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The Effect of Having Aggressive Friends on Aggressive Behavior in Childhood: Using Propensity Scores to Strengthen Causal Inference

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Abstract

This study uses propensity scores to statistically approximate the causal effect of having aggressive friends on aggressive behavior in childhood. Participants were 1,355 children (53% girls; 31% minority) in 97 third and fifth grade classrooms enrolled in the Classroom Peer Ecologies Project. Propensity scores were calculated to control for the impact of 21 relevant confounder variables related to having aggressive friendships and aggressive behavior. The 21 variables included demographic, social, and behavioral characteristics measured at the beginning of the school year. Presence/absence of aggressive friends was measured in the middle of the school year, and aggressive behavior was measured at the end of the school year. Results indicate a significant effect of having one or more aggressive friends on children's aggressive behavior above and beyond the effects of the 21 demographic, social, and behavioral variables. The propensity score model is compared to two other models of peer influence. The strengths and practical challenges of using propensity score analysis to study peer influence are discussed.

Keywords

Peer influence; aggressive behavior; childhood; propensity scores

Introduction

Peer influence is one of the most salient risk factors for the development of aggressive behavior in childhood (Brechwald & Prinstein, 2011; Dishion & Tipsord, 2011). However, causal inferences regarding peer influence are often weak due to the presence of confounding variables (also called third variables). Confounders are variables that affect both the independent variable and the dependent variable. The presence of confounders may obscure the resulting effect of the predictor on the outcome, providing an alternative explanation for study results (Robins, 1989). A number of potential confounders exist in the study of peer influence on aggressive behavior (e.g., demographic, behavioral, and social

characteristics; Cillessen & Mayeux, 2004; Cillessen & Rose, 2005; Hamm, 2000; Kindermann, 2007). It is important to control for confounder variables in order to more accurately measure the relationship between the independent and dependent variables.

The goal of this paper is to apply modern causal inference techniques (Schafer & Kang, 2008) to control for confounding variables that may be biasing the estimates of peer influence on aggressive behavior. This is achieved by balancing confounders across groups in order to mimic randomization (i.e., randomization to peer groups; Rosenbaum & Rubin, 1983). By statistically approximating randomization to aggressive peer influence, we can estimate the degree to which prior findings of peer influence on aggressive behavior were confounded by children's demographic, behavioral, and social characteristics.

The traditional approach to examining the effect of peer influence on youths' behavior is to use regression analyses with longitudinal data. In these models, friends' aggressive behavior is used to predict change in individual aggressive behavior over time. The resulting estimate is interpreted as the estimate of peer influence. Findings from studies using the traditional approach indicate that peers' aggressive behavior is related to an increase in youths' aggressive behavior over time (Brechwald & Prinstein, 2011; Dishion & Tipsord, 2011). Significant aggressive peer influence effects have been reported using a variety of measurement approaches (e.g., self-report, sociometric nominations, participant observations) and sample characteristics (e.g., risk status, age). For example, in a sample of 137 (52% boys) low-risk preschool and kindergarten children, girls' exposure to externalizing peers (measured using playground observations of peer interactions and sociometric nominations of aggressive behavior) significantly predicted change in teacher-rated aggressive behavior, but results were not significant for boys' exposure to externalizing peers (Hanish, Martin, Fabes, Leonard, & Herzog, 2005). Hanish and colleagues (2005) controlled for proportion of time spent in social play and examined effects by gender. In a study of 4,096 children (50.6% boys) in 27 high-risk elementary schools, aggressive behavior of reciprocated friends in second grade (measured using sociometric nominations) significantly predicted change in teacher-rated aggressive behavior from second to third grade (Powers, Bierman, & CPPRG, 2013). Powers and colleagues (2013) controlled for child sex and peer dislike of the child. In a sample of 422 (49% boys) middle school students in 1 middle school in a midwestern town, friends' aggressive behavior (measured using self-report and social network analysis) significantly predicted increases in self-reported fighting from the beginning of the school year to the end of the school year (Espelage, Holt, & Henkel, 2003). Espelage and colleagues (2003) ran analyses separately for males and females; results were consistent across gender.

The three studies reviewed above are typical of studies using the traditional approach to examine peer influence on aggressive behavior in that they control for gender and prior levels of aggressive behavior. However, a number of additional potential confounders may be important to control for when estimating peer influence. Peer influence occurs within a complex developmental context (Bronfenbrenner, 1979), and the presence or absence of aggressive peers can be impacted by a number of behavioral and psychosocial variables. For example, children sort themselves into friendships based on similarities in prosocial behavior (Newcomb & Bagwell, 1995), academic achievement and motivation (Ryan, 2000),

relational aggression (Sijtsema, Ojanen, Veenstra, Lindenberg, Hawley, & Little, 2010), victimization (Salmivalli, 2010; Sentse, Dijkstra, Salmivalli, & Cillessen, 2013), and popularity (Logis, Rodkin, Gest, & Ahn, 2013), all of which have also been linked to the development of aggressive behavior (Loeber & Hay, 1997). These variables are confounders because they are associated with children's selection of aggressive friends and children's development of aggressive behavior. Without careful examination of the confounder variables, it is unknown the degree to which the peer influence estimate is a result of the effect of having aggressive peers versus a result of the effects of confounding variables. Therefore, statistically controlling for the confounder variables enables a more accurate estimation of the relationship between having aggressive peers and the development of aggressive behavior.

A critical confounding variable in traditional models that examine peer influence on aggressive behavior is the selection of friends based on aggressive behavior. That is, peer selection (i.e., the process through which youth choose to interact with other youth; Lazarsfeld & Merton, 1954) and peer influence (i.e., the process through which a youth's behavior is shaped by other youth over time; Friedkin, 1998) are confounded. Here, the concern is that children select friends based on levels of aggressive behavior, which confounds estimation of the effect of peers' influence on aggressive behavior. Stochastic actor based models (SABMs; Snijders, 2001) were recently developed and applied to the study of child development in order to help disentangle the processes of peer selection and influence (Steglich, Snijders, & Pearson, 2010). Two studies that use SABM to examine the effects of friend selection and influence on aggressive behavior in elementary school reported significant effects for selection of aggressive friends (Logis et al., 2013; Molano, Jones, Brown, & Aber, 2013). After controlling for the effects of peer selection, both studies reported significant peer influence on aggression (Logis et al., 2013; Molano et al., 2013). SABMs more accurately disentangle selection and influence, but SABMs are still vulnerable to the third variable problem (Steglich et al., 2010). In these models, variables such as prosocial behavior, academic achievement and motivation, relational aggression, victimization, and popularity may be codetermining the probabilities for network selection and influence based on aggressive behavior.

The “gold standard” for determining the effect of having aggressive friends on aggressive behavior would be to randomize children to conditions where aggressive friends are present or absent (Holland, 1986). Since children's friendships cannot be experimentally manipulated, an alternative approach that statistically approximates the causal effect of having aggressive friends is necessary. Modern causal inference methods (Schafer & Kang, 2008), such as propensity score methods, are increasingly being applied to correlational studies in the social sciences to control for the effects of confounding variables and statistically approximate causal effects.

Propensity scores are a summary of information about the relationships between the confounder variables and the independent variable. Including the propensity score when examining the relationship between the independent and dependent variables enables researchers to control for a large number of confounder variables very efficiently. Inverse propensity weighting (IPW; Hirano & Imbens, 2001) is an approach that uses the propensity

scores to statistically weight the sample. IPW is similar to survey weighting. Individuals with a low probability of having their level of aggressive friends given their confounders are upweighted and individuals with a high probability of having their level of aggressive friends given their confounders are downweighted. Assuming no unmeasured confounders, this design statistically mimics a randomized sample where youth are randomly assigned to the presence or absence of aggressive friends and confounders are evenly distributed between youth who have and do not have aggressive friends.

The current study compares three models examining the association between having aggressive friends and future aggressive behavior. The first model follows from the traditional approach. In this model, we use the presence of aggressive friends to predict future levels of aggressive behavior after controlling for gender and prior levels of aggressive behavior. The second model controls for 21 confounding variables, including demographic characteristics (e.g., gender, ethnicity), social characteristics (e.g., popularity, relationship with teacher), and behavioral characteristics (e.g., academic achievement), in the regression model by including the variables as covariates in the regression equation. This model makes a number of assumptions. First, this model assumes that the confounders are linearly related to the predictor variable. Second, multicollinearity between the confounders may bias estimates of the association of interest. Third, it is unknown the degree to which the confounders are balanced when using this approach. The third model uses IPW to estimate the average causal effect (ACE; Rosenbaum & Rubin, 1983) of the presence of aggressive friends on aggressive behavior in childhood after controlling for the same 21 confounding variables. In the IPW model, there is no assumption that the confounders are linearly related to the predictor variable and multicollinearity between the confounders is not a factor. Additionally, IPW enables the ability to look at diagnostics to ensure that the confounders are balanced between children who have aggressive friends and children who do not have aggressive friends.

In this study, we examine three hypotheses that follow from the three models described above. First, in the traditional model, we hypothesize that there will be a significant positive association between the presence of aggressive friends and future aggressive behavior after controlling for gender and prior levels of aggressive behavior. Second, we hypothesize that the association between presence of aggressive friends and future aggressive behavior will not reach statistical significance in the covariate model due to the specific assumptions associated with this model, explained above. Third, we hypothesize that the statistical approximation of the causal effect of the presence of aggressive friends will be significant and positive. However, we expect that this estimate will be smaller than the estimate from the traditional model because of the additional confounding variables that are controlled for in the causal model.

Method

Participants

Participants were 1,355 children (53% girls; 31% minority) in 97 third and fifth grade classrooms enrolled in the Classroom Peer Ecologies Project (CPEP; Gest & Rodkin, 2011; Rodkin & Gest, 2011), a longitudinal study of teaching practices, classroom peer ecologies,

and youth outcomes. Fifty percent of children were 3rd grade students. Sixty nine percent of children were White, 20% were African American, and 11% were Asian, Hispanic, multiethnic or from other backgrounds. Demographic characteristics for the sample are presented in Table 1.

An original sample of 2,241 children (48% girls; 37% minority) in 101 third and fifth grade classrooms were recruited from urban and suburban areas of Illinois and Indiana and suburban and rural areas of Pennsylvania. Four classrooms ($n = 94$ students) with low student participation rates (<60% participation) were dropped from our analyses because sociometric nomination measures become less stable and less valid when classroom participation rates are low. This reduced the sample size to 2,147 children in 97 classrooms. For these analyses, we use a subsample of children who did not have aggressive friends at the beginning of the school year ($N = 1,355$; 63% of total sample).

Procedure

Study procedures were approved by the University Institutional Review Boards. Data were collected during three consecutive school years (2009-2010 thru 2011-2012), with different schools being sampled each year. Parental consents and student assents were obtained prior to participation in the study. Students and teachers filled out surveys at three time points within the school year—the first few weeks of school (September-October: Wave 1 or W1), approximately 2 months later (November-December: Wave 2 or W2), and near the end of the school year (April-May: Wave 3 or W3). The student survey took approximately 45 minutes to complete, and students filled out surveys during a regular class period. In order to maximize privacy, students placed standing folders around their desks to cover their responses. Participants were reassured that their answers were confidential and that participation was voluntary. A graduate research assistant read aloud instructions and questions while the students followed along and responded to the questions. At least two trained assistants were present to assure privacy and to assist participants.

Participation rates averaged 83% ($SD = 9\%$, $R = 60-100\%$) at each wave. If the student was not a participant at a wave, s/he did not fill out the survey but was included on the roster for other children in the classroom to nominate him/her for sociometric nominations. All nomination procedures included a classroom roster from which students were asked to nominate other students within the classroom. All nomination procedures included an option to nominate no classmates if no one fit the description.

Measures

Aggressive behavior—Aggressive behavior was measured using peer nomination on the item “*Who starts fights?*” Each student in the class could nominate as many classmates as they wished for the item. Proportion scores were calculated by dividing the total number of nominations that each child received by the total number of participants in the classroom. The W1 measure of aggressive behavior is included as a confounder in the propensity model and is included as a covariate in the unweighted and weighted outcome models. The W3 measure of aggressive behavior is the dependent variable. The correlation between aggressive behavior at W1 and W3 is strong ($r = 0.71$, $p < .001$). There was no significant

difference between 3rd and 5th grade students on levels of aggressive behavior at W1 ($F[1, 1,353] = 1.54, p > .05$). At W3, 3rd grade students had significantly higher levels of aggressive behavior when compared to 5th grade students ($F[1, 1,353] = 6.21, p < .05$). The mean level of aggressive behavior for 3rd grade students was 0.13 ($SD = 0.17$), whereas the mean level of aggressive behavior for 5th grade students was 0.11 ($SD = 0.17$). Descriptive statistics for the combined 3rd and 5th grade sample are presented in Table 1.

Number of aggressive friends—Number of aggressive friends was calculated at W2. Participants were asked to nominate classmates whom they perceived as friends (“*who is your friend?*”) and whom they perceived as aggressive (“*who starts fights?*”) by naming as many classmates as they wished. Friendships were reciprocated when two children nominated one another as friends. On average, children had 3.88 reciprocated friends ($SD = 3.24$; $R = 0-17$) at W2. Most students had at least 1 reciprocated friend at W2 ($n = 987$; 73%).

For each participant, we calculated the number of reciprocated friends scoring greater than 1 SD above the mean proportion score for the item “*who starts fights?*” At W2, the mean proportion score was 0.15 ($SD = .18$) for 3rd graders and 0.13 ($SD = 0.19$) for 5th graders. The number of aggressive friends ranged from 0-5 at W2. If a participant did not have any reciprocated friends, his/her number of aggressive friends was coded to 0. Number of aggressive friends was dichotomized such that each participant had either 0 aggressive friends (0) or one or more aggressive friends (1). Nineteen percent of children ($n = 255$) had at least 1 aggressive reciprocated friend at W2. The percentage of children with at least 1 aggressive reciprocated friend did not differ by grade, $\chi^2 = 1.06, p > .05$.

Confounder variables—The propensity model included 21 confounder variables measured at W1, including demographic characteristics (e.g., gender, race/ethnicity), social characteristics (e.g., popularity, relationship with teacher), and behavioral characteristics (e.g., academic achievement, prosocial behavior). A summary of confounder variables can be found in Table 2. Demographic characteristics (grade, gender, race/ethnicity) were obtained from school records. Social and behavioral characteristics were measured using a variety of peer-reported, self-reported, and teacher-reported measures. For peer nominations, the proportion of classmates nominating the student for each social characteristic was calculated as described above for aggressive behavior nominations. Self-reported survey data were collected using the same procedure outlined for the peer nomination survey. Teachers were also surveyed about each student in their classroom, and here, teacher-rated disruptive behavior, achievement, prosocial behavior, student/teacher relationship, and disruptive behavior of students' friends are included as confounder variables.

Results

Analyses progressed in five steps: (1) missing data were imputed using Proc MI in SAS (Schafer, 1997; Schafer & Graham, 2002); (2) we estimated a propensity score for each case using logistic regression and computed weights (Hirano & Imbens, 2001) allowing us to mimic a randomized sample by evenly distributing confounders across the group of children with 0 aggressive friends and the group with 1 or more aggressive friends; (3) we checked

for balance on each of the 21 confounders to ensure that we properly accounted for confounding; (4) we estimated two linear regression models (one controlling for gender and prior levels of aggressive behavior and one controlling for all 21 confounder variables) to examine the association between number of aggressive friends at W2 and aggressive behavior at W3 without adjusting for the propensity score weights; and (5) we estimated the Average Causal Effect (ACE; Rosenbaum & Rubin, 1983) of number of aggressive friends at W2 on aggressive behavior at W3 using linear regression with our weighted sample.

Estimating Propensity Scores and Applying Weights

A propensity score for each participant was calculated using logistic regression. Presence/absence of aggressive friends at W2 was regressed on the 21 confounders measured at W1. The resulting predicted probability values are the estimated propensity scores and represent the probability that an individual has aggressive friends given his/her values on the confounder variables. The propensity scores ranged from 0.04-0.98 ($M = 0.71$, $SD = 0.25$). The stabilized inverse propensity weight (IPW) for each individual is the mean propensity score for his/her group (i.e., 0 aggressive friends or 1+ aggressive friends) divided by his/her propensity to be in his/her group (i.e., his/her propensity to have the level of aggressive friends actually observed). Weights that are too small or too large can lead to estimation problems, so stabilized weights were used. Stabilizing the weights reduces the variance in the weights, reducing the potential for extreme values. The total sum of the weights is equal to the sample size for each group, and the mean of the weights for each group is equal to 1. Weights for the children who had 0 aggressive friends at W2 ranged from 0.83-2.03. Weights for the children who had 1 or more aggressive friends at W2 ranged from 0.31-4.27. The weight for each individual represents how much s/he contributes to the analyses. For example, an individual with a weight equal to 2 would count as 2 individuals in the dataset.

Checking Balance

Balance was checked on the 21 confounders before and after applying the propensity score weights. Using IPW to weight the sample should reduce the mean differences on the confounder variables between the group of children with 0 aggressive friends and the group of children with 1 or more aggressive friends. The standardized mean difference (SMD) between groups should generally be smaller in the weighted sample than in the unweighted sample. As seen in Table 2, overall the SMDs were reduced when weights were applied. The highest SMD in the unweighted sample was for the indicator of number of reciprocated friends ($SMD = 0.36$). All SMDs in the weighted sample had an absolute value of .05 or less, which meets Cohen's definition of a small effect (Cohen, 1988; 1992). This indicated that by applying weights, the group of children with 0 aggressive friends and the group of children with 1 or more aggressive friends would have similar distributions on each of the 21 confounder variables, mimicking a randomized sample.

Unweighted Models

Table 3 presents results for the linear regression analyses using W2 number of aggressive friends to predict W3 aggressive behavior in the unweighted and weighted samples. In the unweighted model, we control for gender and W1 levels of aggressive behavior. After controlling for gender and W1 levels of aggressive behavior, W2 number of aggressive

friends is significantly related to aggressive behavior at W3 ($B = 0.04, p < .01$). In the covariate model, we include the 21 confounder variables as covariates in the linear regression model. Wave 2 number of aggressive friends is significantly related to aggressive behavior at W3 ($B = .03, p < .01$).

Weighted Model

The weighted model uses the weights calculated from the propensity model that included 21 confounder variables measured at W1. The coefficients in the weighted model can be interpreted as the causal effect of having at least 1 aggressive friend versus having 0 aggressive friends. Given the strength of the effect of W1 aggressive behavior on W3 aggressive behavior ($r = 0.72, p < .001$), we added it as a control in our weighted outcome model. Number of aggressive friends at W2 remained significantly related to W3 aggressive behavior in the weighted sample ($B = 0.03, p < .01$).

Discussion

The link between having aggressive friendships and the development of aggressive behavior is well established (Brechwald & Prinstein, 2011; Dishion & Tipsord, 2011). In this study, we compared three models estimating peer influence on aggressive behavior in order to determine the robustness of the peer influence estimate. The peer influence estimate was significant in each of the three models, including the strictest model using inverse propensity weighting (IPW; Hirano & Imbens, 2001). After balancing the sample on 21 variables including demographic, behavioral, and social characteristics, the presence of aggressive friends in the middle of the school year was significantly related to higher levels of aggressive behavior. This study statistically approximates the causal effect of aggressive peer influence by using a rigorous causal approach (Rosenbaum & Rubin, 1983; Schafer & Kang, 2008), and is among the first to examine the effect of having aggressive friends in elementary school while controlling for such a wide range of potential confounders.

The unweighted model controlled for gender and prior levels of aggressive behavior, and we found a significant peer influence effect on aggressive behavior, as expected. This finding is consistent with models that have been run in traditional analyses of peer influence, which typically control for gender and prior levels of aggressive behavior (Espelage et al., 2003; Hanish et al., 2005; Powers et al., 2013). However, the unweighted model does not control for a number of other confounders that may be contributing to the estimate of peer influence (e.g., popularity; ethnicity).

The second model controlled for 21 confounder variables by including them as covariates in the linear regression model. Contrary to our hypothesis, the association between having aggressive friends and future levels of aggressive behavior was significant in this model. However, this model has a number of disadvantages. First, in order for this model to be estimated correctly, each of the confounder variables must be linearly related to the outcome. Second, multicollinearity between the confounder variables could be leading to biased estimates. Third, without the ability to run diagnostics that are available when using IPW, we are unable to be sure that the exposure groups are balanced on the 21 confounder

variables. Although the estimate is significant in this case using this data, it may not be significant in other cases because of these limitations.

Consistent with our third hypothesis, the statistical approximation of the causal effect of having aggressive friends on aggressive behavior was significant. This model used IPW to control for a wide range of potential confounders. The effect sizes in our unweighted ($B = 0.04$) and weighted ($B = 0.03$) models are similar in magnitude. By comparing the effect sizes from our unweighted and weighted models, we can calculate the percentage of the effect of having aggressive friends on aggressive behavior that remains after controlling for the 21 confounder variables. Seventy five percent ($0.03/0.04$) of the original effect size remains in the weighted model. This means that approximately 25% of the original effect estimate in this study is likely due to subtle forms of selection based on similarities in demographic, behavioral, and social characteristics. Children with aggressive friends are likely more similar to one another on a number of characteristics than they are to children without aggressive friends. For example, prior to applying the inverse propensity weights in this study, children with aggressive friends had higher rates of being nominated for the item “*not popular*” than children without aggressive friends. Without controlling for nominations of popularity, the effect of having aggressive friends on aggressive behavior is confounded to the extent that popularity is associated with aggressive behavior. Social and developmental research has extensively linked popularity and aggressive behavior (Cillessen & Mayeux, 2001; Cillessen & Rose, 2005). Therefore, without proper control, it is unclear the extent to which the effect of having aggressive friends on aggressive behavior is actually due to the presence of aggressive friends or to levels of popularity. This example extends to the large number of additional potential confounding variables that may differ between youth with and without aggressive friends. The use of IPW is particularly appropriate in this example because a large number of confounding variables can be included in the propensity score estimation (Hirano & Imbens, 2001).

In this study, we limited our sample to children who did not have aggressive friends at the beginning of the school year. As such, our causal comparison examines the increase in aggressive behavior scores for children who had no aggressive friends at the beginning of the school year compared with kids who selected at least 1 aggressive friend between the beginning of the school year and the middle of the school year. We limited our sample in this way because we do not have a measure of the length of time that a child had aggressive friends, a key potential confounding variable. Here, our focus is on the process of acquiring aggressive friends from the beginning of the school year to the middle of the school year. By doing so, we are more accurately capturing the causal effect of adding an aggressive friend, and we are more closely approximating what would happen in a randomized experiment.

The design and measurement approach taken in this study further increase the rigor of the test of aggressive peer influence. First, longitudinal data are used from three time points within one academic school year. The presence/absence of aggressive friends was measured in the middle of the school year, and children's aggressive behavior was measured at the end of the school year, an approximate 5-month window. The significant effect of having aggressive friends on aggressive behavior in this 5-month span highlights the relatively small developmental window in which aggressive friends have an effect on behavior and points to

the importance of selecting measurement time points that are able to capture developmental change at the pace that it occurs. Children's friendships change within a school year (Hallinan, 1979), but aggressive behavior is highly stable (Huesmann, Eron, Lefkowitz, & Walder, 1984; Loeber & Hay, 1997). In our study, the correlation between aggressive behavior at the beginning and end of the school year was high ($r = 0.71$). The ability to predict change in such a stable construct over the course of a 5-month period points to the robustness of the aggressive peer influence effect. Second, the temporal order of the measurement time points within the academic year further adds to our ability to statistically approximate the causal effect of aggressive peer influence (Holland, 1986). Our 21 confounder variables are measured prior to the measurement of presence/absence of aggressive friends, which is measured prior to aggressive behavior. The temporal ordering combined with our use of a subsample of children who did not have aggressive friends at the beginning of the school year provides confidence in the direction of the effect of having aggressive friends on future aggressive behavior and limits the possibility that the direction of the relationship is actually aggressive behavior causing associations with aggressive friends (i.e., selection).

It is important to note that the peer influence results reported here are specific to physical aggression. The measure of aggressive behavior used in this study was an indicator of being nominated by classmates for "starting fights." Physical aggression likely overlaps with other forms of aggression (e.g., verbal aggression; Loeber & Schmaleng, 1985). However, not all children who engage in physically aggressive behavior also engage in verbal aggression and vice versa (Crick, Grotpeter, & Bigbee, 2002). Children who interact with others who engage in physically aggressive behaviors are likely influenced in the domain of physical aggression, whereas children who interact with verbally aggressive youth are likely influenced in the domain of verbal aggression. Future research should apply IPW to statistically approximate the causal effect of peer influence on other forms of aggression, including verbally/relationally aggressive behavior.

The results from this study should be interpreted within the context of the following limitations. First, estimates of the ACE assume that there are no unmeasured confounder variables (Rosenbaum & Rubin, 1983). As such, the estimates from this study may be biased to the extent that confounder variables not included in our propensity model are important in the relationship between having aggressive friends and future aggressive behavior. Second, we were unable to control for selection of aggressive friends that may have occurred between the measurement of presence/absence of aggressive friends in the middle of the school year and aggressive behavior at the end of the school year. In order to preserve the temporal ordering, confounders included in the model have to occur prior to measurement of the predictor of interest (presence of aggressive friends).

Despite these limitations, this study provides a rigorous test of the effect of having aggressive friends on children's aggressive behavior and is the first to control for such a wide range of variables that may potentially confound the estimates of aggressive peer influence. Propensity score analysis is a flexible approach that could be applied to test a number of research questions about peer influence that have been debated in developmental science. For this study, the predictor variable was conceptualized as presence/absence of aggressive

friends. In this case, children could either stay the same (0 aggressive friends) or add 1 or more aggressive friends. In future research, the predictor variable could be conceptualized as a continuous measure of change in number of aggressive friends. This analysis would help to distinguish between upward versus downward change in number of aggressive friends and would help to determine the degree to which there is an incremental impact of having additional aggressive friends. A propensity score approach can also be used to examine the heterogeneity of peer influence when children have a combination of friends with aggressive and prosocial behaviors. For example, causal comparisons could be made between children who have aggressive friends only versus children who have both aggressive and prosocial friends. This analysis would examine how the aggressive peer influence effect changes in the presence of prosocial friendships.

When using this approach for developmental research, a number of practical considerations are important. First, the standard errors associated with the effect estimates may be larger when using IPW due to the uncertainty associated with estimating the propensity scores. This means that the power to detect effects in the weighted models may be reduced and larger sample sizes may be required. Second, it is important to be mindful of temporal ordering when testing causal hypotheses. The confounders should be measured prior to measuring the predictor of interest, which should be measured prior to the outcome variable. Confounders that are measured after the predictor of interest (also called post-treatment confounders) cannot be included in the propensity score model. Third, the analyses assume no unmeasured confounders. Thus, it is important to measure a wide range of variables theorized to be associated with the predictor and outcome of interest.

Conclusions

The significant average causal effect (Rosenbaum & Rubin, 1983) of having aggressive friends on aggressive behavior is consistent with a large body of research supporting the effect of aggressive peer influence (Brechwald & Prinstein, 2011; Dishion & Tipsord, 2011). By comparing the three models tested, we found that approximately 25% of the peer influence estimate from the traditional model may be due to subtle forms of selection and similarity in children who have aggressive friends. The rigor of our test points to the significance of having aggressive friends in the development of children's aggressive behavior above and beyond a multitude of other etiological risk factors.

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Table 1
Demographic Characteristics and Descriptive Statistics

Demographics	<i>N</i> (%)
Girl	717 (53)
White	902 (69)
African American	262 (20)
Other Ethnicity	148 (11)
3 rd Grade	672 (50)
Number of Aggressive Friends (W2)	
0	1,100 (81)
1+	255 (19)
<i>M</i> (<i>SD</i>)	
Aggressive Behavior (W1)	0.09 (0.14)
Aggressive Behavior (W3)	0.12 (0.17)

Note. *N* = 1,355 students in 97 3rd and 5th grade classrooms. Descriptive statistics are for the weighted sample and are measured at Wave 1. Forty-three students were missing information for ethnicity. Wave 1 occurred in the first few weeks of school (September-October); Wave 2 occurred approximately 2 months later (November-December); and Wave 3 occurred near the end of the school year (April-May). Aggressive behavior was measured using peer nomination on the item “*Who starts fights?*” Proportion scores were calculated by dividing the total number of nominations that each child received by the total number of participants in the classroom. Number of aggressive friends was calculated as the number of reciprocated friends scoring greater than 1 *SD* above the mean proportion score for the item “*Who starts fights?*”

Table 2
Confounder Variables Measured at Wave 1 and Standardized Mean Differences Before and After Weighting

Construct	Item Description	SMD Unweighted	SMD Weighted
Grade	3 rd or 5 th grade student	0.07	0.04
Race/Ethnicity	0 = White, 1 = Minority	0.16	0.03
Gender	0 = Male, 1 = Female	0.11	0.03
Reciprocated Friends	Number of reciprocated friends in classroom	0.36	0.01
Nominated as Friend	Number of friendship nominations	0.12	0.03
Nominated for “ <i>starting fights</i> ”	Proportion of participating classmates nominating youth	0.14	0.04
Nominated for “ <i>liked least</i> ”	Proportion of participating classmates nominating youth	0.14	0.02
Nominated for “ <i>liked most</i> ”	Proportion of participating classmates nominating youth	0.14	0.01
Nominated for “ <i>not popular</i> ”	Proportion of participating classmates nominating youth	0.27	0.01
Nominated for “ <i>popular</i> ”	Proportion of participating classmates nominating youth	0.23	0.02
Nominated for “ <i>nice</i> ”	Proportion of participating classmates nominating youth	0.03	0.01
Nominated for “ <i>cooperates</i> ”	Proportion of participating classmates nominating youth	0.10	0.03
Nominated for “ <i>picked on</i> ”	Proportion of participating classmates nominating youth	0.13	0.05
Nominated for “ <i>gossips</i> ”	Proportion of participating classmates nominating youth	0.15	0.01
Disruptive behavior	Teacher-rated on <i>Teacher Check List</i> (TCL; Dodge & Coie, 1987)	0.15	0.01
Achievement	Teacher-rated (4 items; e.g., <i>works hard at school</i>)	0.09	0.04
Prosocial behavior	Teacher-rated (4 items, e.g., <i>helpful to peers</i>)	0.04	0.01
Relationship with teacher	Teacher-rated on <i>Student-Teacher Relationship Scale</i> (Pianta, 1992)	0.01	0.05
Teacher-child Closeness	Student-rated on <i>Student-Teacher Relationship Scale</i> (Pianta, 1992)	0.01	0.05
Peer Community	Student-rated (e.g., Battistich et al., 1995; Battistich & Horn, 1997)	0.07	0.04
Disruptive Behavior of Friends	Mean teacher-rated disruptive behavior of reciprocated friends	0.19	0.01

Notes. Wave 1 measures were collected at the beginning of the school year (September-October). SMD = Standardized mean difference. After weighting the sample, the standardized mean differences should be < .2 for each confounder (Cohen, 1988; 1992). The SMD for all confounders in this study was <.05, indicating a small effect.

Table 3
The Relationship between Number of Aggressive Friends and Aggressive Behavior

	Unweighted Model	Covariate Model	Weighted Model
	<i>B (SE)</i>	<i>B (SE)</i>	<i>B (SE)</i>
Gender (0=boy)	-0.01 (0.01)		
W1 Aggressive Behavior	0.84 (0.04) ***	0.43 (0.05) ***	0.86 (0.04) ***
W2 Aggressive Friends	0.04 (0.01) **	0.03 (0.01) **	0.03 (0.01) **

**
 $p < .01$,

 $p < .001$.

Notes. $N = 1,355$ students in 97 3rd and 5th grade classrooms. The covariate model includes the 21 confounder variables in the linear regression model. The weighted model uses inverse propensity weighting to balance 21 confounder variables across levels of W2 Number of Aggressive Friends. W1 = Wave 1 and occurred in the first few weeks of school (September-October); W2 = Wave 2 and occurred approximately 2 months later (November-December). The dependent variable is measured at Wave 3 (W3), the end of the school year (April-May). The W3 dependent variable and the W1 control for aggressive behavior are measured using peer nomination on the item “*Who starts fights?*” W2 aggressive friends = number of aggressive friends and was calculated as the number of reciprocated friends scoring greater than 1 *SD* above the mean proportion score for the item “*Who starts fights?*” This variable was dichotomized into presence/absence of at least 1 aggressive friend.