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EMPIRICAL RESEARCH

A Social Network Approach to the Interplay Between Adolescents' Bullying and Likeability over Time

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Abstract Our knowledge on adolescents' bullying behavior has rapidly increased over the past decade and it is widely recognized that bullying is a group process and, consequently, context-dependent. Only since recently, though, researchers have had access to statistical programs to study these group processes appropriately. The current 1-year longitudinal study examined the interplay between adolescents' bullying and likeability from a social network perspective. Data came from the evaluation of the Finnish KiVa antibullying program, consisting of students in grades 7–9 ($N = 9{,}183$, M age at wave 1 = 13.96 years; 49.2 % boys; M classroom size = 19.47) from 37 intervention and 30 control schools. Perceived popularity, gender, and structural network effects were additionally controlled. Longitudinal social network analysis with SIENA revealed that, overall, the higher the students' level of bullying, the less they were liked by their peers. Second, students liked peers with similar levels of bullying and this selection-similarity effect was stronger at low levels of bullying. This selection effect held after controlling for selection-similarity in perceived popularity and gender. Third, students were likely to increase in bullying when they liked peers high on bullying and to decrease in bullying when they liked peers low on bullying. Again, this influence effect held after controlling for the effects of perceived popularity and gender on changes in bullying behavior. No significant differences between control and intervention schools appeared in the effects. The results are discussed in light of their theoretical and methodological implications.

Keywords Bullying · Social status · Social network analysis · Longitudinal · Peer relationships

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Introduction

Although bullying is defined as repeated and intentional harm-doing in a relationship that is imbalanced in power (Olweus 1993), there is more to bullying than a dyadic relationship between the perpetrator and victim. The participant role approach to bullying makes explicit that bullying is a group process and that almost all children in the group are somehow involved in the bullying process (Salmivalli et al. 1996). Whereas some children are more overtly involved by assisting (helping, joining in) the bully, others have a less explicit role by reinforcing (laughing, cheering) the bully. Other children may be involved by defending the victim whereas some witness the bullying but do not step into help (Salmivalli 1999). Based on this group-approach, numerous school programs have been developed to counteract bullying, which is not surprising given that bullying is a widespread problem (up to 25 % of all children suffer from school bullying; see Eslea et al. 2004). However, antibullying programs seem less successful in adolescence (secondary school) as compared to late childhood, in elementary school (Kärnä et al. 2013; Smith 2010). It is likely that transitioning to a new school and the increased importance of the peer group and social

status in adolescence (Ojanen et al. 2005) go hand in hand with more bullying behavior and greater peer influence regarding bullying behavior. As such, adolescence is an important period to study bullying in the peer group.

Both the participant role approach to bullying and the school-based anti-bullying programs that have been developed suggest that bullying should be studied in its context, which should be the classroom as most bullying takes place in school (Smith 2010) and adolescents interact on a daily basis with their classmates. Indeed, previous research has shown that children from the same peer network behave in similar ways in bullying situations (Huitsing and Veenstra 2012). That is, within school classes, peer groups often consist of children with similar participant roles, resulting in peer cliques that consist of children who bully whereas other cliques consist mainly of victims, defenders, or non-involved children (Salmivalli et al. 1997; Sentse et al. 2013). Furthermore, when it comes to bullying, students are strongly affected by their peers and the bullying climate in the classroom (Low et al. 2013; Scholte et al. 2010). The current study tried to acknowledge these previous accounts by studying bullying from a social network perspective. As such, we aimed to examine the longitudinal interplay between sociometric status and school bullying in adolescence.

Bullying and Sociometric Status

Although bullies are often perceived as the "cool kids" (Cillessen and Mayeux 2004), they are, on average, more disliked by their peers than non-involved children (Boulton and Smith 1994; Prinstein and Cillessen 2003). Some studies indicate that bullies have a controversial status in the group, finding that bullying is related to being disliked as well as to being liked (e.g., Salmivalli et al. 1996). Although these previous studies suggest that engagement in bullying might explain, on average, low levels of likeability (Boulton and Smith 1994; Salmivalli et al. 1996), these studies were often cross-sectional in design and the majority of these studies were conducted among children in elementary school. It is unclear how bullying and likeability co-develop over time in adolescence, and more specifically, how these processes evolve within a social network.

Peer group homogeneity as found in previous studies into bullying-related behaviors (Huitsing and Veenstra 2012; Sentse et al. 2013) can either be due to students adjusting their relationships based on their social context and their own behavior (selection processes), or due to students adjusting their behavior based on the behavior of the individuals they are connected with (influence processes). More specifically, it might well be that bullies are disliked by some but liked by others, depending on peer group norms and peers' typical behavior in bullying situations (cf. Sentse et al. 2007; Witvliet et al. 2010). And conversely, adolescents' involvement in bullying might depend on how their peers in the network behave, more specifically the peers they like most. These assumptions have not yet been tested explicitly but recent developments in methodology make it possible to do so currently. This detailed information on how bullying behavior develops in adolescents' social networks is directly relevant for establishing successful and targeted interventions, especially for secondary schools (see Kärnä et al. 2013; Smith 2010).

A Social Network Approach to Bullying

Longitudinal social network analysis (SNA) can model changes of relationships in a network (e.g., classroom) as well as behavioral changes. Doing this simultaneously and longitudinally, it is possible to model how behavior affects the development of peer relationships in a network, and how peer relationships affect students' behavioral development in a given period of time (Veenstra and Dijkstra 2011). The former refers to selection processes whereas the latter refers to influence processes. Selection and influence processes capture the interplay between peer relationships and behavior and have been found to be applicable to a wide range of behaviors, including aggressive behavior (see for a review Veenstra et al. 2013). Translating these processes to the current study, we will look at the extent to which bullying behavior affects who likes whom in the peer network and the extent to which these likeability relationships affect students' bullying behavior over time. Both processes can lead to peer group homogeneity in behavior, as found in previous studies into bullying (Salmivalli et al. 1997), and hence give us more insight into the origin of this behavioral homogeneity.

Selection and influence are not mutually exclusive and SNA can estimate both processes while accounting for shortcomings of conventional (regression) analyses (Steglich et al. 2010). Firstly, feedback processes between network selection and behavioral dynamics are unobserved between two time points and hence not modeled in previous statistical programs, which can lead to overestimation of selection as well as influence processes. SNA models these unobserved changes between time points by using a simulation procedure. Secondly, structural network effects (endogenous to network development) are known to play a role in friendship (or likeability) formation but are not controlled in conventional statistical programs. For example, transitivity (the friends of my friends become my friends) may account for friendship formation rather than similarity in bullying behavior and not controlling for transitivity may thus lead to overestimation of selection effects. Lastly, most previous statistical programs are

unable to account for the interdependencies in the data as independent observations are usually assumed in these programs. However, networks that contain information on all individuals in the network, their relationships, and their behaviors, are interdependent. These dependencies are controlled in SNA (Steglich et al. 2010).

Next to studying the interplay between bullying and likeability, we controlled for perceived popularity when estimating the selection and influence processes. Peer popularity, an indication of social dominance and power, is an important motive for why children engage in bullying (Cillessen and Mayeux 2004; Sijtsema et al. 2009). As such, it might be an alternative or additional explanation to peer influence for why adolescents, over time, engage in bullying. Especially in adolescence, when the transition to secondary school takes place, peer influence and group behavior become increasingly relevant (Bukowski et al. 1996). In addition, prioritizing popularity over socially accepted (likeable) behaviors peaks in early adolescence (LaFontana and Cillessen 2010). Therefore, when examining the interplay between bullying and likeability in adolescents' school networks just after the school transition (grades 7, 8, and 9), perceived popularity should be controlled both in network dynamics (selection similarity) and in behavioral dynamics in order to prevent overestimation of selection and influence effects. A similar argument goes for the inclusion of gender, as it is known that friendships and likeability relationships exist most often between same-gender individuals (Burk et al. 2007). In addition, it has been found that boys are more likely than girls to engage in bullying behaviors (Nansel et al. 2001). Again, not controlling for gender could lead to overestimation of selection similarity in bullying (when this selection effect is actually driven by being same gender) and peer influence effects (when changes in bullying behavior are actually driven by gender).

Hypotheses

Our data comprised complete classroom networks in grades 7, 8, and 9 covering one year each (three time points). In line with the theoretical arguments above and the existing literature on bullying and sociometric status we hypothesized that *over time* (1) engagement in bullying leads, on average, to being less liked in the peer network (peer avoidance effect; negative selection effect), (2) adolescents like similar others the most, that is they like peers who are similar to themselves in terms of bullying behavior (selection-similarity effect for bullying) after controlling for selection similarity in gender and perceived popularity, and (3) adolescents adapt their bullying behavior to the behavior of the students they like most (peer influence effect), after controlling for effects of gender and perceived popularity on (changes in) bullying behavior. The names of the specific effects through which our hypotheses can be evaluated are described in the method section.

Our data came from a large evaluation study of the KiVa antibullying program, and as such we were able to explore whether the social network processes in bullying differed between control and intervention schools. The content and the goals of the KiVa antibullying program are extensively described in Kärnä et al. (2013), and are based on the theoretical assumption that changing bystanders' behaviors will interfere with the rewards gained by bullies (i.e., a likeable and dominant position in the group) and hence their motivation to bully (Salmivalli et al. 1996). Intervention-related changes can be evaluated with three processes that can be estimated using social network analysis (cf. Gest et al. 2011). These intervention-related changes, as compared to control schools, correspond to our three earlier mentioned hypotheses: (1) a decrease in the tendency to like peers who engage in bullying, (2) a decrease in the degree to which students like peers who are similar to themselves in (the higher ranges of) bullying, and (3) students being more resistant to the influence of peers who engage in bullying (in line with Salmivalli 1999). However, these hypotheses on intervention-related network effects are still tentative and only serve as a stepping stone for an alternative way to evaluate group-based intervention effectiveness in future studies.

Methods

Participants and Procedure

In the fall of 2006, recruitment letters were sent to all 3,418 schools in mainland Finland. Of the 275 volunteering schools, 125 schools (either grades 1–3, 4–6, or 7–9) were randomly assigned to the control or intervention condition. The content of the KiVa antibullying program and its theoretical basis are described in detail elsewhere (Kärnä et al. 2013). For this study we focused on the lower secondary education, i.e., grades 7–9, which comprised of 78 schools (39 control and 39 intervention). Data were collected at three time points: May 2008 (pre-intervention test), December 2008, and May 2009. Four control schools dropped out without providing any data, and one intervention school participated only in the first wave of data collection which left us with 73 schools, of which 38 were intervention and 35 were control schools, consisting in total of 19,191 students. Of these students, 16,764 (87.4 %) had active parental consent to participate. After wave 1 there were students who dropped out (261) which reduced the sample to 16,503 students. However, as there were no

pretest (wave 1) measures for students who attended grade 7 during the intervention year, these students needed to be excluded from the sample, retaining a number of 11,070 students in 686 classrooms in 73 schools (attending either grade 7 or 8 during the pretest and grade 8 or grade 9 during the intervention year). Attrition and missing data were extensively inspected in Kärnä et al. (2013) and will therefore not be reported here.

To accommodate longitudinal social network analyses, we needed information of complete classroom networks present at all three waves with less than 20 % missingness (Ripley et al. 2013). As a consequence, classrooms in which only a few students (<10) participated at either wave were excluded from the analyses, as well as classrooms that only consisted in total of 10 students or less. The latter was decided in order to increase the reliability of peer reports and to increase the chance of good model convergence. There were 484 classrooms eligible (i.e., moderately stable and present at all three waves) for longitudinal network analyses which were part of 37 intervention schools and 30 control schools, of which 54 % were in grade 8 (grade 7 during pretest) and 46 % were in grade 9 (grade 8 during pretest). The total number of students was 9,183 (M age at wave 1 = 13.96 years; 49.2 % boys; M classroom size = 19.47, M school size = 176), with the majority being native Finnish and the percentage of immigrants being 2.4 %. All these 9,183 students were included in our analyses, despite the possibility of having missing values for variables at one of the waves, which were coded as such. That is, some adolescents may have been absent during one of the measurements (wave 1: 11.7 %; wave 2: 11.8 %; wave 3: 14.5 %) and hence provided no data on that particular occasion, but they could still be nominated by others and thus were part of the network.

Students completed internet-based questionnaires during regular school hours, under supervision of their teachers who received detailed instructions 2 weeks prior to data collection. Students were assured that their answers would not be revealed to teachers or parents. In addition, teachers were offered support through phone or e-mail prior to and during data collection. The order of the questions, items, and scales in the questionnaire were extensively randomized to alleviate any systematic order effect. At the beginning of the questionnaire, the term "bullying" was defined for the students based on the Olweus' Bully/Victim Questionnaire (Olweus 1996) definition, which emphasizes the repetitive nature of bullying and the power imbalance between bully and victim.

Measures

Likeability

From a list of classmates presented on the computer screen, students were asked to nominate an unlimited number of classmates they liked most. This question was asked at all three waves and formed our network of ties at the classroom level (see Table 1 for the means of like most nominations given and received at individual and classroom level). For each classroom, a matrix was created consisting of zero's and one's, indicting absence or presence of a *like most* nomination from one classmate to another. Note that in the analyses, all given and received likeability nominations were used, regardless of reciprocity. The SIENA program accounts for reciprocity via the inclusion of the reciprocity network parameter (see analysis strategy).

Bullying

Using the Participant Role Questionnaire (Salmivalli and Voeten 2004), students were presented with items describing different ways to behave in bullying situations, and they were asked to nominate an unlimited number of classmates who usually behaved in the way described in each item. The bullying scale consisted of three items; "Starts bullying", "Makes others join in the bullying", and "Always finds new ways of harassing the victim". The received peer nominations were totaled and divided by the number of possible nominators to account for differences in classroom size. Reliabilities between the three items were high at all three time points (Cronbach's alpha's were .94, .93, and .91, respectively). As SIENA requires ordered categories as dependent variables, the bullying scores were transformed into a 4-point ordinal scale (cf., Dijkstra et al. 2012; Sentse et al. 2013). We used increments of .50 around the mean of the continuous z-score as cut-off points (lowest through $-0.5 = 1$; -0.5 through $0 = 2$; 0 through $0.5 = 3$; 0.5 through highest $= 4$), with sufficient numbers of students in each category; see Table 1 for the percentages of students who are stable, decreasing, and increasing across waves.

Control Variables

Students also nominated peers for perceived popularity ("Choose three of your classmates who are the most popular in your class"). The received nominations were totaled and divided by the number of nominators, resulting in proportion scores ranging from 0.00 to 1.00. The scores at the first and the second wave were used as control variables for changes in likeability and bullying between waves one and two, and between waves two and three, respectively. In addition, gender entered the analyses as a covariate (0 = girls, 1 = boys).

Analytical Strategy

Analyses were conducted with SIENA (Simulation Investigation for Empirical Network Analyses) in R 3.0.2.

Table 1 Descriptive statistics for like most network, bullying, and popularity across waves and schools

	Wave 1			*Wave 2*			*Wave 3*		
	Total	Control	Intervention	Total	Control	Intervention	Total	Control	Intervention
Individual level									
Like most nominations									
Given: mean (SD)	4.64 (3.78)	4.52 (3.54)	4.72 (3.92)	4.57 (3.82)	4.63 (3.80)	4.52 (3.85)	4.15 (4.05)	4.11 (3.86)	4.17 (4.16)
Received: mean (SD)	4.14 (2.38)	3.98 (2.33)	4.24 (2.40)	3.99 (2.30)	4.09 (2.30)	3.93 (2.30)	3.46 (2.15)	3.42 (2.15)	3.49 (2.16)
Bullying (1–4)									
Mean (SD)	2.41 (1.17)	2.41 (1.17)	2.41(1.17)	2.41 (1.15)	2.42 (1.16)	2.41 (1.15)	2.42 (1.12)	2.42 (1.14)	2.40 (1.11)
Popularity (0–1)									
Mean (SD)	0.12 (0.18)	0.13 (0.19)	0.12 (0.18)	0.11 (0.17)	0.12 (0.18)	0.11 (0.17)	0.10 (0.15)	0.10 (0.16)	0.10 (0.15)
Classroom level									
Like most nominations									
Mean (SD)	79.61 (27.37)	75.65 (24.46)	82.16 (28.80)	78.28 (28.53)	79.21 (26.53)	77.68 (29.73)	67.43 (25.53)	65.92 (24.30)	68.39 (26.24)
Bullying (1–4)									
Mean: min–max	2.05–2.77	2.05–2.76	2.05–2.77	2.00–2.76	2.00–2.74	2.00–2.76	2.00–2.89	2.00–2.76	2.00–2.89

Transitions	*Wave 1–2*			*Wave 2–3*		
Bullying	Total (%)	Control (%)	Intervention (%)	Total (%)	Control (%)	Intervention (%)
Stable	51.1	50	51.8	51.2	48.2	53
Decrease	24.2	24.9	23.8	23.7	25.8	22.5
Increase	24.7	25.1	24.4	25.1	26	24.5

Columns "Total" represent 9,183 students from 484 classrooms in 67 schools; columns "Control" represent 3,586 students from 191 classrooms in 30 schools; columns "Intervention" represent 5,597 students from 293 classrooms in 37 schools

SIENA is an actor-based model for the co-evolution of social networks and individual behaviors over time (Ripley et al. 2013). Through an iterative Markov Chain Monte Carlo approach, SIENA estimates developmental changes between time points which are modeled in two types of dependent variables: network characteristics (likeability dynamics) and individual behaviors (bullying dynamics). SIENA simultaneously models changes in the *like most* network (*selection* when this originates from behavior) and changes in bullying behavior (*influence* when this originates from likeability relationships), while estimating effects of the covariates (gender, perceived popularity) and structural network effects (Burk et al. 2007; Steglich et al. 2010).

Controlling for endogenous network effects is an important way to account for the dependencies in our data as these consist of network ties within school classes (Steglich et al. 2010). Firstly, we controlled for the tendency of sparseness in the network, that is, there is selectivity of who likes whom in the network. This effect is expressed in the *density*, the number of outgoing ties. Secondly, via the *reciprocity* parameter we controlled for the tendency that nominations are likely to be reciprocated, reflecting mutual trust and affection in the likeability relationships (Hartup 1996). Thirdly, to control for local clustering and network closure which is known to be present in social relationships we included the *transitivity* parameter, which reflects the tendency to like the peers who are liked by peers one likes most (i.e., the friends of my friends become my friends as well). Finally, we controlled for a self-reinforcing effect in likeability nominations as expressed in the *likeability alter*, the tendency to like peers who have high in-degrees i.e. are liked by many others too.

We also estimated the following selection effects: *bullying alter* is the effect of bullying on being liked by others. A negative effect means that higher levels of bullying decrease the chance of being liked by peers; *bullying ego* is the effect of bullying on giving like most nominations to others; and *bullying similarity* is the extent to which students like peers who are similar to themselves on bullying. To interpret these three selection effects as a whole, ego-alter selection tables will be provided, showing at which levels the strength of attraction is higher or lower. Similarly, we also included these selection effects for perceived popularity (as time-varying covariate) and gender, i.e., the

extent to which *like most* nominations are related to popularity or gender of the student.

With regard to the behavioral dynamics, we included the following effects. *Bullying linear shape* is an intercept expressing the average tendency to low bullying (negative value) or high bullying (positive value). *Bullying quadratic shape* is a feedback effect of bullying on itself (Snijders et al. 2010). A negative value indicates a self-correcting effect (regression to the mean); a positive value is a self-reinforcing effect (regression to extreme values). The effect reflecting influence processes is *bullying average similarity*, or the tendency of students to become similar to the average bullying level of the peers they like most. Gender and perceived popularity again were added as covariates.

To increase the power of the relatively small classroom networks, we combined the classrooms pertaining to the same school and grade using structural zero's (see Ripley et al. 2013). The structural zero's indicate that nominations between classrooms were not possible. The models were then estimated separately for each network using all three time points and combined in a SIENA meta-analysis (Snijders and Baerveldt 2003). Next to a meta-analysis on the total sample, we performed meta-analyses on control schools and intervention schools separately to test whether the social network processes differed between control and intervention schools. Hence, the results to be discussed refer to the mean estimates as found in the meta-analyses for which also the between-school (network) variation will be reported (cf. Snijders and Baerveldt 2003). Whether parameter estimates of the control and intervention schools significantly differ from each other will be tested and reported using a test statistic for differences between independent groups (cf. Ripley et al. 2013; see also Rambaran et al. 2013).

Results

Descriptive Statistics

Table 1 includes the average number of *like most* nominations, given and received, and the means of the bullying measures for the students in all schools and separately for control and intervention schools. These trends will be accounted for in the behavioral dynamics in the SIENA models (linear shape effect). Bullying seemed stable over time (*overall* means), but variability over time *within* networks is still possible, which is tested in the network analyses. In addition, Table 1 shows how many students increased or decreased in incoming nominations for bullying over time; about 25 % of the students decreased or increased in bullying over time, whereas about 50 % of the students remained stable over time. Again, these percentages were similar for control and intervention schools.

Table 2 shows the correlations between the study variables. None of the correlations significantly differed between control and intervention schools. Being a boy correlated positively with bullying and perceived popularity, and negatively with receiving *like most* nominations. Popularity correlated highly across waves and, to a lesser extent, as well did bullying and *like most* nominations (both incoming and outgoing) across waves. Received *like most* nominations were negatively correlated with bullying at wave 3. Lastly, perceived popularity was only moderately associated with receiving *like most* nominations, which highlights that likeability and popularity are different constructs.

Social Network Analyses

Table 3 summarizes the results of the SIENA meta-analyses for all schools, control schools, and intervention schools. The results from the total sample will be discussed below unless there were indications of different trends between control and intervention schools.

Network Effects

The negative density parameter indicated that less than half of all possible *like most* relationships occurred, that is, students named fewer than half of their classmates as peers they liked most. The positive reciprocity parameter indicated that *like most* nominations were likely to be reciprocated, and this effect was stronger in control schools as compared to intervention schools ($z = 2.71$, $p < .01$). The positive transitive triplets parameter indicated that over time, students liked the peers who were liked by the ones they themselves liked most. Lastly, the negative likeability alter effect indicated that students did not prefer students who were already liked by many others, i.e., students did not become increasingly liked simply by being highly liked already.

Selection Effects

The positive gender and perceived popularity similarity parameters showed that students liked same-gender and similar-popularity peers more than students who are different on these variables. Students who were perceived as popular tended to receive and give more *like most* nominations than unpopular students, as indicated by the positive alter and ego effects. The latter effect was significantly higher for intervention schools as compared to control schools ($z = -3.22$, $p < .01$). The negative gender alter parameter indicated that boys were less likely than girls to receive *like most* nominations. For bullying, the negative alter and ego effects showed that students high on bullying

Table 2 Correlations among gender, like most nominations, bullying, and perceived popularity, across waves

	1.	2.	3.	4.	5.	6.	7	8.	9.	10.	11.	12.
1. Gender (1 = boy)		.05**	.00	−.02	−.05**	−.08**	−.11**	.40**	.36**	.29**	.08**	.06**
2. Like most given wave 1	.04*		.34**	.26**	.19**	.16**	.12**	.03	.03	.03	.05**	.06**
3. Like most given wave 2	.01	.30**		.32**	.16**	.19**	.16**	.02	.01	.02	.05**	.05**
4. Like most given wave 3	−.05**	.22**	.34**		.11**	.14**	.18**	−.05**	−.05**	−.04**	.02	.02
5. Like most received wave 1	−.04*	.22**	.15**	.09**		.63**	.52**	.01	.01	−.01	.32**	.31**
6. Like most received wave 2	−.11**	.21**	.19**	.14**	.62**		.60**	−.01	−.01	−.02	.26**	.30**
7. Like most received wave 3	−.10**	.15**	.16**	.19**	.48**	.62**		−.03*	−.03*	−.03*	.20**	.24**
8. Bullying wave 1	.40**	.07**	.05**	−.01	.01	.00	−.04*		.57**	.44**	.29**	.27**
9. Bullying wave 2	.36**	.06**	.03	−.01	.02	.01	−.01	.55**		.50**	.29**	.29**
10. Bullying wave 3	.32**	.04*	.03	−.04*	−.02	−.03*	−.05**	.44**	.48*		.23**	.25**
11. Popularity wave 1	.06**	.07**	.04*	.02	.35**	.27**	.22**	.27**	.26**	.19**		.79**
12. Popularity wave 2	.06**	.08**	.06**	.02	.34**	.32**	.26**	.26**	.28**	.22**	.80**	

* $p < .05$; ** $p < .01$. Below the diagonal for control schools, above the diagonal for intervention schools

were less likely to receive *like most* nominations and less likely to give *like most* nominations as compared to those low on bullying. There was also a significant selection-similarity effect for bullying, which in general means that students with similar levels of bullying liked each other more than students with different levels in bullying. However, we need Table 4 to interpret the bullying ego, alter, and similarity selection effects together. The numbers on the diagonal of Table 4 show that the selection-similarity effect was stronger at low levels of bullying, meaning that students low on bullying preferred others low on bullying more than students high on bullying preferred others high on bullying.

Influence Effects

The negative linear shape of bullying indicated an overall average tendency to low levels of bullying. The positive quadratic shape means that over time, students with higher bullying scores were more likely to turn to higher values, whereas students with lower bullying scores were likely to decrease even further in bullying (self-reinforcing or polarization effect). The changes in bullying were significantly influenced by gender and perceived popularity. Both positive parameters indicated that boys as well as popular students were more likely to increase in bullying over time than were girls or unpopular students, with the effect for gender being stronger in control schools than in intervention schools ($z = 2.01$, $p < .05$). In addition, changes in students' bullying were influenced by the bullying behavior of the peers they liked most. This was expressed in the positive average similarity effect. Table 5 shows the relative strength of this peer influence effect for the various average bullying scores of the peers who students liked most. The differences in the bottom rows are larger than in the top rows, indicating that students were more likely to increase in bullying when liking peers high on bullying (row 4) than to decrease in bullying when liking peers low on bullying (row 1).

Discussion

Previous studies suggest that engagement in bullying might explain, on average, low levels of likeability (e.g., Boulton and Smith 1994; Salmivalli et al. 1996), but these studies were often cross-sectional in design and the majority of these studies were conducted among children in elementary school. It is unclear how bullying and likeability co-develop over time in adolescence, and more specifically, how these processes evolve within a social network. The current study was set out to elucidate on previously found peer group homogeneity in bullying behavior (e.g., Salmivalli et al. 1997), by looking at selection and influence processes in adolescents' social networks. Using social network analysis on an adolescent sample of school classes in grades 7, 8, and 9, we were able to estimate both processes while accounting for shortcomings of conventional (regression) analyses (Steglich et al. 2010). Effects of perceived popularity, gender, and structural network effects were controlled and additionally we explored whether the processes differed between control and intervention schools during the implementation of a group-based anti-bullying program.

The results of this study firstly confirmed the effects related to network formation as found in previous network studies on friendships (Steglich et al. 2010), showing that there is selectivity in likeability nominations (indicated by a negative density), that nominations tend to be reciprocated (indicative of mutual trust and affection), that there is

Table 3 Meta-analyses of longitudinal social network modeling of like most networks and bullying behavior in grades 7-9

Network dynamics	All schools			Control schools			Intervention schools			Difference score[b]
	Est.	*SE*	*SD*	*Est.*	*SE*	*SD*	*Est.*	*SE*	*SD*	*z*
Density	−0.99***	.03	0.36[a]	−0.99***	.05	0.37[a]	−0.98***	.04	0.36[a]	0.22
Reciprocity	0.35***	.03	0.30[a]	0.43***	.04	0.27[a]	0.29***	.04	0.31[a]	2.71**
Transitivity	0.29***	.01	0.06[a]	0.28***	.01	0.05[a]	0.29***	.01	0.06[a]	−0.44
Likeability alter	−0.13***	.01	0.07[a]	−0.13***	.01	0.07[a]	−0.13***	.01	0.08[a]	−0.35
Gender alter (1 = boy)	−0.06**	.02	0.25[a]	−0.04	.04	0.28[a]	−0.07*	.03	0.23[a]	0.53
Gender ego	0.02	.02	0.24[a]	0.03	.03	0.24[a]	0.01	.03	0.24[a]	0.60
Gender similarity	0.58***	.02	0.18[a]	0.56***	.02	0.18[a]	0.60***	.02	0.19[a]	−1.40
Perceived popularity alter	1.63***	.06	0.70[a]	1.62***	.10	0.78[a]	1.65***	.08	0.64[a]	−0.22
Perceived popularity ego	0.60***	.06	0.65[a]	0.39***	.08	0.60[a]	0.75***	.08	0.64[a]	−3.22**
Perceived popularity similarity	0.97***	.05	0.52[a]	0.87***	.08	0.57[a]	1.04***	.06	0.47[a]	−1.75
Bullying alter	−0.03**	.01	0.13[a]	−0.05*	.02	0.14	−0.03*	.01	0.12[a]	0.87
Bullying ego	−0.03*	.01	0.13[a]	−0.01	.02	0.14[a]	−0.03*	.01	0.12[a]	0.99
Bullying similarity	0.36***	.10	1.05[a]	0.42**	.17	1.18[a]	0.32*	.12	0.96[a]	0.47
Behavioral dynamics										
Linear shape	−0.05***	.01	0.11	−0.04*	.02	0.11	−0.06***	.01	0.10	1.20
Quadratic shape	0.38***	.02	0.18[a]	0.36***	.02	0.14	0.39***	.03	0.23[a]	−0.91
Average similarity	5.08***	.79	8.36[a]	5.87***	1.67	11.85[a]	3.67***	.27	2.14[a]	1.30
Effect from gender	0.16***	.02	0.20	0.20***	.03	0.21	0.13***	.02	0.19	2.01*
Effect from popularity	0.65***	.06	0.63	0.54**	.08	0.61	0.75***	.08	0.64	−1.84

[a] Significant between-network variation in parameter

[b] Based on the estimated parameters and standard errors in two independent groups (control and intervention schools) with the formula $\frac{\hat{\beta}_a - \hat{\beta}_b}{\sqrt{S.E._a^2 + S.E._b^2}}$ (cf. Ripley et al. 2013)

* $p < .05$; ** $p < .01$; *** $p < .001$

Table 4 Ego-alter selection table for bullying in the total sample

Students' bullying	Peers' bullying			
	1	2	3	4
1	0.24	0.09	−0.07	−0.23
2	0.10	0.18	0.03	−0.13
3	−0.05	0.04	0.12	−0.03
4	−0.20	−0.11	−0.02	0.06

Numbers in the table reflect the strength of attraction for students to like certain peers based on their levels of bullying (columns dependent on rows)

Table 5 Ego-alter influence table for bullying in the total sample

Average bullying of most liked peers	Students' bullying			
	1	2	3	4
1	2.97	0.58	−1.06	−1.94
2	1.27	2.27	0.64	−0.24
3	−0.42	0.58	2.33	1.45
4	−2.12	−1.12	0.64	3.15

Numbers in the table reflect the strength of peer influence on certain levels of bullying for the student resulting from the average levels of their most liked peers' bullying (columns dependent on rows)

local clustering known as transitivity, and that there is no self-reinforcing effect in likeability nominations. The latter finding is in contrast to the "Matthew effect" (i.e., the rich get richer) that has typically been found in large networks such as infrastructures (Borgatti and Everett 1999) and it is therefore not surprising that such a hierarchical structure effect is not present in smaller, classroom based networks. Overall, after controlling for these structural effects, we found that (1) adolescents high on bullying were less likely to receive *like most* nominations (peer avoidance effect), (2) adolescents liked peers with similar levels of bullying the most and this selection-similarity effect was stronger at low levels of bullying, and (3) adolescents were influenced by their peers, being more likely to increase in bullying when they liked peers high on bullying than to decrease in bullying when they liked peers low on bullying. These effects were found above and beyond the effects of perceived popularity and gender on these developments in

likeability and bullying behavior. No significant differences between control and intervention schools appeared in the estimated effects of interest.

Bullying-Based Selection Effects

Based on theoretical accounts of the participant role approach to bullying (Salmivalli et al. 1996) and peer group homogeneity in bullying behavior (e.g., Huitsing and Veenstra 2012; Scholte et al. 2010), as well as previous research into bullying and social status, we had three hypotheses, of which two regarding the selection part of our model. Firstly, we hypothesized that, on average, bullying is not accepted behavior (Salmivalli et al. 1996). This hypothesis would be expressed in a negative tendency to like peers who engage in bullying. In line with this, we found that students high on bullying were less likely to receive *like most* nominations, and this applied equally to control and intervention schools. From previous research, we know that bullies are not well-liked by their peers (e.g., Boulton and Smith 1994) and this is in line with our finding. It must be said though that this effect was small (corresponding odds ratio of 0.49) and its significance may be resulting from our large sample size (and its low standard error). That being said, that bullies are not *more* disliked in intervention schools as compared to control schools is in contrast to what we expected and can have several reasons. Most importantly, it might be that some bullies have other, more attractive behavioral attributes that in a way compensate for their bullying behavior. For instance, some students may be strategic in their behavior, displaying pro-social behavior (e.g., helping) toward some peers while at the same time bullying other peers (Olthof et al. 2011). As such, these strategic bullies may still be well-liked by peers (Dijkstra et al. 2009). It would be interesting for future research to see how these behaviors (bullying, prosociality) co-evolve in social networks.

Secondly, we hypothesized that adolescents liked peers who were similar to themselves, resulting in peer group homogeneity. Consistent with this hypothesis, as well as other social network studies (e.g., Logis et al. 2013), we found a selection-similarity effect for gender and perceived popularity. This means that boys liked other boys more than girls and vice versa, and that adolescents liked peers with a similarly popular status in the group the most. Both effects are in line with pioneer theories on homophily (Lazarsfeld and Merton 1954) and similarity attraction (Byrne 1971), confirming that similarity attracts. Moreover, we found this selection-similarity effect also for bullying, indicating that students with similar levels of bullying liked each other more than students with different levels in bullying, even after accounting for the gender and popularity selection-similarity. The selection-similarity effect was stronger at low levels of bullying, meaning that students low on bullying preferred others low on bullying more than students high on bullying preferred others high on bullying. This selection-similarity is one explanation for the finding that peer cliques often engage in the same behavior in bullying situations (Huitsing and Veenstra 2012; Salmivalli et al. 1997). Again, there was no significant difference between control and intervention schools in this effect. This would indicate that homophily and similarity attraction are stronger forces in network development than the efforts of the antibullying program to decrease the likability of bullying behavior.

Bullying-Based Influence Effects

Our third hypothesis refers to the behavioral dynamics part of the social network model, and entailed that we expected peer influence with regards to bullying. In line with this, our results showed that changes in adolescents' bullying were influenced by the bullying behavior of the peers they liked most. The peer influence effect was found despite the overall tendency toward lower levels of bullying over time, and above and beyond the effects of gender and perceived popularity. That is, boys were more likely than girls to increase in bullying over time, and perceived popularity likewise explained higher engagement in bullying over time, consistent with arguments that social power and status are an important motivation to engage in bullying (Cillessen and Mayeux 2004; Sijtsema et al. 2009). The peer influence effect, next to selection-similarity, is a second explanation for the finding that peer cliques often engage in the same behavior in bullying situations (Salmivalli et al. 1997; Sentse et al. 2013).

Moreover, we found that adolescents were more likely to increase in bullying when they liked peers high on bullying than to decrease in bullying when they liked peers low on bullying. This again highlights the attractiveness of bullying behavior among adolescents, that is, they prioritize popularity over socially accepted behaviors (LaFontana and Cillessen 2010) and at the same time are more permissive towards bullying (Swearer and Cary 2003). It also highlights the difficulty for anti-bullying programs to effectively prevent or intervene in bullying in this age group, if adolescents are indeed less susceptible to intervention. It seems so, because we found no differences in the peer influence effect between control and intervention schools while we had expected that adolescents in intervention schools would be more resistant to the influence of peers who engage in bullying as compared to those in control schools (in line with Salmivalli 1999).

These non-significant differences in effects between control and intervention schools are consistent with the overall non-significant intervention effect on peer-reported

bullying in the multilevel study of Kärnä et al. (2013) among adolescents, whereas significant intervention effects were found in lower age groups (e.g., grades 3–6; Kärnä et al. 2011). As suggested by Kärnä et al. (2013), it might become increasingly difficult to change the classroom norms about bullying when students grow older. This might partly be due to the fact that, in secondary school, adolescents form less stable and cohesive groups than in primary school, with more than one classroom teacher (depending on the subject to be taught), which could make the group-based and teacher-dependent KiVa program less effective in decreasing bullying in secondary schools as compared to primary schools. Hence, more attention should be given to examining ways in which antibullying programs can be designed and implemented in secondary schools.

Limitations

This study also had some limitations. First, we had to construct ordered categories for the dependent bullying variable as required by the SIENA program. This implies that information got lost, although we limited the loss by avoiding a dummy variable indicating bullies versus non-bullies. Second, we have no information on how truly similar students become in bullying, as we do not know whether they are also bullying the same peers. There is some evidence that friends who are bullies share the same victims (Huitsing et al. 2012). Whether bullies target the same victims should be explored in future research on networks of bullying, victimization, and friendships (or likeability), using network questions specifying who bullies *whom* and who is bullied *by whom*. Third, our sample was representative for grades 7–9 in mainland Finland, but it is not clear whether the findings can be generalized to other countries or to other age-groups. Finally, although this study examined differences in network processes between control and intervention schools, it cannot be portrayed as an intervention-evaluation study. Even if the dynamics of bullying and likeability were similar across the two conditions, future studies should continue exploring ways in which intervention effects may be reflected in network dynamics related to bullying.

Conclusion

Our study demonstrated a different way of studying bullying in secondary schools by applying a social network approach that accounted for limitations subject to most previous studies in this area. As such, this study extended the existing literature by looking specifically at peer group homogeneity with regards to adolescents' bullying and likeability over time, while accounting for structural network effects and effects of gender and perceived popularity. Although no differences were found between intervention and control schools, which complemented a previous article on the KiVa antibullying program in grades 7–9 (Kärnä et al. 2013), it was shown that both selection and influence processes are relevant for studying changes in adolescents' bullying and network relationships.

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Author contributions MS conceived of the study, participated in its design and coordination, performed the statistical analysis, and drafted the manuscript; NK, RV, and CS participated in its design and coordination and helped to draft the manuscript. All authors read and approved the final manuscript.

Ethical standard Ethical standards were followed in the execution of this study. The manuscript does not contain clinical studies or patient data.

Conflict of interest The authors declare that they have no conflict of interest.

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