that strengthens inference. Moreover, whereas the Add Health sample consists of youth residing in predominantly rural (27.7%) and suburban (37.4%) settings, 100% of the Teen Survey participants lived in a lower middle-income urban neighborhood. A further advantage is that the Teen Survey sample has an unusually high consent rate for a social network study, resulting in more valid representation of peer effects. Fully 87% of the middle-school-age student population had both individual and peer measures, compared to just over 60% of the Add Health sample.

The theoretical notions of the false consensus effect and pluralistic ignorance lead to two competing hypotheses regarding accuracy and bias in estimation of peer substance use. The first hypothesis, based on the false consensus effect, is that adolescents will be biased toward perceiving their peers as behaving like them. The result would be similar accuracy for both users' and non-users' estimates of friend substance use, but users' and non-users' biases would be in opposite directions (i.e., substance users would assume that their friends use substances, and non-substance-users would assume that their friends do not). The second hypothesis is based on the theory of pluralistic ignorance. This hypothesis would be supported if we found that adolescents are biased toward overestimating their peers' substance use regardless of their own use or non-use. If so, substance users would be more accurate than non-substance users in their perceptions of friend substance use.

Method

Samples

Samples from two separate studies were used in this research. The first was collected from the second author's doctoral dissertation (Teen Survey; Kobus, 1998) and the second was taken from the saturated schools sub-sample of the National Longitudinal Study of Adolescent Health (Add-Health; Bearman, Jones, & Udry, 1997). Table 1 reports the demographic characteristics of both samples.

Teen Survey—Participants in Teen Survey were recruited from a population of sixth-, seventh-, and eighth-grade students who attended regular education classes at a K-8 Chicago public elementary school. The data were collected in May, 1997. The participating school was selected based on its size (n = 700) and rate of daily attendance (93.8%; Chicago Panel on School Policy and Finance, 1996), both of which were near the median for Chicago Public Schools (63.4 percentile for size, 55.5 percentile for attendance rate). A total of 165 (88%) of the 188 eligible students returned signed parental consent and student assent forms. Of these, 163 (87% of the eligible population) completed study measures. The age range of participants was 11.7 to 15.6 years (median = 13.4). As can be seen in Table 1, the sample

was approximately equally divided by gender (48.5% female) and predominantly reported white ethnicity (65.6%). One fourth (25.2%) of students reported that their mothers did not complete high school.

Add Health—The second sample was drawn from the Add Health survey (Bearman, et al., 1997). These analyses used data from the wave 1 in-home interviews. Wave 1 interviews were conducted between April and December 1995. The sample for the current study included 2,194 students in nine high schools and their feeder middle schools who nominated at least one friend. This sample represents 60.5% of the students in the Add Health Saturated School Sample who were in grades 8–11 and had non-missing estimates of peer substance use and friend nomination data. The Saturated School Sample consisted of schools in which all students took part in the Add Health study, allowing for network analysis. The median age of the sample was 16.7 years (range = 12.5 to 20.7), and 18.1% were below 15 years of age. The sample was roughly equally divided by gender (52.3% female), and like the Teen Survey sample, nearly two-thirds (62.8%) reported white ethnicity. Of the parents completing the Add-Health Parent Questionnaire, 15.3% reported less than a high school education. In order to compare results from the two samples, we split the Add Health sample at age 15. This was a natural dividing point because the survey questions administered to those over 15 differed slightly from those administered to youth under 15. However, all of the questions used in this study were identical across age groups. The under 15 age group was comprised of 397 youth with a median age of 13.9 years (range = 12.5 to 14.9). In the 15 and older age group, there were 1,797 youth whose median age was 17.0 years (range = 15 to 20.7).

Measures

Individual substance use—Each participant in the Teen Survey sample was asked, “During the past six months, how often did you [use substance].” Respondents answered on a 9-point scale anchored by 0 (not at all) and 8 (every day). Responses were coded dichotomously for any use (1) vs. no use (0). In the Add-Health study each participant was asked, “How many days in the past 30 days did you [use substance]?” Responses could be any number between 0 and 30, and were dichotomized to indicate any use (1) vs. no use (0) as with the Teen Survey sample.

Friend-reported substance use—In the Teen Survey sample, peer nominations were collected by asking participants “Who are the people at your school and in the 6th, 7th, or 8th grade that are your friends? That is, the people that you spend time with and do things with?” Students were provided with space to write the first and last name of up to six friends, beginning with the person who was their best friend. Friend nominations were limited to those youth who attended the participating K-8 elementary school. Study personnel were available with lists of names to assist students. In the Teen Survey sample, 89.9% reported that half or more of their friends attended their same school.

In the Add Health sample, the in-home survey asked each student to nominate up to five male and five female friends in order of preference. Although students could nominate any friends, study identification numbers were assigned only to friends who attended either the same school or a sister school (a middle school or junior high school in the same town). In Wave 1 of Add-Health, 77.9% of the nominated friends attended the same school as the nominator and were assessed as part of the study.

For both samples, the adolescents nominated by each participant comprised the friendship network (ego-centered networks; Wasserman & Faust, 1994, p. 731). If any members of the ego network reported using a substance, the network score for that substance was coded 1. If

no member reported use of the substance, the network score for that substance was coded 0. Thus, in both the Teen Survey and Add Health samples, we calculated network scores for alcohol, tobacco, and marijuana use. We regarded these scores as measures of friend reports of substance use for the purpose of calculating accuracy of perceptions.

Perceived friend substance use—Perceived friends' use of cigarettes, alcohol, and marijuana in the Teen Survey sample was assessed by the question, "About how many of your friends [use substance]." Responses were made on a 4-point Likert-type scale anchored by 0 (none) and 3 (most or all). In the Add Health sample, perceived friend use was measured by the question, "Of your 3 best friends, how many [use substance]." Responses could be any number between 0 and 3. In order to measure accuracy and bias, we dichotomized perceived friend use in both samples at 0 = no friends use or 1 = any friends use.

Data Analysis Plan

Initially, we conducted main analyses to determine whether either of our competing hypotheses warranted further investigation. That is, was there evidence of discrepancy between perceptions of peer substance use and actual peer use from peer self reports? If so, did that discrepancy vary as a function of individual substance use? If no discrepancy was found and no variation in the discrepancy by individual use, the null hypothesis -- contradicting both theories -- would be accepted. Gender and age also were included as predictors. Whether or not the effect of individual substance use on the association between peer-reported and perceived peer substance use varied by gender or age was assessed in the main analyses with interaction terms between gender, age, and individual substance use.

Based on significant results from the main analysis, we calculated accuracy and bias of perceptions within levels of the predictors and their interactions. We then used random permutation tests to compare accuracy and bias across levels of the predictors that were found to be significant in the overall models (i.e., substance users vs. non-users and older vs. younger adolescents). These tests allowed us to evaluate the specific differences found in the overall models, and to evaluate the correspondence of the results with the competing theories.

Overall Models—The overall models were multinomial logistic regression models, fit through SAS PROC CATMOD (SAS Institute Inc., 2004) in which the outcome variable was the cross-tabulation of perceived friend substance use and friends' reports of use as depicted in Figure 1. In the figure, each cell represents a different component of perceptual accuracy and bias. For example, cell *d* is the number of participants who correctly predicted that their friends used a substance, or *Hits*, whereas cell *c* contains the number of participants who perceived that their friends used a substance when in fact they did not, or *False Alarms*.

The outcome variables for the categorical models were the log-odds of a case appearing in cells *a* (Correct Rejection), *b* (Miss), or *c* (False Alarm) compared to cell *d* (Hit). For example, if the effect of being female on cell *a* equaled 0, it would mean that females were exactly as likely as males to correctly say that their friends did not use the substance (*Correct Rejection*). If the effect of being female on cell *a* equaled 0.69 (natural log of 2.0), it would mean that females were twice as likely as males to correctly say that their friends did not use the substance (*Correct Rejection*). However, if the effect of being female on cell *c* equaled 0.69, it would mean that females were twice as likely as males to say their friends used substances when in fact their friends did not report doing so (*False Alarm*).

We fit one model for each substance within each sample and interpreted the overall *chi-square* tests for the predictors. For the Teen Survey sample, the predictors were individual substance use and gender. For the Add Health sample, predictors were individual substance use, age (< 15, ≥15), gender, and the interaction between age and individual substance use.

Calculating accuracy and bias—Measures of accuracy and bias provide a means for reducing the complexity of the signal detection analyses described above. We examined accuracy and bias within levels of individual substance use in both samples, and stratified by age in the Add Health sample. We measured the accuracy of perceived friend substance use vis-à-vis ego-network calculations of friend substance use with a nonparametric measure called "A-prime" (A'; Donaldson, 1992). A' takes into account both the Hit Rate (H; perceptions of friend substance use consistent with friends' reports) and the False Alarm Rate (F; perceptions of friend substance use inconsistent with friends' reports). The formula for A' is:

$$A' = 1/2 + \frac{(H-F)(1+H-F)}{4H(1-F)}.$$

Along with accuracy, it is important to estimate the extent of response bias, or more colloquially, how "itchy" one's trigger finger is. In this context, bias is the degree of eagerness or reluctance to identify friends as substance users. Thus, bias is directional. We calculated bias with Donaldson's (1992) nonparametric index, B''_D:

$$B''_D = \frac{(1-H)(1-F)-HF}{(1-H)(1-F)+HF}.$$

This formula was found to produce the optimal nonparametric estimate of response bias in a Monte Carlo study comparing the usefulness of five different measures of response bias in research on vigilance, or the ability to remain alert to signals over a prolonged period (See, Warm, Dember, & Howe, 1997). Negative values of B''_D indicate a liberal bias where people claim a signal is present regardless of its actual presence, and positive values indicate a conservative bias against identifying a signal.

Comparing Accuracy and Bias—We used random permutation tests (Fisher, 1935) to compute the probability of obtaining group differences in accuracy and bias as large as, or larger than, those obtained in this study. A statistic (accuracy or bias) was computed for each group (e.g., male and female), and the difference between groups calculated, providing the observed difference. Next, and 1,000 times over, the data were randomly reordered (permuted) and the group statistics and difference computed, and compared with the observed difference. The number of times these repetitions found a difference as large or larger than that obtained from the sample divided by 1,000 provided the probability of obtaining the observed difference by chance.

Results

Table 1 reports the prevalence of use of each substance in both samples. It should be recalled that the time periods used in the questions about substance use were 6 months for Teen Survey and 30 days for Add Health.

Predictors of correspondence between perceptions and friend reports of substance use

In order to test the effects of gender, age, and individual substance use on the association between perceived peer use and friend reports of use, we fit one categorical model for each substance, as described above. In initial runs of these models, we evaluated the interactions between gender and individual substance use in both samples, and the three-way interactions between age, gender, and substance use in Add Health. None of the interactions with gender were significant. As a result, we included the main effects for gender but not the interactions in the final models.

As can be seen in Table 2, in the Teen Survey models the individual's own substance use was a significant predictor of the odds of a correct rejection vs. a hit (*a* vs. *d*) for all substances, and for the odds of a miss vs. a hit (*b* vs. *d*) for tobacco and alcohol use. We found no significant effects for gender. These results indicate that the association between perceptions of peer substance use and self-reported substance use of peers varied as a function of whether or not the participant used each substance, but not as a function of gender.

In the Add Health models, reported in Table 3, individual substance use significantly predicted all three parameters for tobacco and alcohol use, but not for marijuana use. Non-users of tobacco and alcohol were more likely than users to correctly perceive their friends as not using, to miss substance use in their friends, and, interestingly, to falsely see their friends as using substances.

Gender, in Add Health, predicted correct rejection vs. hit (*a* vs. *d*) for all substances, miss vs. hit (*b* vs. *d*) for alcohol and marijuana, and false alarm vs. hit (*c* vs. *d*) for marijuana. Females were less likely than males to correctly reject tobacco use in their friends, but more likely than males to correctly reject alcohol and marijuana use. Females also were more likely than males to miss alcohol and marijuana use in their friends, and more likely than males to incorrectly perceive that their friends used marijuana (*False Alarm*).

In Add Health, age group also was a significant predictor of correct rejection vs. hit (*a* vs. *d*) and miss vs. hit (*b* vs. *d*) for tobacco and marijuana, and of false alarm vs. hit (*c* vs. *d*) for marijuana use. All of these contrasts were positive, indicating greater likelihood of correct rejections, misses, and false alarms for the younger group. There were significant interactions between age and own substance use for miss vs. hit (*b* vs. *d*) on tobacco ($B = 0.25$, $p < .05$) and alcohol ($B = -0.11$, $p < .05$). It should be noted that analysis of individual marijuana use by age produced an empty cell, making it impossible to obtain an overall test of this interaction effect.

Table 4 reports results related to accuracy and bias by substance, sample, and use vs. non-use. We report the rates and numbers in each cell, as well as calculated accuracy and bias. We also report the results of random permutation tests (Fisher, 1935) used to indicate whether differences in accuracy and bias by substance use, age, and gender were statistically significant. Random permutation tests produce exact probabilities by repeatedly calculating a statistic with different random sortings of the variables. The bottom two rows of Table 4 report the exact probabilities from random permutation tests of accuracy and bias between substance users and non-users.

Accuracy and bias comparisons

By respondent's own use—As can be seen in the bottom two rows of Table 4, for both samples, substance users and non-users did not differ significantly in their accuracy of identifying substance use in their friends. However, in both samples and across substances and age categories, users and non-users differed significantly in their biases. With the

exception of tobacco use in Teen Survey, non-users across samples, ages, and substances had a conservative bias (tending not to see their friends as substance users), whereas users had a liberal bias (tending to see their friends as users). In the case of Teen Survey tobacco use, although non-users' bias was slightly liberal ($B''_D = -0.15$), it still differed significantly from the perfect liberal bias of users ($B''_D = -1.0$; $p < .01$).

By substance—In order to determine whether the observed differences in the biases of users and non-users were consistent across substances, we collapsed all substances into a single multinomial categorical model in which the outcome variables were correct rejections, misses, and false alarms compared to hits; and the predictors were substance (tobacco, marijuana, alcohol), own use (0, 1), and the interaction between own use and substance. A significant interaction term for own use by substance would indicate the possibility that the bias associated with one's own use differed by substance. In the Teen Survey data no significant interaction was detected, $\chi^2(6, N=481)=1.09$, *ns,* indicating that the observed biases associated with substance use or non-use did not differ significantly by substance. Similarly, we found no significant interaction between own use and substance, $\chi^2(6, N=6595)=5.71$, *ns* in the Add Health sample. There also was no significant three-way interaction between substance, own use, and age group in Add Health, $\chi^2(6, N=6595)=4.76$, *ns,* indicating that the bias by own substance use did not differ by age in the Add Health sample. Thus, there was no evidence that the biases differed by substance.

By age—Results of random permutation tests showed that in the Add Health sample there were no significant differences in accuracy between older and younger participants. However, across substances, older and younger participants differed significantly in their biases, with younger participants being more conservative in their estimates of friend substance use than older participants (*Tobacco* $B''_D = .81$ vs. .31; *Alcohol* $B''_D = .80$ vs. .31; *Marijuana* $B''_D = .95$ vs. .49, for young and old participants respectively; $p < .01$ for all comparisons).

By gender—Random permutation tests found no significant gender differences in accuracy in either sample. In the Teen Survey sample, a significant gender difference in bias was found for marijuana, with boys having a more conservative bias than girls (*Female* $B''_D = 0.38$; *Male* $B''_D = 0.64$; $p = .01$). In the Add-Health study, we also found that males had a more conservative bias than females for tobacco (*Female* $B''_D = 0.36$, *Male* $B''_D = 0.49$; $p < .05$) and marijuana (*Female* $B''_D = 0.54$, *Male* $B''_D = 0.66$; $p < .01$).

Discussion

Results from two data sets employing different assessments of perceptions and individual substance use suggest that adolescents' reports of their friends' substance use are biased in the direction of their own use. Substance users consistently exhibit a liberal bias, assuming that their friends also use substances. In parallel fashion, non-substance users consistently assume their friends are non-users, exhibiting a significant conservative bias. Some differences in bias were observed between older and younger adolescents and between females and males, with younger adolescents and males being more conservative than older adolescents and females. Nevertheless, the results point to an overwhelming tendency for adolescents to (mis)perceive peer substance use in a direction consistent with their own use or non-use. These results are consistent with a false consensus effect or normative fallacy, according to which people believe that others behave as they do. The findings do not support the hypothesis of pluralistic ignorance, whereby people overestimate others' engagement in high risk behavior.

When examining peer influences, researchers often ask adolescents to report on their own friends' substance use (Kobus, 2003). As a result of the false consensus effect, such studies are likely to under-estimate rates of peer substance use. That is, because non-users generally outnumber users, and non-users tend to perceive others as not using, a lower than actual estimate of peer use is likely to be observed. Paradoxically, the *effects* of peer substance use on the individual may be over-estimated. This occurs because the tendency to see peers as behaving like oneself will magnify the correlation between peer and individual substance use. This is consistent with other researchers' observations that relying on perceptions of peer substance use may produce inflated estimates of use (Bauman & Ennett, 1996; Bauman & Fisher, 1986; Kandel, 1996; Ross, et al., 1977). With data from two samples, the present study supports this contention, finding that respondents appear to project their own use onto estimates of their friends' use. This tendency appears to be more pronounced among substance users, who in both samples demonstrated nearly perfect liberal biases.

The findings from this study suggest that the optimal approach to studying peer effects on substance use is to use peers' reports of their own behavior. Multiple researchers have recommended and found viable the use of such sociometric methods (Ennett & Bauman, 1993; Henry & Kobus, 2007; Kobus & Henry, 2010). This approach not only provides the most accurate estimates of friends' behaviors, and their association with individual use, but also allows for description of the prevalence and variability in peer substance use. In addition, sociometric methods provide the opportunity to assess other network characteristics that may bear on the relation between peer and individual substance use, such as network density, centrality of the individual in the network, and network position.

If directly assessing respondents' friends is impractical, it may be possible to obtain improved accuracy and less bias by assessing respondents' perceptions of each friend's behavior individually rather than asking a general question about the number or proportion of friends who engage in a target behavior. Henry, Tolan, and Gorman-Smith (2001) used such a method in assessing peer effects on violent and nonviolent delinquency. Future research should evaluate this method against social network analysis and global self-reports.

A second implication of this study is that the results assist in understanding the unintended negative consequences found by some normative feedback intervention studies (Grabosky, 1996). Some studies of binge drinking have found positive effects of a normative feedback intervention for heavy drinkers, but unintended negative effects on light drinkers (Grabosky, 1996; Lintonen & Konu, 2004). In other words, presenting a light drinker with evidence based on the assumption that youth underestimate drinking among their peers may increase their drinking. Because it is likely that non-users will be biased toward underestimating their friends' substance use rather than overestimating it, normative feedback prevention efforts might do better to direct feedback only to those already displaying higher levels of substance use. Thus, such interventions should be regarded as selective or targeted, rather than universal, interventions.

One strength of this study is the use of two samples, both of which included peer nominations of friendships, assessment of individual substance use, and perceptions of peer substance use. One study allowed nomination of 5 male and 5 female friends whereas the other allowed for six friends at their school. Both studies asked that friends be nominated in order of preference. One study queried individual substance use for the preceding 30 days, whereas the other queried use over the preceding six months. One study assessed perceptions of peer substance use for three best friends and the other for friends overall. One study examined a predominantly rural and suburban population, the other 100% urban. The fact that these studies used different measures and obtained similar results suggests that

these results are not an artifact of a particular method, measure, sample, population, or demand characteristic of a single study (Orne, 1962).

These results must be evaluated in light of four limitations. The first is that we cannot determine with absolute certainty, in either the Teen Survey or the Add Health samples, that the friends on whom youth were asked to report their perceptions of substance use behaviors were the same friends nominated in the social network assessments. Kandel (1996) suggested that an optimal study would have measures of the adolescent's behavior, the friend(s)' self-reported behaviors, and the adolescent's perception of the same friend's behaviors. The Bauman and Fisher (1986) study is the only extant study to have assessed perceptions and friend reports of use in the same groups of friends. They found results consistent with the biases found in this study, namely that subjects' reports of friends' behaviors were a stronger correlate of adolescent behavior than were the friends' reports of their own behavior. The effect of the inexact matching between nominated friends and perceived friend substance use in this study would have been to increase random error or noise in the data, which would have decreased the likelihood of significant differences by substance use or non-use. This would have been true whether the friends who were not assessed were all substance users, all non-users, or a mix of users and non-users.

A second limitation is that Teen Survey and Add Health used different time frames when asking about individual substance use. Teen Survey used "past six months," but Add Health used "past 30 days." Despite this difference, we obtained substantially similar results across samples, suggesting, perhaps, that youth who reported substance use in the past 6 months would also have reported use in the past 30 days, and vice-versa.

Third, using dichotomous variables for perceived peer and individual substance use involves loss of information. We had no option but to dichotomize for two reasons. First, neither data set provided individual information on perceptions of peer use. Thus, we were not able to compare actual and perceived use on individually named friends. Second, calculation of accuracy and bias through signal detection theory requires binary variables. The loss of information through dichotomization restricted our ability to detect effects, but did not increase the likelihood of spurious findings. Additionally, the cost of potential loss of information is offset by the ability to use signal detection analyses, which requires binary data

A fourth limitation is the use of non-reciprocated friendship nominations and ego networks instead of reciprocated nominations. In both data sets, we had the option to use reciprocated nominations, but chose to use non-reciprocated nominations (ego-networks) in order to maximize the available sample size for analysis. In the Add Health data set, using only reciprocated nominations would have resulted in the loss of friendship data on participants whose friends were absent or did not participate in the peer nomination procedure. This was less of an issue in Teen Survey, which had nearly complete participation. Our decision to use unilateral nominations of friendship is supported by findings that such relationships represent hoped-for friendships that may be more influential on substance use than reciprocated friendships (Aloise-Young, Graham, & Hansen, 1994).

Despite these limitations, our study is the first to assess accuracy and bias in the most commonly used measure of peer substance use, that is, "how many of your friends use," and to compare this measure with the self-reported substance use of nominated friends. Because of the critical importance of peers in adolescence, further study of the processes involved in peer relationships and substance use is needed. This study speaks to the need to better understand two aspects of peer effects on adolescent substance use. The first is the role of actual friend substance use on individual use, which is supported by findings from multiple

social network studies (Kobus & Henry, 2010; Pearson & Michell, 2000). The second is the role of perceptions, which have been implicated in findings of unintended negative consequences in social norms interventions (Grabosky, 1996). Differentiating the effects of actual peer use from those of perceptions of peer use, and more generally examining the dynamics of adolescent peer relationships in substance use may help locate potentially critical points of leverage for interventions.

Acknowledgments

This research uses data from Add Health, a program project directed by Kathleen Mullan Harris and designed by J. Richard Udry, Peter S. Bearman, and Kathleen Mullan Harris at the University of North Carolina at Chapel Hill, and funded by grant P01-HD31921 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development, with cooperative funding from 23 other federal agencies and foundations. Special acknowledgment is due Ronald R. Rindfuss and Barbara Entwisle for assistance in the original design. Information on how to obtain the Add Health data files is available on the Add Health website (http://www.cpc.unc.edu/addhealth). No direct support was received from grant P01-HD31921 for this analysis.

The Teen Survey data were collected as part of the second author's dissertation. The authors would like to thank the Chicago Tribune and the Chicago Bulls for their financial support of this project. We gratefully acknowledge the assistance of Olga Reyes, Karen Gillock, Michael Heinstein, George Greene, Bernadette Sanchez, and the teachers and principal at the participating school, as well as the anonymous reviewers whose comments contributed to this article.

This analysis was supported, in part by grant RO1-HD520444 to David B. Henry.

References

Adamczyk A, Felson J. Friends' religiosity and first sex. Social Science Research. 2006; 35(4):924–947.

Aloise-Young PA, Graham JW, Hansen WB. Peer influence on smoking initiation during early adolescence: A comparison of group members and group outsiders. Journal of Applied Psychology. 1994; 79:281–287. [PubMed: 8206817]

Bauman KE, Ennett ST. On the importance of peer influence for adolescent drug use: Commonly neglected considerations. Addiction. 1996; 91:185–198. 0965-2140/96/020185-14. [PubMed: 8835276]

Bauman KE, Fisher LA. On the measurement of friend behavior in research on friend influence and selection: Findings from longitudinal studies of adolescent smoking and drinking. Journal of Youth and Adolescence. 1986; 15:345–353.

Bearman PS, Jones J, Udry JR. The National Longitudinal Study of Adolescent Health: Research Design [WWW document]. 1997

Bourgeois MJ, Bowen A. Self-organization of alcohol-related attitudes and beliefs in a campus housing complex: An initial investigation. Health Psychology. 2001; 20(6):434–437. [PubMed: 11714185]

Chicago Panel on School Policy and Finance. Chicago Public School data book school year 1994–1995. Chicago, IL: Author; 1996.

Cohen LL, Shotland RL. Timing of first sexual intercourse in a relationship: Expectations, experiences, and perceptions of others. Journal of Sex Research. 1996; 33:291–299.

Cunningham JA, Selby PL. Implications of the normative fallacy in young adult smokers aged 19–24 years. American Journal of Public Health. 2007; 97(8):1399–1400. [PubMed: 17600252]

D'Amico E, McCarthy DM. Escalation and initiation of younger adolescents' substance use: The impact of perceived peer use. Journal of Adolescent Health. 2006; 39:481–487. [PubMed: 16982381]

D'Amico EJ, Metrik J, McCarthy DM, Frissell KC, Applebaum M, Brown SA. Progression into and out of binge drinking among high school students. Psychology of Addictive Behaviors Special Issue: Understanding binge drinking. 2001; 15(4):341–349.

Donaldson W. Measuring recognition memory. J Exp Psychol Gen. 1992; 121(3):275–277. [PubMed: 1402701]

Ellickson PL, Bird CE, Orlando M, Klein DJ, McCaffrey DF. Social context and adolescent health behavior: Does school-level smoking prevalence affect students' subsequent smoking behavior? Journal of Health and Social Behavior. 2003; 44(4):525–535. [PubMed: 15038147]

Ennett ST, Bauman KE. Peer group structure and adolescent cigarette smoking: A social network analysis. Journal of Health and Social Behavior. 1993; 34:226–236. [PubMed: 7989667]

Ennett ST, Bauman KE, Hussong A, Faris R, Foshee VA, Cai L, et al. The peer context of adolescent substance use: Findings from social network analysis. Journal of Research on Adolescence. 2006; 16(2):159–186.

Fang X, Li X, Stanton B, Dong Q. Social network positions and smoking experimentation among Chinese adolescents. American Journal of Health Behavior. 2003; 27:257–267. [PubMed: 12751622]

Fisher LA, Bauman KE. Influence and selection In the friend-adolescent relationship: Findings from studies of adolescent smoking and drinking. Journal of Applied Social Psychology. 1988; 18(4): 289–314.

Fisher, RA. The Design of Experiments. 3. London: Oliver & Boyd; 1935.

Gillmore MR, Wells EA, Simpson EE, Morrison DM, Hoppe MJ, Wilsdon AA, et al. Children's beliefs about smoking. Nicotine and Tobacco Research. 2002; 4:177–183. [PubMed: 12028850]

Grabosky, PN. Unintended consequences of crime prevention. In: Homel, C., editor. Crime Prevention Studies. Vol. 5. New York: Criminal Justice Press; 1996.

Griesler PC, Kandel DB, Schaffran C, Hu MC, Davies M. Adolescents' inconsistency in self-reported smoking: A comparison of reports in school and in household settings. Public Opinion Quarterly Special Issue: Cell phone numbers and telephone surveying in the US. 2008; 72(2):260–290.

Guo G, Elder GH, Cai T, Hamilton N. Gene–environment interactions: Peers' alcohol use moderates genetic contribution to adolescent drinking behavior. Social Science Research. 2009; 39(1):213–224.

Henry D, Kobus K. Early adolescent social networks and substance use. Journal of Early Adolescence. 2007; 27:346–362.

Henry D, Schoeny M, Deptula D, Slavick J. Peer selection and socialization effects on adolescent intercourse without a condom and attitudes about the costs of sex. Child Development. 2007; 78:825–838. [PubMed: 17517007]

Henry D, Tolan PH, Gorman-Smith D. Longitudinal family and peer group effects on violence and non-violent delinquency. Journal of Clinical Child Psychology. 2001; 30:172–186. [PubMed: 11393918]

Holmes DS. Dimensions of Projection. Psychological Bulletin. 1968; 69(4):248–268. [PubMed: 4873052]

Ianotti RJ, Bush PJ. Perceived vs. actual friends' use of alcohol, cigarettes, marijuana, and cocaine: Which has the most influence? Journal of Youth and Adolescence. 1992; 21(3):375–389.

Kandel DB. The parental and peer contexts of adolescent deviance: an algebra of interpersonal influence. Journal of Drug Issues. 1996; 26:289–315.

Katz, D.; Allport, F. Students' Attitudes: A Report of the Syracuse University Reaction Study. Syracuse, NY: Craftsman Press; 1931.

Keefe K. Perceptions of normative social pressure and attitudes toward alcohol use: Changes during adolescence. Journal of Studies on Alcohol. 1994; 55(1):46–54. [PubMed: 8189725]

Kobus, K. Doctoral Dissertation. University of Illinois; Chicago: 1998. Social Networks and the Academic Achievement and Psychological Well-being of Adolescents.

Kobus K. Peers and adolescent smoking. Addiction. 2003; 98(Suppl 1):37–55. [PubMed: 12752361]

Kobus K, Henry D. Interplay of Network Position and Peer Substance Use in Early Adolescent Cigarette, Alcohol, and Marijuana Use. Journal of Early Adolescence. 2010; 30(2):225–245.10.1177/0272431609333300

Kumar R, O'Malley PM, Johnston LD, Schulenberg JE, Bachman JG. Effects of school-level norms on student substance use. Prevention Science. 2002; 3(2):105–124. [PubMed: 12088136]

Lai MK, Ho SY, Lam TH. Perceived peer smoking prevalence and its association with smoking behaviours and intentions in Hong Kong Chinese adolescents. Addiction. 2004; 99:1195–1205. [PubMed: 15317641]

Lintonen TP, Konu AI. The misperceived social norm of drunkenness among early adolescents in Finland. Health Education Research. 2004; 19:64–70. [PubMed: 15020546]

Mäkelä K. Drinking, the majority fallacy, cognitive dissonance and social pressure. Addiction. 1997; 92(6):729–736. [PubMed: 9246800]

Mouw T, Entwisle B. Residential segregation and interracial friendship in schools. American Journal of Sociology. 2006; 112(2):394–441.

Murstein BI, Pryer RS. The concept of projection: A review. Psychological Bulletin. 1959; 56(5):353–374.

Norton EC, Lindrooth RC, Ennett ST. How measures of perception from survey data lead to inconsistent regression results: evidence from adolescent and peer substance use. Health Economics. 2003; 12:139–148.10.1002/hec.705 [PubMed: 12563661]

Orne MT. On the social psychology of the psychological experiment: With particular reference to demand characteristics and their implications. American Psychologist. 1962; 17(11):776–783.

Pearson M, Michell L. Smoke rings: Social network analysis of friendship groups, smoking and drug taking. Drugs: Education, Prevention & Policy. 2000; 7:21–36.

Poulin F, Pedersen S. Developmental changes in gender composition of friendship networks in adolescent girls and boys. Developmental Psychology. 2007; 43(6):1484–1496. [PubMed: 18020826]

Prentice DA, Miller DT. Pluralistic ignorance and alcohol use on campus: Some consequences of misperceiving the social norm. Journal of Personality and Social Psychology. 1993; 64(2):243–256. [PubMed: 8433272]

Prinstein MJ, Wang SS. False consensus and adolescent peer contagion: Examining discrepancies between perceptions and actual reported levels of friends' deviant and health risk behaviors. Journal of Abnormal Child Psychology. 2005; 33(3):293–306. [PubMed: 15957558]

Ross L, Greene D, House P. The false consensus effect: An egocentric bias in social perception and attribution processes. Journal of Experimental Social Psychology. 1977; 13:279–301.

SAS Institute Inc. SAS OnlineDoc® 9.1.3. Cary, NC: SAS Institute Inc; 2004.

See JE, Warm JS, Dember WN, Howe SR. Vigilance and signal detection theory: An empirical evaluation of five measures of response bias. Human Factors. 1997; 39(1):14–29.

Segrist DJ, Corcoran KJ, Jordan-Fleming MK, Rose P. Yeah, I Drink …but not as much as other guys: The majority fallacy among male adolescents. North American Journal of Psychology. 2007; 9(2): 307–320.

Wang H, Kao G, Joyner K. Stability of interracial and intraracial romantic relationships among adolescents. Social Science Research. 2006; 35(2):435–453.

Wasserman, SS.; Faust, K. Social Network Analysis: Methods and Applications. New York, NY: Cambridge University Press; 1994.

Wen M, Van Duker H, Olson LM. Social contexts of regular smoking in adolescence: Towards a multidimensional ecological model. Journal of Adolescence. 2009; 32(3):671–692. [PubMed: 18691748]

		Actual Peer Substance Use	
		No	Yes
Perceived Peer Substance Use	No	a (Correct Rejection)	b (Miss)
	Yes	c (False Alarm)	d (Hit)
		a+c	b+d

Figure 1.
Accuracy and bias in estimating peer substance use as a 2 × 2 n.

Table 1

Demographic Characteristics and Reported Substance Use by Sample

	Teen Survey (Age 11–15)	Add Health	
		Younger (Age 12–14)	Older (Age 15–20)
N	163	397	1797
Gender:			
Female	79 (48.5%)	231 (58.2%)	917 (51.0%)
Ethnicity [a]:			
White	107 (65.6%)	312 (78.6%)	1066 (59.3%)
Latino	27 (16.6%)	22 (5.5%)	353 (19.6%)
African-American	7 (4.3%)	73 (18.4%)	207 (11.5%)
Asian	5 (3.0%)	5 (1.3%)	356 (19.8%)
Other	17 (10.4%)	6 (1.5%)	58 (3.2%)
Substance Use (% of participants that report use)			
Tobacco	43 (26.4%)	53 (15.9%)	514 (28.6%)
Alcohol	42 (25.8%)	106 (26.8%)	954 (53.1%)
Marijuana	14 (8.6%)	7 (1.8%)	289 (16.2%)

Notes: Time frames for reports of substance use varied by study. Teen Survey participants were asked about the past six months, and Add-Heallth participants were asked about the number of days in the past 30 they used the substance in question.

[a]Ethnicity frequencies sum to more than the total and percentages sum to more than 100% because respondents in Add-Health were permitted to select multiple categories to describe ethnicity.

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Table 2

Categorical Models of the Accuracy and Bias in Estimates of Peer Substance Use: Teen Survey Data, N = 161

		Tobacco Use			Alcohol Use			Marijuana Use		
Effect	**Contrast**	**Estimate**	**SE**	**χ^2**	**Estimate**	**SE**	**χ^2**	**Estimate**	**SE**	**χ^2**
Intercept	a vs. d	−1.94	0.38	25.60**	−1.49	0.38	15.12**	−0.05	0.42	0.01
	b vs. d	−1.94	0.38	25.64**	−0.98	0.29	11.65**	−0.78	0.44	3.11
	c vs. d	−1.81	0.29	39.73**	−1.69	0.30	30.94**	0.00	0.32	0.00
Use (No)	a vs. d	0.96	0.38	6.17*	1.40	0.38	13.31**	1.35	0.42	10.50**
	b vs. d	0.98	0.38	6.52*	1.22	0.29	17.87**	0.70	0.43	2.65
	c vs. d	0.16	0.29	0.32	0.11	0.30	0.13	0.39	0.31	1.53
Gender (female)	a vs. d	−0.23	0.24	0.95	0.05	0.23	0.04	0.11	0.23	0.23
	b vs. d	−0.07	0.23	0.08	−0.01	0.21	0.00	−0.43	0.31	1.93
	c vs. d	−0.28	0.27	1.06	0.05	0.30	0.03	0.45	0.26	2.99

Note:

*$p < .05$.

**$p < .01$.

Contrasts: a vs. d = Correct rejection vs. hit; b vs. d = miss vs. hit; c vs d = false alarm vs. hit

Table 3

Categorical Models of the Accuracy and Bias in Estimates of Peer Substance Use: Add-Health Data, N = 2194

		Tobacco Use			Alcohol Use			Marijuana Use		
Effect	**Contrast**	**Estimate**	**SE**	**χ^2**	**Estimate**	**SE**	**χ^2**	**Estimate**	**SE**	**χ^2**
Intercept	a vs. d	−0.65	0.13	23.21**	−1.48	0.13	125.57**	0.24	0.18	1.80
	b vs. d	−0.49	0.12	17.64**	−0.03	0.08	0.18	−0.43	0.18	5.78*
	c vs. d	−1.21	0.13	85.30**	−2.08	0.15	190.79**	−0.33	0.17	3.79
Use (No)	a vs. d	1.77	0.13	174.41**	1.53	0.13	135.45**	0.00	0.06	0.00
	b vs. d	1.18	0.12	102.20**	0.96	0.08	158.48**	0.04	0.07	0.42
	c vs. d	0.56	0.13	18.08**	0.30	0.15	3.94*	0.08	0.08	1.02
Gender (female)	a vs. d	−0.12	0.06	3.96*	0.77	0.13	34.49**	1.70	0.13	165.08**
	b vs. d	−0.02	0.06	0.13	0.47	0.08	38.06**	1.34	0.12	121.58**
	c vs. d	−0.02	0.08	0.05	0.24	0.15	2.49	0.26	0.09	8.73**
Age (12–14)	a vs. d	0.58	0.13	18.83**	−0.09	0.13	0.47	1.07	0.13	65.26**
	b vs. d	0.25	0.12	4.61*	0.06	0.08	0.58	0.49	0.14	11.34**
	c vs. d	0.20	0.13	2.29	−0.01	0.15	0.01	0.53	0.16	10.42**
Use by age	a vs. d	0.14	0.13	1.17	−0.07	0.08	0.72	-[a]	-[a]	-[a]
	b vs. d	0.25	0.12	4.46*	−0.11	0.05	4.04*	-[a]	-[a]	-[a]
	c vs. d	0.22	0.13	2.88	0.01	0.10	0.01	-[a]	-[a]	-[a]

Note:

*$p < .05$.

**$p < .01$.

Contrasts: a vs. d = Correct rejection vs. hit; b vs. d = miss vs. hit; c vs d = false alarm vs. hit

[a]Effect not estimable due to sparse data.

Table 4

Accuracy and Bias of Adolescent Estimates of Friends' Substance Use, by Substance, Sample and Substance Use vs. Non-use

	Non-Users – rate (*n*)								
Rates	**Teen Survey (Age 11–15)**			**Add-Health (Age 12–14)**			**Add-Health (Age 15–20)**		
	Tobacco	**Alcohol**	**Marijuana**	**Tobacco**	**Alcohol**	**Marijuana**	**Tobacco**	**Alcohol**	**Marijuana**
Hit rate	0.72 (60)	0.44 (34)	0.49 (20)	0.23 (29)	0.19 (38)	0.17 (12)	0.45 (317)	0.40 (268)	0.40 (278)
Miss rate	0.28 (23)	0.56 (43)	0.51 (21)	0.77 (95)	0.81 (164)	0.83 (59)	0.55 (384)	0.60 (400	0.60 (417)
False Alarm Rate	0.34 (12)	0.18 (7)	0.30 (31)	0.11 (23)	0.09 (8)	0.07 (23)	0.19 (108)	0.20 (36)	0.19 (150)
Correct Rejection Rate	0.66 (23)	0.82 (31)	0.70 (73)	0.89 (187)	0.91 (80)	0.93 (295)	0.81 (474)	0.80 (143)	0.81 (655)
Accuracy (A′)	0.78	0.72	0.66	0.67	0.66	0.67	0.73	0.69	0.70
Bias B″D	−0.15	0.70	0.42	0.93	0.95	0.97	0.68	0.71	0.74
	Substance Users – rate (*n*)								
Hit rate	1.00 (38)	0.92 (36)	1.00 (8)	0.84 (42)	0.63 (59)	1.00 (5)	0.84 (362)	0.80 (723)	0.90 (190)
Miss rate	0.00 (0)	0.08 (3)	0.00 (0)	0.16 (8)	0.37 (34)	0.00 (0)	0.16 (68)	0.20 (179)	0.10 (21)
False Alarm Rate	1.00 (5)	0.86 (6)	1.00 (6)	0.54 (7)	0.50 (7)	1.00 (2)	0.75 (63)	0.78 (52)	0.79 (64)
Correct Rejection Rate	0.00 (0)	0.14 (1)	0.00 (0)	0.46 (6)	0.50 (7)	0.00 (0)	0.25 (21)	0.22 (15)	0.21 (17)
Accuracy (A′)	0.50	0.63	0.50	0.75	0.62	0.50	0.62	0.54	0.66
Bias B″D	−1.00	−0.97	−1.00	−0.72	−0.27	−1.00	−0.88	−0.87	−0.94
	Probabilities from Random Permutation Tests between Users and Non-users								
Accuracy	.620	.711	.216	.665	.857	.554	.110	.061	.631
Bias	.006	.000	.023	.000	.000	.001	.000	.000	.000

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