

Supplementary Online Content

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This supplementary material has been provided by the authors to give readers additional information about their work.

eAppendix

Detailed Methods

Methods supplemental information:

Substance abuse measures

Adolescent history of alcohol abuse was assessed in Waves I and II by asking “Over the past 12 months, on how many days have you gotten drunk or “very, very high” on alcohol. A question on binge drinking asked “Over the past 12 months, on how many days did you drink five or more drinks in a row?” Tobacco use was measured by asking “During the past 30 days, on how many days did you smoke cigarettes?” Adolescent use of marijuana was assessed in Waves I and II by asking “During the past 30 days, how many times have you used marijuana?”

Parenting measures

Those without resident biological mothers responded to the questions regarding the woman performing the role of mother to them. Because questions regarding the father were less extensive than those regarding the mother, and at least 1/3 of the adolescents in the survey did not have a father in the home, our analysis is limited to responses regarding the adolescent’s mother.

Parenting measures control

1.) “Do your parents let you make your own decisions about the time you must be home on weekend nights?” 2.) “Do your parents let you make your own decisions about the people you hang around with?” 3.) “Do your parents let you make your own decisions about what you wear?” 4.) “Do your parents let you make your own decisions about how much television you watch?” 5.) “Do your parents let you make your own decisions about which television programs you watch?” 6.) “Do your parents let you make your own decisions about what time you go to bed on week nights?” 7.) “Do your parents let you make your own decisions about what you eat?”

Parenting measures warmth

These were answered using a 5-point scale ranging from “strongly agree” (1) to “strongly disagree” (5): 1.) “Most of the time, your mother is warm and loving toward you.” 2.) “Your mother encourages you to be independent.” 3.) “When you do something wrong that is important, your mother talks about it with you and helps you understand why it is wrong.” 4.) “You are satisfied with the way your mother and you communicate with each other.” 5.) “Overall, you are satisfied with your relationship with your mother.”

Model Specification

We specified longitudinal regression models with a basic form wherein the ego’s status (e.g., smoking or not) at wave $t+1$, (Wave II) denoted y_{t+1}^{ego} (with distribution Y_{t+1}^{ego}), was a function of various time-invariant attributes of egos, such as gender and education (captured by the k variables denoted by x on the right), their status at wave t (Wave I), denoted (y_t^{ego}), and, most pertinently, the status of their alters at waves t (y_t^{alter}) and $t+1$ (y_{t+1}^{alter}).¹ This model is similar to those described by Valente¹.

We use generalized estimating equations to account for multiple observations of the same ego across waves and across ego-alter pairings². And we only include observations in which ego and alter had a relationship at both wave t and wave $t+1$ on the grounds that people who are disconnected from each other should not influence each other that much, if at all³.

Our basic model is thus:

$$g\left(E\left[Y_{t+1}^{ego}\right]\right) = \alpha + \beta_1 y_t^{ego} + \beta_2 y_{t+1}^{alter} + \beta_3 y_t^{alter} + \sum_{i=1}^k \gamma_i x_i \quad (1)$$

where $g()$ is a link function determined by the form of the dependent variable. For dichotomous data, $g(a) = \log(a / (1 - a))$.

Since we are using GEE, we also estimate the covariance structure of correlated observations for each ego. The covariance matrix of Y^{ego} is modeled by $V_{ego} = \phi A_{ego}^{1/2} R A_{ego}^{1/2}$ where ϕ is a scaling constant, A is a diagonal matrix of scaling functions, and R is the working correlation matrix. We assume an independence working correlation structure for the clustered errors, which has been shown to yield asymptotically unbiased and consistent, although possibly inefficient, parameter estimates (the β and γ terms) even when the correlation structure is misspecified.⁴

To be clear, our basic model, based on an error correction model, assumes that there is no correlation of ego's substance use at $t+1$ with alter's substance use at $t+1$ except via influence, and no other effects on ego's substance use at $t+1$ except via the effect of ego's past substance use at wave t and the effect of the measured covariates (including ego's parents parenting style), i.e., conditional on no unobserved confounding⁵. These are common assumptions in regression models of observational data, of course. However, a special consideration here is that this assumption implies that there is no unobserved homophily beyond that on the observable variables.

The time-lagged dependent variable (lagged to the prior exam) helps control for ego's genetic endowment or any intrinsic, stable predilection to evince a particular trait. The lagged ego parenting variable helps control for homophily due to parenting styles, in other words the possibility that ego and alter were friends because of a similarity in their home environments. The lagged independent variable for an alter's trait (such as alter's parents parenting or alter's substance use) helps account for homophily (especially with respect to the observed trait that is the object of inquiry) because it makes ego's current state unconditional on the state the alter was in when the ego and alter formed a connection¹. Conditioning on the lagged alter's trait, however, would not comprehensively deal with homophily on *unobserved* traits that are both time-varying and also associated with the outcome of interest. This term also does not address the issue of a shared context (confounding), but we deal with that by including a fixed effect for each adolescent's school. We have used this methodology to examine social influence in a variety of contexts⁶⁻¹⁰. For a review of this literature, see Fowler and Christakis (in press).¹¹

Mediation model

A variable M mediates the relationship between an independent variable X and a dependent variable Y if (1) X significantly predicts Y , (2) X significantly predicts M , and (3) M significantly predicts Y controlling for X ¹². While significant results for these tests do not prove there is a causal pathway (since the tests are based on observational data), they do allow us to reject the hypothesis of a causal relationship if the associations are not all significant. A formal test of mediation, called the Sobel test, determines whether the indirect effect is significantly different from zero^{12,13}. The result of that Sobel test is a z score that can be compared to a critical value determined from a standard normal distribution. Like a z score, Sobel scores with a value greater than 1.96 are considered significant. Furthermore, mediation can be assessed by evaluating the degree to which the coefficient of the main effect of X on Y decreases in the presence of the mediator M (proposition 3 above). In complete mediation, the coefficient for X on Y should reduce to almost zero, meaning that the mediation path can explain the entire effect of X on Y . Partial mediation occurs when the coefficient of X on Y decreases in the presence of M , but not completely.

References

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**eTable 1: Multivariate association between friend's mother's parenting style and adolescent risk behavior *
(clustering standard errors on friends id instead of respondent's id)**

	Binge drinking in last year ^a N=2056			Smoked in last month ^b N=2033			Was drunk in last year ^c N=2061			Used marijuana in last month ^d N=2003		
	Beta	Std. err	P value	Beta	Std. err	P value	Beta	Std. err	P value	Beta	Std. err	P value
(Intercept)	-0.68	1.34	0.61	-3.59	1.39	0.01	-1.14	1.45	0.43	-1.50	1.91	0.43
Friend mother permissive Wave II	-0.20	0.17	0.22	-0.16	0.16	0.34	-0.23	0.17	0.16	-0.14	0.22	0.53
Friend mother authoritarian Wave II	-0.42	0.20	0.03	-0.19	0.18	0.29	-0.20	0.20	0.31	0.11	0.23	0.64
Friend mother authoritative Wave II	-0.48	0.23	0.03	-0.55	0.21	0.01	-0.52	0.21	0.01	-0.56	0.30	0.06
Friend mother permissive Wave I	0.23	0.19	0.22	0.18	0.19	0.35	0.24	0.19	0.19	0.01	0.24	0.96
Friend mother authoritarian Wave I	-0.08	0.19	0.67	0.15	0.18	0.42	-0.08	0.19	0.68	-0.05	0.23	0.81
Friend mother authoritative Wave I	0.03	0.21	0.88	0.41	0.20	0.04	-0.08	0.20	0.69	0.05	0.26	0.84
Own mother permissive Wave II	-0.35	0.17	0.04	-0.79	0.17	0.00	-0.34	0.17	0.05	-0.60	0.23	0.01
Own mother authoritarian Wave II	-0.33	0.19	0.07	0.06	0.19	0.73	-0.60	0.19	0.00	-0.14	0.24	0.56
Own mother authoritative Wave II	-0.55	0.24	0.02	-0.61	0.22	0.00	-0.85	0.25	0.00	-0.15	0.29	0.59
Own mother permissive Wave I	-0.12	0.18	0.52	-0.16	0.19	0.39	-0.13	0.18	0.48	0.40	0.25	0.11
Own mother authoritarian Wave I	-0.49	0.18	0.01	-0.07	0.18	0.71	-0.18	0.18	0.33	0.66	0.25	0.01
Own mother authoritative Wave I	-0.51	0.21	0.01	0.31	0.19	0.11	-0.56	0.20	0.01	0.28	0.29	0.34
Friend use Wave 1	0.54	0.14	0.00	0.49	0.14	0.00	0.61	0.14	0.00	1.07	0.20	0.00
Own use Wave 1	2.06	0.14	< 2e-16	2.44	0.15	< 2e-16	2.08	0.14	< 2e-16	2.41	0.20	< 2e-16

*reference is neglectful

^aConsumed 5 or more drinks in a row at one time within last year

^bSmoked cigarettes at least once in last month

^cBeen drunk or high on alcohol at least once in last year.

^dSmoked or used marijuana at least once in last month

All models run controlling for *controlling for respondent age, gender, race, mother's education, mother's income plus school level fixed effects.* “

eTable 2: Mediation analysis testing whether the effect on adolescent alcohol abuse of the friend's parent's parenting style* is mediated through friend alcohol abuse

	Main effect: Friend's mother-> Own alcohol use			Main to mediator: Friend's mother->friend alcohol			Mediator to Outcome: Controlling for main predictor		
	Beta	Std.err	P value	Beta	Std.err	P value	Beta	Std.err	P value
Intercept	-1.14	1.79	0.52	-2.53	1.45	0.08	-1.19	1.80	0.51
Friend mother permissive Wave II	-0.23	0.16	0.16	-0.32	0.16	0.04	-0.22	0.16	0.19
Friend mother authoritarian Wave II	-0.20	0.20	0.30	-0.55	0.18	0.00	-0.17	0.20	0.38
Friend mother authoritative Wave II	-0.52	0.20	0.01	-0.88	0.22	0.00	-0.48	0.20	0.02
Friend mother permissive Wave I	0.24	0.19	0.19	-0.28	0.18	0.12	0.25	0.19	0.17
Friend mother authoritarian Wave I	-0.08	0.20	0.70	-0.20	0.17	0.24	-0.07	0.20	0.73
Friend mother authoritative Wave I	-0.08	0.20	0.69	-0.33	0.19	0.08	-0.07	0.21	0.74
Own mother permissive Wave II	-0.34	0.23	0.14	0.14	0.17	0.41	-0.35	0.23	0.13
Own mother authoritarian Wave II	-0.60	0.26	0.02	-0.35	0.20	0.07	-0.58	0.26	0.03
Own mother authoritative Wave II	-0.85	0.32	0.01	-0.33	0.21	0.12	-0.84	0.32	0.01
Own mother permissive Wave I	-0.13	0.25	0.61	-0.04	0.18	0.83	-0.13	0.25	0.61
Own mother authoritarian Wave I	-0.18	0.25	0.49	-0.14	0.19	0.44	-0.17	0.25	0.50
Own mother authoritative Wave I	-0.56	0.28	0.04	-0.02	0.19	0.90	-0.55	0.28	0.05
Friend alcohol use Wave II							0.28	0.14	0.04
Friend alcohol use Wave I	0.61	0.14	0.00	2.00	0.13	0.00	0.50	0.15	0.00
Own alcohol use Wave I	2.08	0.19	0.00	0.34	0.14	0.02	2.07	0.19	0.00
Sobel test for mediation -1.80									
Deviance	285.26			305.61			283.80		
Null Deviance	427.82			449.72			427.82		
N=2061 *Consumed 5 or more drinks in a row at one time within last year * reference is neglectful First three columns show logistic regression model of adolescent's past year alcohol abuse (the outcome variable) on friend's mother's parenting style(the explanatory variable). Second three columns show logistic regression model of friend's past year alcohol abuse (the mediator variable) on friend's mother's parenting style (the explanatory variable). Last three columns show logistic regression model of adolescent's past year alcohol abuse (the outcome variable) on friend's past year alcohol abuse (the mediator variable) controlling for friend's mother's parenting style (the explanatory variable). Models were estimated using a general estimating equation with clustering on the adolescent and an independent working covariance structure All models run controlling for controlling for respondent age, gender, race, mother's education, mother's income plus school level fixed effects.									

Table 3: Mediation analysis testing whether the effect on adolescent smoking of the friend's parent's parenting style* is mediated through friend smoking

	Main effect: Friend's mother-> adolescent smoking			Main to mediator: Friend's mother->friend smoking			Mediator to Outcome: Controlling for main predictor		
	Beta	Std.err	P value	Beta	Std.err	P value	Beta	Std.err	P value
(Intercept)	-3.59	1.68	0.03	-2.95	1.28	0.02	-3.63	1.72	0.03
Friend mother permissive Wave II	-0.16	0.15	0.31	-0.33	0.16	0.04	-0.14	0.16	0.37
Friend mother authoritarian Wave II	-0.19	0.18	0.29	0.27	0.19	0.16	-0.23	0.18	0.20
Friend mother authoritative Wave II	-0.55	0.20	0.01	-0.23	0.21	0.26	-0.54	0.21	0.01
Friend mother permissive Wave I	0.18	0.19	0.34	0.06	0.18	0.73	0.19	0.19	0.32
Friend mother authoritarian Wave I	0.15	0.19	0.45	-0.31	0.20	0.11	0.19	0.19	0.32
Friend mother authoritative Wave I	0.41	0.19	0.03	0.37	0.20	0.06	0.37	0.19	0.06
Own mother permissive Wave II	-0.79	0.23	0.00	-0.16	0.18	0.36	-0.79	0.23	0.00
Own mother authoritarian Wave II	0.06	0.25	0.80	-0.01	0.20	0.97	0.06	0.26	0.81
Own mother authoritative Wave II	-0.61	0.29	0.04	-0.38	0.20	0.07	-0.57	0.29	0.05
Own mother permissive Wave I	-0.16	0.27	0.55	0.01	0.20	0.98	-0.17	0.27	0.53
Own mother authoritarian Wave I	-0.07	0.25	0.78	0.09	0.19	0.66	-0.09	0.25	0.72
Own mother authoritative Wave I	0.31	0.28	0.26	0.38	0.20	0.06	0.26	0.27	0.34
Friend smoking Wave II							0.73	0.15	0.00
Friend smoking Wave I	0.49	0.16	0.00	2.69	0.16	0.00	0.10	0.17	0.57
Own smoking Wave I	2.44	0.20	0.00	0.41	0.17	0.01	2.43	0.20	0.00
Sobel test for mediation: Non significant									
Deviance	307.82			302.29			301.06		
Null Deviance	449.19			463.83			449.19		
N=2033 ^a Smoked cigarettes at least once in last month *reference is neglectful First three columns show logistic regression model of adolescent's past month smoking (the outcome variable) on friend's mother's parenting style (the explanatory variable). Second three columns show logistic regression model of friend's month smoking (the mediator variable) on friend's mother's parenting style (the explanatory variable). Last three columns show logistic regression model of adolescent's past month smoking (the outcome variable) on friend's past month smoking (the mediator variable) controlling for friend's mother's parenting style (the explanatory variable). Models were estimated using a general estimating equation with clustering on the adolescent and an independent working covariance structure. All models run controlling for controlling for respondent age, gender, race, mother's education, mother's income plus school level fixed effects.									

eTable 4: Mediation analysis testing whether the effect on adolescent marijuana use of the friend's parent's parenting style* is mediated through friend marijuana use^a

	Main effect: Friend's mother-> adolescent marijuana use			Main to mediator: Friend's mother->friend marijuana use			Mediator to Outcome: Controlling for main predictor		
	Beta	Std.err	P value	Beta	Std.err	P value	Beta	Std.err	P value
(Intercept)	-1.50	2.37	0.53	-3.35	1.63	0.04	-1.46	2.43	0.55
Friend mother permissive Wave II	-0.14	0.20	0.51	-0.72	0.21	0.00	-0.06	0.21	0.78
Friend mother authoritarian Wave II	0.11	0.22	0.62	-0.02	0.23	0.93	0.13	0.23	0.56
Friend mother authoritative Wave II	-0.56	0.28	0.05	-0.71	0.27	0.01	-0.51	0.28	0.07
Friend mother permissive Wave I	0.01	0.24	0.96	-0.11	0.23	0.64	0.02	0.25	0.94
Friend mother authoritarian Wave I	-0.05	0.24	0.82	0.04	0.23	0.88	-0.06	0.24	0.82
Friend mother authoritative Wave I	0.05	0.26	0.84	0.16	0.24	0.50	0.03	0.26	0.90
Own mother permissive Wave II	-0.60	0.31	0.05	0.26	0.21	0.22	-0.66	0.31	0.03
Own mother authoritarian Wave II	-0.14	0.34	0.67	0.56	0.23	0.01	-0.21	0.34	0.53
Own mother authoritative Wave II	-0.15	0.39	0.69	-0.21	0.29	0.47	-0.15	0.39	0.71
Own mother permissive Wave I	0.40	0.35	0.25	0.04	0.25	0.86	0.41	0.35	0.24
Own mother authoritarian Wave I	0.66	0.36	0.07	-0.02	0.22	0.91	0.66	0.36	0.07
Own mother authoritative Wave I	0.28	0.38	0.46	0.27	0.26	0.29	0.25	0.38	0.52
Friend marijuana Wave II							0.90	0.21	0.00
Friend marijuana Wave I	1.07	0.21	0.00	2.65	0.19	0.00	0.66	0.22	0.00
Own marijuana Wave I	2.41	0.27	0.00	0.55	0.23	0.02	2.40	0.27	0.00
Alter's mother authoritative: Sobel test for mediation: -2.24									
Deviance	181.4850			203.68			177.57		
Null Deviance	232.1418			264.09			232.14		
N=2003									
^a Smoked or used marijuana at least once in last month									
*reference is neglectful									
First three columns show logistic regression model of adolescent's past month marijuana use (the outcome variable) on friend's mother's parenting style (the explanatory variable). Second three columns show logistic regression model of friend's month marijuana use (the mediator variable) on friend's mother's parenting style (the explanatory variable). Last three columns show logistic regression model of adolescent's past month marijuana use (the outcome variable) on friend's past month marijuana use (the mediator variable) controlling for friend's mother's parenting style (the explanatory variable). Models were estimated using a general estimating equation with clustering on the adolescent and an independent working covariance structure. All models run controlling for controlling for respondent age, gender, race, mother's education, mother's income plus school level fixed effects.									

eTable 5: Mediation analysis testing whether the effect on adolescent binge drinking of the friend's parent's parenting style* is mediated through friend binge drinking^a

	Main effect: Friend's mother-> adolescent binge drinking			Main to mediator: Friend's mother->friend binge drinking			Mediator to Outcome: Controlling for main predictor		
	Beta	Std.err	P value	Beta	Std.err	P value	Beta	Std.err	P value
(Intercept)	-0.68	1.68	0.69	-4.27	1.48	0.00	-0.60	1.67	0.72
Friend mother permissive Wave II	-0.20	0.16	0.20	-0.60	0.16	0.00	-0.16	0.16	0.31
Friend mother authoritarian Wave II	-0.42	0.18	0.02	-0.55	0.17	0.00	-0.39	0.19	0.04
Friend mother authoritative Wave II	-0.48	0.22	0.03	-0.91	0.22	0.00	-0.43	0.22	0.05
Friend mother permissive Wave I	0.23	0.19	0.23	-0.41	0.18	0.02	0.26	0.19	0.18
Friend mother authoritarian Wave I	-0.08	0.20	0.68	-0.21	0.17	0.22	-0.07	0.20	0.72
Friend mother authoritative Wave I	0.03	0.21	0.88	-0.22	0.18	0.24	0.04	0.21	0.85
Own mother permissive Wave II	-0.35	0.24	0.15	-0.06	0.17	0.73	-0.35	0.24	0.15
Own mother authoritarian Wave II	-0.33	0.26	0.20	-0.40	0.19	0.04	-0.30	0.26	0.25
Own mother authoritative Wave II	-0.55	0.32	0.09	-0.30	0.20	0.14	-0.53	0.32	0.10
Own mother permissive Wave I	-0.12	0.26	0.65	0.13	0.19	0.49	-0.13	0.26	0.62
Own mother authoritarian Wave I	-0.49	0.26	0.06	0.13	0.19	0.49	-0.50	0.26	0.05
Own mother authoritative Wave I	-0.51	0.29	0.08	0.17	0.20	0.39	-0.52	0.29	0.08
Friend binge drinking Wave II							0.39	0.15	0.01
Friend binge drinking Wave I	0.54	0.14	0.00	1.87	0.14	0.00	0.40	0.15	0.01
Own binge drinking Wave I	2.06	0.20	0.00	0.29	0.14	0.04	2.05	0.20	0.00
Sobel test for mediation: alter's mother authoritative -2.17									
Deviance	287.04			312.56			284.87		
Null deviance	427.80			440.02			427.80		
N=2056									
^a Consumed 5 or more drinks in a row at one time within last year									
* reference is neglectful									
First three columns show logistic regression model of adolescent's past year binge drinking (the outcome variable) on friend's mother's parenting style (the explanatory variable). Second three columns show logistic regression model of friend's past year binge drinking (the mediator variable) on friend's mother's parenting style (the explanatory variable). Last three columns show logistic regression model of adolescent's past year binge drinking (the outcome variable) on friend's past year binge drinking (the mediator variable) controlling for friend's mother's parenting style (the explanatory variable). Models were estimated using a general estimating equation with clustering on the adolescent and an independent working covariance structure. All models run controlling for respondent age, gender, race, mother's education, mother's income plus school level fixed effects.									