Chapter 3

Multidimensional similarity in multiplex networks

Friendships between same- and cross-gender bullies and same- and cross-gender victims

THIS CHAPTER IS BASED ON
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Similar peers are more likely to become friends, but it remains unclear how the combination of multiple characteristics, known as multidimensional similarity, influences friendships. This study aimed to investigate whether similarity in gender (attribute) and bullying or victimization (network position) contributes to friendships. The school-level networks of friendships and victim-bully relationships in 17 Dutch elementary schools (2,130 students) were examined using multiplex longitudinal social network models (RSiena). The results showed that friendships were more likely to occur between same-gender peers and between bullies sharing their targets of victimization. Multidimensional similarity (similarities in gender as well as bullying) increased the likelihood of friendships for same-gender bullies targeting the same victims, but not for same-gender victims sharing bullies. The findings underline the importance of unraveling the interplay between different dimensions of similarity for children’s relationships, and surpass unidimensional similarity based on single attributes.
MULTIDIMENSIONAL SIMILARITY IN MULTIPLEX NETWORKS
FRIENDSHIPS BETWEEN SAME- AND CROSS-GENDER BULLIES
AND SAME- AND CROSS-GENDER VICTIMS

Similarity is important for children's relational choices, such as friendships. It is assumed to facilitate agreement and understanding because similar peers are likely to share norms and values that are important to establish and maintain friendships (McPherson et al., 2001). By contrast, dissimilarity is assumed to lead to strain and tension in relationships (Sherif, Harvey, White, Hood, & Sherif, 1961). This may explain a strong regularity of social life, the “principle that a contact between similar people occurs at a higher rate than among dissimilar people” (McPherson et al., 2001, p. 416), called homophily. Homophily can be imposed by social structure, but an important source of homophily is also a preference to befriend similar peers (Kandel, 1978; Lazarsfeld & Merton, 1954; McPherson et al., 2001). Homophily preferences occur on several dimensions, including gender (Dijkstra et al., 2007; Mehta & Strough, 2009), ethnicity (Echols & Graham, 2018; Fortuin et al., 2014; Jugert et al., 2018; Moody, 2001; Quillian & Campbell, 2003; Rivas-Drake et al., 2017; Smith, Maas, & Van Tubergen, 2014a; Stark & Flache, 2012; Wittek et al., 2019), academic achievement (Flashman, 2012; Gremmen et al., 2017; Kretschmer et al., 2018), or music taste (Franken, Keijsers, Dijkstra, & Ter Bogt, 2017). In addition, recent research has found homophily mechanisms based on the position of individuals in the network; children with a structurally equivalent position in the network (e.g., friends of the same classmates or bullies of the same victims) are more likely to have a positive relationship (Echols & Graham, 2018; Huitsing et al., 2012).

Children can be similar to their peers on several dimensions. However, most researchers have focused on homophily based on one dimension (referring to either an attribute or a network position) at a time, whereas only a few studies investigated the effects of multidimensional similarity on friendship formation (Block & Grund, 2014; Kupersmidt et al., 1995; Schaefer, 2010). Although it is assumed that similarity in more than one dimension increases the likelihood of friendships, being similar on more than one attribute (e.g., gender, socio-economic status, ethnicity) had a diminishing marginal effect on friendship (Block & Grund, 2014).

Research on multidimensional similarity only accounted for similarity in multiple attributes, but did not examine the additional influence of similarity in network positions. Compared with given attributes, such as gender or ethnicity, behavior and network position are more actively and freely decided upon by the children themselves. Similarity in behavior and network position may therefore have a salient influence on children's friendships. We focus on two similarities that may contribute to friendships: gender similarity and similarity in network positions with regard to bullying and victimization; children sharing the same role in bullying (referring to being victims of the same bullies as well as bullies targeting the same victims) are more likely to form a positive peer
relationship over time, such as becoming friends or defending each other (see Figure 3.1; Huitsing et al., 2014; Rambaran et al., 2015). The interplay between different homophily mechanisms may be of specific importance in the context of bullying, in which the development of positive relationships with peers buffers against the negative impact of bullying experiences (Fox & Boulton, 2006; Hodges, Boivin, Vitaro, & Bukowski, 1999).

### 3.1 Theory

**Homophily Preferences**

There are several reasons why individuals are more likely to affiliate with similar others. Similarity simplifies relationships through increasing the predictability of other people’s behavior (Hamm, 2000; Ibarra, 1992). The costs of developing and maintaining friendships with similar peers are lower than for friendships with dissimilar peers (Felmlee et al., 1990). Peers who are similar are more likely to meet and have therefore more chances to form friendships than non-similar peers (Feld, 1982).

Following balance theory (Cartwright & Harary, 1956; Heider, 1946), befriending similar peers is preferred because it creates balance in relationships whereas befriending dissimilar peers leads to imbalance. Balance theory describes how people’s relations to persons, events or attributes influence their relationship to another person. In these triadic relationships (referring to relationships between two people and a third person,

*Figure 3.1.* Graphical representation of the mechanisms of sharing the same role as bullies (lower part) or as victims (upper part) on the formation of friendship ties
event, or attribute) balanced closure of relationships is preferred. This is achieved when people with a similar relation to a third person (e.g., in terms of bullying or victimization), event, or attribute (e.g., being same-gender) become positively related to each other. When people who are positively related to each other are, however, dissimilar in their relation to a third person, event, or attribute, such an imbalanced relationship creates tension. Individuals are then triggered to change their relationships in order to achieve a balanced state, because congruent relationships are perceived as more stable and comfortable.

Gender is the most salient attribute on which children base their friendship choices (e.g., Maccoby, 1998; Mehta & Strough, 2009; Smith-Lovin & McPherson, 1993). Boys and girls differ often in their friendship behaviors, with girls valuing affiliation and emotional closeness more in friendships than boys (Felmlee, 1999; Felmlee, Sweet, & Sinclair, 2012).

Research into homophily based on children's position in the network is relatively scarce. Positive ties are likely between children who are structurally similar in a negative network. For example, children tended to like and defend each other when they were victimized or rejected by the same classmates, and bullies or aggressors were likely to associate with each other when sharing their targets (Huitsing & Monks, 2018; Huitsing et al., 2014, 2012; Huitsing & Veenstra, 2012). Similarly, children who disliked the same classmates were likely to become friends (Rambaran et al., 2015). If victims were bullied by the same bullies, a friendship may not only be the result of a preference for a balanced and comfortable relationship, but could also be the result of a need for support to prevent or ease the negative consequences of bullying (Fox & Boulton, 2006; Hodges et al., 1999). For bullies targeting the same victims, a friendship may also be the result of peer contagion (Dishion & Tipsord, 2011), recognition of similarity in norm-deviating behavior, and the need for reinforcement of their behavior which may benefit their visibility and status in the peer group.

MULTIDIMENSIONAL SIMILARITY

The concept of multidimensional similarity originates from early work on individuals’ position in social space, examining individuals’ involvement in multiple dimensions or “social circles” in life (McPherson, 1983; Simmel, 1950, p. 135). Despite the longstanding tradition most studies only control for similarity in multiple dimensions, but do not examine the interplay between these dimensions. There are several reasons to assume that being similar in different dimensions, referring to multidimensional similarity, matters for friendships (Block & Grund, 2014). Being similar in more than one dimension creates more meeting opportunities, shared experiences, and interests, resulting in an increased likelihood of forming friendships. Consequently, same-gender peers who share the same role in bullying have an increased likelihood of becoming friends. Generally, it can be expected that being similar in more than one dimension increases friendship likelihood.

Studies on multidimensional similarity based on multiple attributes found that
individuals who were similar in several dimensions were more likely to become friends than individuals who were similar in only one dimension (Block & Grund, 2014; Kupersmidt et al., 1995; Schaefer, 2010). However, friendships between peers who were similar in two attributes were less likely than the mere additive effect of both homophily effects would suggest (Block & Grund, 2014). Specifically, for same-gender adolescents, additional similarity on ethnicity or socio-economic status increased the likelihood of a friendship only marginally. This reflects the idea of diminishing marginal returns, implying that additional similarity will result in smaller increases in the likelihood of friendship.

Whereas some dimensions (e.g., gender) are more salient in determining children’s friendship choices, other dimensions are less visible (e.g., sharing the same role in bullying; De Klepper, Sleebos, Van de Bunt, & Agneessens, 2010; Van Duijn, Zeggelink, Huisman, Stokman, & Wasseur, 2003). Previous research indicates that being similar in one dimension makes dissimilarity in another dimension less salient, creating opportunities for less visible dimensions to influence friendship formation (Block & Grund, 2014). Moreover, for peers who are dissimilar on a ‘first’ dimension, being similar on a ‘second’ dimension adds to the likelihood of friendships, even more so than is the case for peers who are already similar on the ‘first’ dimension.

THE PRESENT STUDY
We tested multidimensional similarity by investigating how (dis)similarity in gender and the role in bullying influences the formation and maintenance of friendships separately and simultaneously. We investigated whether being similar in one dimension diminishes the effect on friendship formation of the (dis)similarity in the other dimension. Previous research focused primarily on multidimensional similarity based on attributes. We tested the extension to multidimensional similarity based on attributes and network positions. Other than ascribed attributes (such as gender or ethnicity), behavior and network position result from children’s relational choices and may thus be a more salient indicator of personality and social similarity between children. We hypothesized that similar peers (referring to same gender, \(H1_a\), or sharing the role in bullying, \(H1_b\)) would be more likely to become friends or maintain friendships than dissimilar peers (referring to cross-gender peers or peers not sharing the same role in bullying). Moreover, we hypothesized that peers being similar on both dimensions (referring to same-gender peers who share the same role in bullying) would be more likely to become friends than peers being similar in only one dimension (\(H2\)). However, building on earlier research, the influence of multidimensional similarity on friendships was expected to be smaller than the mere addition of both homophily effects would suggest (diminishing marginal returns effect, \(H3\)). In line with the notion that similarity in salient behaviors and network position affects friendship formation more than similarity in fixed attributes, we further hypothesized that cross-gender peers who share the same role in bullying are more likely to become friends or maintain friendships than cross-gender peers who do not share the
same role in bullying ($H4$). That is, for children who share the same role in bullying, the negative effect of dissimilarity in gender on their friendship relationships is less salient.

We examined friendship and bullying school-level networks of 2,130 children (age 7- to 12-years-old) in 17 Dutch elementary schools using novel multiplex network descriptives and longitudinal social network models (stochastic actor-based models; Snijders et al., 2010). Friendships and bullying relationships are dynamic. Whereas friendships are proposed to be present for some time (Butts & Marcum, 2017), bullying involves a combination of long term, short term, and event-based relationships (Van der Ploeg, Steglich, & Veenstra, 2019). Stochastic actor-based models are necessary to account for these dynamics by examining the creation, maintenance, and dissolution of friendships and bullying relationships over time. Because friendships and bullying relationships are naturally interdependent, stochastic actor-based models are needed to investigate the simultaneous development of these behaviors (who is friends with whom, who is bullied by whom) and their interplay with gender.

### 3.2 Method

**Procedure**

Our data stem from control schools that participated in the research on the evaluation of the Dutch implementation of the KiVa anti-bullying program. Data were collected in May 2012 (6 to 8 weeks before the end of the school year; grades 2 to 5), October 2012 (6 to 8 weeks into the new school year; grades 3 to 6), and May 2013. After the pre-assessment in May 2012, schools were randomly assigned by the Netherlands Bureau for Economic Policy Analysis (CPB) to either the control condition (34 schools) or the intervention condition (66 schools). We included only control schools, who continued their usual ways of dealing with bullying in the classroom (“care as usual”). This enabled us to investigate the natural dynamics of children’s relationships in the interplay between friendships and bullying.

Students filled in internet-based questionnaires during regular school hours. The process was administered by the teachers, who were given detailed instructions concerning the procedure. In addition, teachers were offered support through phone or e-mail prior to and during the data collection. Teachers distributed individual passwords to the students, needed to log in to the questionnaire. Teachers were present to answer questions and to assist students when necessary. The order of the questions and scales was randomized so that the order of presentation would not affect the results.

Students were presented with five short videos, all in a school setting, in which a professional actress explained the goal of the questionnaire (“investigating the well-being of children at school”), how to fill in the questionnaire (including a sample item), and some basic rules, one of which being that students were not allowed to talk to each other about their answers. In these movies, it was explained that students’ answers would remain confidential, but that their teacher might receive general feedback to improve the classroom climate. In one of the videos the term bullying was defined in the way
formulated in Olweus’ bully/victim questionnaire (Olweus, 1996). Several examples covering different forms of bullying were given, followed by an explanation emphasizing the intentional and repetitive nature of bullying and the power imbalance.

Prior to the pre-assessment in May 2012 (and for new students prior to the other assessments), schools sent passive consent forms to the students’ parents. Students did not participate when their parents refused participation or when they themselves did not want to fill in the questionnaire. For all waves, the participation rate exceeded 98%. The main reasons for this high response rate are that the data were collected online and that students who incidentally missed the scheduled day of data collection could participate another time within a month.

PARTICIPANTS
Given that participating students were able to skip questions in the questionnaire, students might have missing values on some of the network questions. Out of the 34 control schools, we selected the 24 schools in which at least 80% of the children answered the network questions in at least one wave because we wanted networks that had a substantial proportion of participating children. In seven of these schools, we were unable to run our analyses (for several reasons; e.g., the Jaccard index in the bullying network was very low or there was a low number of bullying relationships). Table A3.1 in the appendix reports descriptive statistics on the seven excluded schools. The final sample consisted of 17 schools with 2,130 students in grades 2 to 6 (Dutch grades 3 to 8) at T1 and in grades 3 to 6 (Dutch grades 4 to 8) at T2 and T3 (Mage = 10 years, SD = 13 months). Boys and girls were equally represented.

MEASURES
In Dutch schools, children regularly change classrooms between school years, for example because grades are combined within one classroom. To overcome model estimation problems because of instability in the composition of the classroom, we measured friendships and bullying relationships on the school level. School-level networks contain more information on children’s peer relationships than the classroom-level networks.

Friendship. Children were asked to nominate both classmates and schoolmates they perceived as their best friends ("Who are your best friends?"). For the classroom-level nominations, children were presented with a roster showing the names of all classmates. For the school-level nominations, children could type the name of any student in school, using a search function to select the names of matching students from the database. Children could nominate an unlimited number of cross- and same-gender classmates.

Bullying. Children were first asked whether they were being victimized on any of the eleven self-reported Olweus’ (1996) bully/victim items, concerning general, physical, verbal (2 items), relational (2 items), material, cyber, racist, and sexual victimization and an open question. If they indicated that they were victimized at least once on any item,
they were asked whether they were victimized by classmates, other students from the school, or others outside the school. If children reported that they were victimized by classmates, they were asked "Who starts when you are victimized?" (classroom-level nominations), and if children were victimized by children from other classrooms, they were asked "By which students are you victimized?" (school-level nominations).

**Gender and age.** Girls were coded as 0 and boys were coded as 1. Children’s age in months was constructed by extracting children’s date of birth from the date of measurement.

**ANALYTICAL STRATEGY**

**Descriptive statistics.** We inspected common descriptive statistics of the friendship and bullying networks, including information about, for example, density and tie changes (see appendix). Information on the descriptive statistics of the observed data were used to examine whether our theoretically assumed model can be estimated in all schools. The inclusion of parameters in the model of which the corresponding configuration is absent in the data usually leads to convergence problems.

For the interplay between the networks, we inspected specific multiplex descriptive statistics to see how often the mechanisms we aim to test occur in the networks (see Table 3.3). For example, we examined how many times children shared the same role in bullying, and how often bullies or victims were friends. These multiplex descriptive statistics were derived using matrix multiplication (see Bonacich & Lu, 2012; Wasserman & Faust, 1994), and provided information on the presence of configurations in the empirically observed data.

**Stochastic actor-based models.** We examined the networks using stochastic actor-based models with RSiena (Simulation Investigation for Empirical Network Analyses in R, version 1.2.4, see Snijders et al., 2010). Stochastic actor-based models are statistical models for longitudinal social network data and can be used to analyze the co-evolution of multiple networks over time (Snijders, Lomi, & Torló, 2013). The model predicts changes between subsequent observed states of the networks and uses simulation to infer which social mechanisms have contributed to tie changes. Similarly to an agent-based model, the simulation consists of many small micro-steps. In each step, a probabilistically selected actor receives the opportunity to create or dissolve a network tie, or maintain the existing ties. In the simulations, actors’ decisions are based on effects that are assumed to be theoretically important for network formation (Ripley, Snijders, Boda, Vörös, & Preciado, 2019). The statistical model then selects the combination of effects that, according to the simulated network changes, yields the best approximation of the observed data.

The school-level networks were examined separately for the 17 schools with the same model specification. Parameters were fixed and tested using a score-type test when inclusion of the parameters resulted in convergence problems, for example because configurations were absent in the observed networks. Consequently, results for the
separate schools were summarized using the R-package metafor (Viechtbauer, 2010). Each parameter in the network model was treated separately in the meta-analysis. Average parameter estimates with standard errors were obtained using a restricted maximum likelihood estimator.

Based on parameter estimates in the model, conditional parameter estimates can be calculated for how likely a friendship relationship is to be created or maintained between certain actors compared to a baseline category (Krause, Huisman, & Snijders, 2018). The conditional parameter estimates consist of the effects that apply specifically to the actors of interest. For example, to examine the likelihood for same-gender actors who are in the same classroom to become friends, compared to the likelihood for cross-gender actors from different classrooms, we combine the same gender effect, the same class effect, and the interaction between both effects into a conditional parameter estimate. Table 3.1 specifies the parameter estimates used to calculate the conditional parameter estimates for the actors of interest in this study. The conditional parameter estimates of sets of actors can be compared using pairwise comparison tests for linear combinations of parameters. For example, to compare the likelihood of creating or maintaining a friendship tie for same-gender peers who are in different classrooms to the likelihood for same-gender peers who are in the same classroom, we tested whether the conditional parameter estimate for the first set of actors \( (PE_{same\ gender}) \) is different from the conditional parameter estimate for the second set of actors \( (PE_{same\ gender} + PE_{same\ classroom} + PE_{same\ gender \ast same\ classroom}) \). That is, we tested whether the linear combination of the parameters \( (PE_{same\ classroom} + PE_{same\ gender \ast same\ classroom}) \) was significantly different from 0. Comparison tests were carried out by testing the joint parameters and joint variances of the relevant variables using the metafor package (Viechtbauer, 2010). Joint variances given to metafor were calculated by summing the variances and two times the covariances of the variables. Joint parameters were calculated by summing the parameter estimates of the variables. Using the default restricted maximum likelihood estimator, metafor fits a random effects model to test the pairwise comparisons.

**Model specification.** The model consists of three main parts: *Uniplex structural*

### Table 3.1. Specification of the construction of conditional parameter estimates

| Shared bully | Not sharing a bully | Sharing a bully | Not sharing a victim | Sharing a victim |
|--------------|---------------------|-----------------|----------------------|-----------------|
| Cross-gender | Reference category  | SB               | Reference category   | SV              |
| Same-gender  | SG                  | SG + SB +       | SG                   | SG + SV +       |
|              |                     | SG*SB            |                      | SG*SV           |

*Note: SG = same gender; SB = shared bully; SV = shared victim.*
effects model how changes in each network (friendship, bullying) depend on the network itself (e.g., reciprocity, transitive closure); *multiplex structural effects* model the bullying and vice versa); *covariate effects* model how changes in each network depend on actor attributes (here: gender, age, and class). All models control for a set of general structural effects which reflect basic mechanisms underlying the formation of friendship and bullying networks, such as outdegree, reciprocity, and transitive closure. The set of dependence of change in each network on the other network (friendship depending on control effects we used are similar to ones used in previous studies into friendship and bullying (Gremmen et al., 2017; Huitsing et al., 2014, 2012; Rambaran et al., 2015; Sentse et al., 2013). The presented results concentrate on the effects that are relevant for our hypotheses, which are the multiplex effects and the actor covariate effects for gender in the friendship network. All other effects, including the uniplex effects, the actor covariate effects for age and class, and the effects for the bullying network are explained in the appendix. Table A3.4 in the appendix gives an overview of all effects, including graphical representations.

The analyses were separated into two models. Model 1 tested the basic mechanisms of gender homophily and sharing the same role in bullying and Model 2 included the interaction between the different homophily effects. Table 3.2 specifies the parameter estimates in the specific models used to test our hypotheses. The first hypothesis stated that similar peers would be more likely to become friends than dissimilar peers. To test hypothesis 1a for gender, we calculated how likely boys were to select boys or girls as their friends and vice versa. These likelihoods were calculated based on three covariate effects in Model 1: (1) the dyadic *same* effect captures whether ties are more likely to be created or maintained between same-gender children than between cross-gender children; (2) the *sender* effect captures whether boys are more likely to send ties than girls, (3) the *receiver* effect captures whether boys are more likely to receive ties than girls. To test hypothesis 1b for sharing the same bullies, we added a multiplex structural effect that examined whether nominating the same peers as bully increased the likelihood of friendships between victims in Model 1 (shared bullies mechanism; *shared outgoing bullying ties → friendship*; see Figure 3.1). Thus, we examined whether children are more likely to create new friendship ties or to maintain existing ones toward peers with whom they share bullies compared to those with whom they do not share bullies. Similarly, to test the first hypothesis for sharing the same victims, we added a multiplex structural effect that examined whether being nominated as a bully by the same victims increased the likelihood of friendships between bullies in Model 1 (shared victims mechanism; *shared incoming bullying ties → friendship*; see Figure 3.1).

Hypotheses 2, 3 and 4 considered the combination of homophily effects. Therefore, we added interaction effects between *same gender* and the effects for sharing the same role in bullying in Model 2 (*same gender * *shared outgoing bullying ties → friendship* and *same gender * *shared incoming bullying ties → friendship*). To test hypothesis 2 stating that peers being similar on both dimensions would be more likely to become friends than
### Table 3.2. Specification of the effects used to test the hypotheses

| Hypothesis | Effects used | Model | Results in Table |
|------------|--------------|-------|------------------|
| **H1** - Similar peers would be more likely to befriend each other than dissimilar peers | Gender: Boy: receiver, sender, SG | 1 | 3.5 |
| | Shared bullies: SB | 1 | 3.4 |
| | Shared victims: SV | 1 | 3.4 |
| **H2** - Peers who are similar on both dimensions would be more likely to become friends than peers who are similar in one dimension | Similar in both dimension vs. only same-gender: JP: $PE(SB) + PE(SG*SB)$, JV: $\text{var}(SB) + \text{var}(SG*SB) + 2*\text{cov}(SB & SG*SB)$ | 2 | 3.6 |
| | Similar in both dimensions vs. only shared bullies: JP: $PE(SG) + PE(SG*SB)$, JV: $\text{var}(SG) + \text{var}(SG*SB) + 2*\text{cov}(SG & SG*SB)$ | 2 | 3.6 |
| **H3** - The influence of multidimensional similarity on friendships would be smaller than the mere addition of both homophily effects would suggest | SG*SB | 2 | 3.4 |
| **H4** - Cross-gender peers who share the same role in bullying are more likely to become friends than cross-gender peers who do not share the same role in bullying | JP: $PE(SB)$, JV: $\text{var}(SB)$ | 2 | 3.6 |

*Notes.* For H2, H3, and H4, only the variant for shared bullies is reported. SG = same gender; SB = shared bullies; JP = joint parameters; JV = joint variances.

Peers being similar in only one dimension, we compared the conditional parameter estimates of the creation or maintenance of a friendship tie in dyads that are similar in both dimensions to the conditional parameter estimates of the creation or maintenance of a friendship tie between peers who are similar in only one dimension. Table 3.2 specifies which joint parameters and variances were used to calculate and compare the conditional parameters for hypothesis 2.

The interaction effects in Model 2 were also used to test hypothesis 3 that the influence of multidimensional similarity in friendships would be smaller than the mere addition of both homophily effects would suggest. A negative parameter estimate of the interaction effect would suggest a diminishing effect of multidimensional similarity. A positive estimate indicates that multidimensional similarity adds to the likelihood of the creation or maintenance of a friendship relationship over and above the separate homophily effects.

Finally, hypothesis 4, stating that cross-gender peers who share the same role in bullying are more likely to become friends than cross-gender peers who do not share the same role in bullying, was tested by comparing the conditional parameter estimates of the
creation or maintenance of a friendship tie between cross-gender peers who share the same role in bullying and cross-gender peers who do not share the same role in bullying. Table 3.2 specifies the joint parameters and variances used to calculate and compare these conditional parameter estimates.

3.3 RESULTS

MULTIPLEX NETWORK DESCRIPTIVES
Means and standard deviations of the multiplex configurations of the shared bullies and shared victims configurations are in Table 3.3. The table shows that, on average, there was a friendship in 7.0-7.7% of all dyads across all schools in the three waves (configuration 2). Whereas 11.5-12.8% of the same-gender dyads had a friendship (configuration 6), for cross-gender dyads this was less likely to occur with 2.4-2.6% (configuration 11), which was in line with the gender homophily assumption. Table 3.3 shows that of all victims sharing bullies, on average 14.3-16.8% were friends (configuration 4a). For bullies sharing victims, on average 25.7-27.2% were friends (configuration 4b). This indicates that there were more friendships between children when they share the same role in bullying than when they do not share the same role in bullying. In addition, there were more friendships between bullies than between victims who were in a similar network position.

Table 3.3 shows that the proportion of friendships increased for both same- and cross-gender victims when sharing bullies. Same-gender victims who share bullies were more often friends than cross-gender victims sharing bullies (on average 21.3-25.5% versus 5.5-7.5%; configuration 8a and 12a). Similarly, both same- and cross-gender bullies were more often friends when they target the same victims, with a higher likelihood for same-gender bullies (33.7-37.6% versus 9.7-10.5%; configuration 8b and 12b). This suggest that sharing the same role in bullying further contributes to friendships, over and above children’s gender.

NETWORK MODELS’ RESULTS
The discussion of the network models is limited to the multiplex effects and their interaction with gender (Table 3.4). The complete table, including uniplex effects, and the goodness of fit is provided in the appendix.

The coefficients for the sender-receiver and homophily selection effects for gender in Table 3.4 (Model 1) can be combined to calculate selection effects for friendship creation or maintenance in same- and cross-gender friendships (Table 3.5; Snijders et al., 2010). In line with hypothesis 1, friendships were gender segregated: Boy-boy (0.53) and girl-girl (0.55) friendships were more likely to occur than cross-gender friendships (boy mentioning girls: -0.02; girls mentioning boys: 0.002).

Model 1 in Table 3.4 further shows that victims sharing the same bullies were not more likely to become friends and maintain friendships than non-victims or victims not sharing bullies (shared bullies → friendship, $PE = 0.04, p = .35$). This parameter was fixed
Table 3.3. Descriptive statistics of shared bully and victim mechanisms across all schools

| Configuration | 1   | 2   | 3a  | 4a  | 5   | 6   | 7a  | 8a  | 9   | 10  | 11a | 12a |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| % of          | 1   | 1   | 3a  | 1   | 5   | 6   | 7a  | 1   | 9   | 9   | 11a | 12a |
| Wave 1        | 17376 | 7.0% | 6.0% | 16.6% | 50.3% | 11.5% | 6.2% | 24.4% | 49.7% | 2.4% | 5.8% | 7.5% |
|               | (20744.8) | (3.3) | (4.9) | (7.7) | (1.4) | (5.3) | (4.9) | (12.5) | (1.4) | (1.3) | (5.0) | (3.4) |
| Wave 2        | 16642 | 7.5% | 3.1% | 16.8% | 50.3% | 12.5% | 3.5% | 25.5% | 49.7% | 2.5% | 2.7% | 6.3% |
|               | (17301.3) | (4.1) | (2.3) | (9.2) | (1.2) | (6.5) | (3.2) | (16.1) | (1.2) | (1.8) | (1.8) | (6.2) |
| Wave 3        | 16203 | 7.7% | 2.7% | 14.3% | 50.2% | 12.8% | 2.8% | 21.3% | 49.8% | 2.6% | 2.5% | 5.5% |
|               | (17461.5) | (3.9) | (2.0) | (5.6) | (0.9) | (6.1) | (2.1) | (9.1) | (0.9) | (1.8) | (2.0) | (5.9) |

| Configuration | 3b  | 4b  | 7b  | 8b  | 11b |
|---------------|-----|-----|-----|-----|-----|
| % of          | 1   | 3b  | 6   | 7b  | 9   |
| Wave 1        | 5.9% | 27.2% | 7.4% | 35.9% | 4.3% |
|               | (4.9) | (16.0) | (6.2) | (20.6) | (3.7) |
| Wave 2        | 4.1% | 25.8% | 5.4% | 33.7% | 2.7% |
|               | (3.5) | (13.8) | (4.7) | (17.0) | (2.4) |
| Wave 3        | 3.8% | 30.5% | 4.9% | 37.6% | 2.7% |
|               | (3.8) | (17.0) | (5.0) | (23.4) | (2.6) |

Notes. Standard deviations are given between brackets. Solid lines indicate friendships, dotted lines indicate bullying relationships in the graphical representations of the configurations. Non-filled circles indicate that gender is not specified. White lines indicate that relationship is not specified. Presented percentages are nested. For example, 3a represents the percentage of dyads with shared bullies from the total number of possible dyads (1), and 4a presents the percentage of befriended dyads with shared bullies from the total number of dyads with shared bullies (3a).

1 Possible dyads (non-specified relationship). 2 Befriended dyads. 3 Dyads (non-specified relationship) with shared bullies/victims. 4 Befriended dyads with shared bullies/victims. 5 Possible same-gender dyads (non-specified relationship). 6 Befriended same-gender dyads. 7 Same-gender dyads (non-specified relationship) with shared bullies/victims. 8 Befriended same-gender dyads with shared bullies/victims. 9 Possible cross-gender dyads (non-specified relationship). 10 Befriended cross-gender dyads. 11 Cross-gender dyads (non-specified relationship) with shared bullies/victims. 12 Befriended cross-gender dyads with shared bullies/victims.
Table 3.4. *Multiplex RSiena meta analysis for friendship*

| Parameter | PE   | (SE) | p     | N schools |
|-----------|------|------|-------|-----------|
| **Uniplex actor covariate effects** |       |      |       |           |
| Boy       |      |      |       |           |
| Receiver  | 0.002| (0.02)| .93   | 17        |
| Sender    | -0.02| (0.02)| .48   | 17        |
| Same gender | 0.55 | (0.02)| <.001 | 17        |
| **Multiplex structural effects** |       |      |       |           |
| Shared bullies → friendship | 0.04  | (0.05)| .35   | 16        |
| Shared victims → friendship | 0.18  | (0.05)| <.001 | 17        |

**Model 2**

| Parameter | PE   | (SE) | p     | N schools |
|-----------|------|------|-------|-----------|
| Boy       |      |      |       |           |
| Receiver  | -0.004| (0.02)| .87   | 17        |
| Sender    | -0.02 | (0.02)| .61   | 17        |
| Same gender | 0.58 | (0.03)| <.001 | 17        |
| **Multiplex structural effects** |       |      |       |           |
| Shared bullies → friendship | -0.56 | (0.52)| .29   | 16        |
| Shared victims → friendship | 0.55  | (0.23)| .02   | 17        |
| **Multiplex actor covariate effects** |       |      |       |           |
| Same gender * shared bullies → friendship | -0.08 | (0.09)| .36   | 11        |
| Same gender * shared victims → friendship | -0.05 | (0.17)| .77   | 13        |

Notes. The models also account for the baseline network and network change effects of friendship and bullying; see appendix for the complete models. The parameter values are part of the objective functions of actors, which expresses how likely it is for the actors to change their network ties. Higher values of (effects in) the objective function can be interpreted as preferences for the creation or maintenance of specific relationships.

in one of the seventeen schools (the score-type test was non-significant, indicating that the parameter did not add significantly to the model). Bullies targeting the same victims were more likely to become friends than non-bullies or bullies who do not target the same victims (shared victims → friendship, $PE = 0.18$, $p < .001$). These results therefore are partly in line with hypothesis 1, showing that same-gender peers and bullies targeting the same victims are more likely to become friends, but not victims bullied by the same bullies.

To test hypothesis 2 (peers who are similar to each other on two dimensions are more likely to become friends than peers who are similar in only one dimension), Table 3.6 reports the conditional parameter estimates for the combinations of main and interaction homophily effects for victims sharing bullies (left part of Table 3.6). Same-gender victims sharing bullies were more likely to create or maintain friendships ($PE = 0.61$) than cross-gender victims sharing bullies ($PE = 0.12$; $z = 4.60$, $p < .001$). Nevertheless, same-gender victims sharing bullies were not more likely to become friends
Table 3.5. Sender-receiver selection effects for gender in the friendship network based on Model 1

| Sender  | Receiver |  |  |
|--------|---------|---|---|
|        | Girl    | Boy |
| Girl   | 0.55    | 0.002 |
| Boy    | -0.02   | 0.53  |

than same-gender victims not sharing bullies (\(PE = 0.56; z = 0.83, p = .40\)). Thus, being same-gender increased the likelihood for victims who share bullies to become friends, but sharing bullies was not found to contribute to friendships for same-gender victims, partially in line with hypothesis 2.

For bullies sharing victims (right part of Table 3.6), the results are in line with hypothesis 2; sharing both similarities increased the likelihood to become friends compared to both unidimensional homophily effects. Same-gender bullies targeting the same victims were more likely to create or maintain friendships (\(PE = 0.74\)) than cross-gender bullies sharing targets (\(PE = 0.21; z = 4.23, p < .001\)) and same-gender bullies not sharing their targets (\(PE = 0.55; z = 3.32, p < .001\)).

Hypothesis 3 (the influence of multidimensional similarity is smaller than the mere additive effect of both homophily effects would suggest) is examined by testing the interaction effects between same-gender and sharing the same role in bullying. Model 2 in Table 3.4 shows that both interaction effects were not statistically significant (same gender * shared bullies \(\rightarrow\) friendship, \(PE = -0.08, p = .36\); same gender * shared victims \(\rightarrow\) friendship, \(PE = -0.05, p = .77\)). This indicates that the influence of being similar on both dimensions was not found to be larger than the mere additive effect of both homophily effects.

Finally, Table 3.6 shows that both cross-gender victims targeted by the same

**Table 3.6. Parameter estimates of different combinations in interactions**

|                                            | Shared bullies (n = 11) | Shared victims (n = 13) |
|--------------------------------------------|-------------------------|------------------------|
|                                            | Not sharing bullies     | Sharing bullies        | Not sharing victims | Sharing victims |
| Cross-gender                               | 0                       | \(p = .14\)            | 0.12                 | 0             | \(p = .19\)            | 0.21                 |
|                                            | \(p < .001\)            | \(p < .001\)           | \(p < .001\)         | \(p < .001\) |
| Same-gender                               | 0.56                    | \(p = .40\)            | 0.61                 | 0.55          | \(p < .001\)            | 0.74                 |

**Notes.** Conditional parameter estimates were only calculated for schools in which all relevant effects were estimated. Conditional parameter estimates for each type of dyad were calculated, see Table 3.1, and compared to each other. The differences between the parameter estimates were tested using pairwise comparison tests, for which \(p\) values are given.
bullies and cross-gender bullies sharing victims were not more likely to become friends than cross-gender who do not share the same role in bullying (shared bullies: $PE = 0.12; z = 1.48, p = .14$; shared victims: $PE = 0.21; z = 1.30, p = .19$). Although both effects are in the expected direction, these results do not support hypothesis 4, stating that cross-gender peers who share the same role in bullying are more likely to become than cross-gender peers who do not share the same role in bullying.

### 3.4 DISCUSSION

This study investigated whether multidimensional similarity, referring to similarity on multiple dimensions, is an important factor driving children’s friendship choices. Although it can be expected that similarity in more than one dimension increases the likelihood of friendships, being similar in more than one attribute may have a diminishing marginal effect on friendship formation (Block & Grund, 2014). We tested multidimensional similarity based on attributes as well as the position of children in the bullying network. Moreover, we investigated whether being similar in one dimension diminished the salience and importance of (dis)similarity in the other dimension. Overall, multidimensional similarity increased the likelihood of creating or maintaining a friendship for same-gender bullies targeting the same victims, but not for same-gender victims targeted by the same bullies.

**HOMOPHILY PREFERENCES**

In line with our first hypothesis, children were more likely to become friends with same-gender peers than cross-gender peers. Also, bullies sharing victims were more likely to create or maintain friendships than non-bullies or bullies who do not share victims. These findings are in line with balance theory (Cartwright & Harary, 1956; Heider, 1946), suggesting that befriending similar peers is preferred because it facilitates balanced closure, whereas befriending dissimilar peers is less likely to occur in order to avoid tension and conflict. Whereas the proportion of victims (being victimized by the same bullies) having a friendship was descriptively larger compared to the overall proportion of children having a friendship, we did not find in the longitudinal network models that victims were more likely to become friends than non-victims. For these shared bullies configurations, our findings were not in line with our first hypothesis.

These mixed results for sharing the same role in bullying are largely in line with previous research. Whereas we did not find a friendship effect for victims sharing bullies, previous research found this effect on defending relationships between victims (Huitsing et al., 2014; Huitsing & Veenstra, 2012), although this effect for positive relationships was also estimated weaker for victims than for bullies. Friendships may be more intensive to establish than defending relationships. Our findings suggest that friendships between bullies are more pronounced than friendships between victims (see also Huitsing et al., 2014). Children’s perception of the risk of being victimized may make victims reluctant to befriend other victims (Sentse et al., 2013), potentially explaining the absence of the
shared victims mechanisms. Results in the appendix, however, showed that in our analyses, bullies were not found to bully the friends of their victims over time. Nevertheless, victims may be reluctant to befriend other victims, irrespective of whether this risk actually exists or not.

Furthermore, the shared bullies configuration may not only be the result of a selection mechanism in which bullies of the same victims select each other as friends, it could also be the result of an influence mechanism on children’s bullying behavior. Namely bullies who tend to bully the victims of their friends (see for such a initiating bullying hypothesis: Huitsing et al., 2014; Rambaran, Dijkstra, & Veenstra, 2019; Veenstra & Huitsing, 2020). Results in the appendix found support for such an effect. Nevertheless, even after controlling for influence, the selection effect of shared bullies was found to contribute to the formation of children’s friendship ties. Moreover, both mechanisms resulting in befriended bullies who target the same victims contributed to bullies’ social position in the peer group (Sentse, Kiuru, Veenstra, & Salmivalli, 2014). Whereas befriending other victims may put victims at risk, befriending other bullies may have benefits. Therefore, becoming friends with peers who share the same role in bullying may be more beneficial for bullies than for victims.

MULTIDIMENSIONAL SIMILARITY

On multidimensional similarity, we found that not all combinations of dimensions increased the likelihood for friendships. Same-gender victims sharing bullies were more likely to become friends than cross-gender victims sharing bullies, but they were not more likely to become friends than same-gender victims not sharing bullies. Thus, only being same-gender had an additional contribution on friendships for victims sharing their bullies, which is partly in line with the ideas on multidimensional similarity. For bullies sharing victims, however, we found that being similar in both dimensions (referring to same-gender bullies sharing victims) increased the likelihood of creation or maintenance of a friendship compared to being similar in either of the two dimensions, which is in line with our second hypothesis. These results suggest that clear-cut categorization into bullies and victims that characterizes the bullying network does not map onto a similarly clear-cut distinction between different layers in the friendship network.

We did not find support for our third hypothesis, posing that, multidimensional similarity for friendships is smaller than the additive effect of both homophily effects would suggest. The interactions between the different homophily mechanisms were non-significant, not supporting the expectation that the influence of similarity in one dimension on the formation and maintenance of friendships is diminished for dyads who are similar or dissimilar in another dimension. The likelihood of forming or maintaining friendships when dyads are similar in both dimensions does not seem to be different from what we would expect based on the separate homophily effects. This finding is not in line with previous research that found that being similar in more than one dimension had a diminishing marginal effect on friendship (Block & Grund, 2014). That previous study
examined homophily based on two fixed attributes simultaneously, but we investigated similarities in two different types of dimensions (referring to attribute and network position based on bullying behavior). It could be that multidimensional similarity only had a diminishing marginal effect on friendship formation when the similarity is based on the same type of dimension. By investigating multiple combinations of different types of dimensions, further research may examine the influence of multidimensional similarity in more detail.

Finally, we did not find that cross-gender bullies or victims were more likely to become friends when sharing victims or bullies. Our results therefore did not support our fourth hypothesis that for children who share the same role in bullying, the negative effect of dissimilarity in gender on their friendship relationships is less salient. These findings suggest that gender boundaries in children’s friendship relationships are stronger than the need to prevent victimization and find support for victims and the ability to secure and expand visibility in the peer group for bullies.

STRENGTHS, LIMITATIONS, AND FUTURE DIRECTIONS

Our study relates to two relatively new fields of research. So far only a few researchers have investigated the longitudinal interplay between multiple peer networks (Berger & Dijkstra, 2013; Kisfalusi, Takács, & Pál, 2019; Pál et al., 2016; Rambaran et al., 2015; Stadtfeld, Vörös, Elmer, Boda, & Raabe, 2019). Furthermore, research on the impact of multidimensional (dis)similarity on friendship formation is only emerging. By investigating multidimensional similarity using multiplex network analyses, we bridged both fields.

Gender homophily is a stable and well-acknowledged feature of children’s peer relationships and our study shows that gender influences other relationship dynamics. This may be of interest for further research that wants to investigate ways to cross boundaries in children’s friendships, including ethnic and socio-economic status boundaries.

In interpreting our findings it should be taken into account that we selected schools with a substantial number of bullying relationships; seven schools were excluded from the analyses. In addition, parameters were fixed to facilitate convergence in several models. Schools might, however, differ in the extent to which mechanisms, such as sharing the same role in bullying, influence friendships and the role of gender in friendship networks. Examining the impact of network structure (e.g., density, number of ties) and school characteristics (e.g., gender composition, size, pedagogical mission) on relationship dynamics would be an avenue for further research.

Because of the complexity of our models, we were able to examine the gender of the bullies targeting the same victims and victims bullied by the same bullies only. An interesting follow-up question would be whether the gender of the third person involved matters for the friendship formation between bullies and victims alike. Does the likelihood of a friendship between same-gender bullies differ between bullying same-
gender peers and bullying cross-gender peers? A potential problem with this approach might be that a lot of possible gender-combinations in triads are theoretically and empirically possible. A large dataset would be needed to answer this question.

We used victim-reported bullying. Perspectives from bullies, peers, or teachers may also be relevant (Huitsing et al., 2019; Veenstra et al., 2007). Victims and bullies differ in their perception of bullying behavior. Consequently, our findings on bullies sharing victims could also be attributed to other factors influencing children’s friendships. For example, given that bullies are often popular (De Bruyn, Cillessen, & Wissink, 2010), peers who are mentioned by the same schoolmates as bullies may become friends because they are both popular.

In conclusion, we investigated how the interplay between gender similarity and sharing the same role in bullying influence friendships in schools. Same-gender peers and bullies who share victims were likely to become friends over time. Moreover, multidimensional similarity increased the likelihood of friendship for same-gender bullies targeting the same victims, but not for same-gender victims targeted by the same bullies. By taking into account multidimensional aspects of similarity, we were able to show the importance of considering simultaneously the interplay between important mechanisms underlying children’s peer relationships.
Appendix Chapter 3
## DESCRIPTIVE STATISTICS ON THE SEVEN EXCLUDED SCHOOLS

Table A3.1. Descriptive statistics of friendship and bullying networks across 7 deselected schools \((N_{\text{total}} = 736 \text{ students}; N_{\text{mean}} = 105; N_{\text{minimum}} = 30; N_{\text{maximum}} = 264)\)

| Variable                | Friendship networks | Bullying networks |
|-------------------------|---------------------|-------------------|
|                         | Wave 1 | Wave 2 | Wave 3 | Wave 1 | Wave 2 | Wave 3 |
| **Gender**              |         |        |        |        |        |        |
| Boy                     | 51.6%   | 47.7%  | 49.8%  | 50.3%  | 49.4%  | 50.1%  |
| Girl                    | 48.4%   | 52.3%  | 50.2%  | 49.7%  | 50.6%  | 49.9%  |
| **Age**                 |         |        |        |        |        |        |
| Wave 1                  | 115 (1.86) | 14.74 (0.86) | 88 (4.60) | 138 (1.42) |
| Wave 2                  | 119 (3.31) | 13.42 (1.33) | 94 (4.01) | 139 (0.61) |
| Wave 3                  | 124 (3.42) | 12.69 (1.13) | 100 (3.83) | 145 (0.42) |
| **Density**             | .07 (.03) | .08 (.05) | .08 (.05) | .02 (.01) | .01 (.01) | .01 (.01) |
| **Average degree**      | 5.06 (4.77) | 4.98 (1.19) | 545.8 (536.7) | 518.8 (94.8) |
| **Number of ties**      | 554 (536) | 536 (546) | 101 (107) | 75 (94.8) |
| **% ties outside the classroom** | 17% (9.34) | 19% (6.37) | 21% (15.27) | 29% (22.11) |
| **Mutual dyads**        | 268 (268.7) | 286 (268.6) | 4 (6) | 2 (3.73) |
| **Asymmetric dyads**    | 540 (519.4) | 516 (497.0) | 182 (198) | 145 (187.2) |
| **Total sample (students)** |         |        |        |        |        |        |
| Percentage of sinks\(^b\) | 4% (7.30) | 5% (9.06) | 1% (1.09) | 30% (4.31) | 20% (13.2) | 19% (8.55) |
| Percentage of sources\(^b\) | 2% (2.49) | 3% (2.80) | 1% (1.11) | 19% (4.22) | 14% (8.56) | 14% (5.92) |
| Percentage of isolates\(^b\) | 9% (9.21) | 17% (9.94) | 16% (11.11) | 35% (13.61) | 51% (24.88) | 59% (19.82) |
| Percentage of actives\(^b\) | 85% (13.07) | 75% (11.35) | 82% (10.98) | 16% (11.19) | 15% (11.35) | 8% (7.11) |

**Tie changes**

|                    | Wave 1 | Wave 2 | Wave 3 | Wave 1 | Wave 2 | Wave 3 |
|--------------------|--------|--------|--------|--------|--------|--------|
| Creating tie \((0 \rightarrow 1)\) | 243 (227.9) | 233 (223.7) | 87 (111.3) | 51 (60.6) |
| Dissolving tie \((1 \rightarrow 0)\) | 260 (237.2) | 223 (241.4) | 81 (69.5) | 82 (96.2) |
| Stable tie \((1 \rightarrow 1)\)     | 288 (303.3) | 311 (293.3) | 19 (23.9) | 24 (39.5) |

**Jaccard index**

|                | Wave 1 | Wave 2 | Wave 3 |
|----------------|--------|--------|--------|
| \(\text{Jaccard index}\) | .28 (.13) | .42 (.03) | .08 (.04) | .10 (.08) |

Notes. \(^a\) The frequency distribution of nominal variables is indicated in percentages. \(^b\) Sinks are actors with zero out-ties and at least one in-tie; Sources are actors with at least one out-tie and zero in-ties; Isolates are actors with zero in-ties and zero out-ties; Actives are actors with at least one out-tie and as well as one in-tie.
Table A3.2. Descriptive statistics of shared bully and victim mechanisms across 7 deselected schools

| Configuration | % of | 1   | 2   | 3a  | 4a  | 5   | 6   | 7a  | 8a  | 9   | 10  | 11a | 12a |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Wave 1        |      | 12594| 9.5% | 3.9% | 17.4%| 50.5%| 15.2%| 3.6% | 28.8%| 49.5%| 3.6% | 4.1% | 6.3% |
| (17655.2)     |      | (5.3)| (4.5)| (8.6)| (2.6)| (7.9)| (4.4)| (15.6)| (2.6)| (2.1)| (4.7)| (4.9)|      |
| Wave 2        |      | 11966| 11.6%| 5.1% | 13.5%| 50.7%| 18.5%| 5.2% | 20.4%| 49.3%| 4.5% | 5.4% | 4.0% |
| (17094.9)     |      | (6.7)| (6.7)| (7.6)| (3.5)| (10.2)| (5.8)| (11.0)| (3.5)| (3.3)| (9.5)| (7.2)|      |
| Wave 3        |      | 11873| 12.4%| 2.4% | 28.4%| 50.6%| 19.4%| 3.2% | 28.8%| 49.4%| 5.2% | 1.6% | 13.2%|
| (16976.9)     |      | (7.3)| (2.9)| (22.9)| (3.6)| (10.8)| (4.0)| (31.7)| (3.6)| (3.9)| (1.8)| (18.3)|      |

| Configuration | % of | 1   | 3b  | 4b  | 7b  | 8b  | 11b | 12b |
|---------------|------|------|------|------|------|------|------|------|
| Wave 1        |      | 6.3% | 32.6%|      |      |      |      |      |
| (5.4)         |      | (10.3)|      |      |      |      |      |      |
| Wave 2        |      | 9.2% | 26.1%|      |      |      |      |      |
| (12.9)        |      | (15.9)|      |      |      |      |      |      |
| Wave 3        |      | 3.7% | 38.1%|      |      |      |      |      |
| (5.2)         |      | (13.1)|      |      |      |      |      |      |

Notes. Standard deviations are given between brackets. Solid lines indicate friendships, dotted lines indicate bullying relationships in the graphical representations of the configurations. Non-filled circles indicate that gender is not specified. White lines indicate that relationship is not specified. Presented percentages are nested. For example, 3a represents the percentage of dyads with shared bullies from the total number of possible dyads (1), and 4a presents the percentage of befriended dyads with shared bullies from the total number of dyads with shared bullies (3a).

1 Possible dyads (non-specified relationship). 2 Befriended dyads. 3 Dyads (non-specified relationship) with shared bullies/victims. 4 Befriended dyads with shared bullies/victims. 5 Possible same-gender dyads (non-specified relationship). 6 Befriended same-gender dyads. 7 Same-gender dyads (non-specified relationship) with shared bullies/victims. 8 Befriended same-gender dyads with shared bullies/victims. 9 Possible cross-gender dyads (non-specified relationship). 10 Befriended cross-gender dyads. 11 Cross-gender dyads (non-specified relationship) with shared bullies/victims. 12 Befriended cross-gender dyads with shared bullies/victims.
**DESCRIPTIVE STATISTICS ON THE 17 INCLUDED SCHOOLS**

**Table A3.3.** Descriptive statistics of friendship and bullying networks across all 17 schools  
\(N_{\text{total}} = 2130\) students; \(N_{\text{mean}} = 125; N_{\text{minimum}} = 53; N_{\text{maximum}} = 306\)

| Variable            | Mean       | Standard deviation | Minimum | Maximum |
|---------------------|------------|--------------------|---------|---------|
| **Age**             |            |                    |         |         |
| Wave 1              | 116 (2.44) | 13.63 (0.97)       | 94 (3.40) | 139 (0.63) |
| Wave 2              | 119 (2.25) | 12.30 (1.05)       | 94 (4.06) | 140 (0.37) |
| Wave 3              | 124 (3.84) | 11.96 (2.42)       | 94 (6.60) | 144 (1.03) |
| **Friendship networks** |          |                    |         |         |
| Density             | .06 (.03)  | .06 (.03)          | .02 (.02) | .01 (.00) |
| Average degree      | 5.87       | 6.16               | 170     | 128     |
| Number of ties      | 739        | 766                | 170     | 128     |
| % ties outside the classroom | 18% | 22%               | 23%     | 28%     |
| Mutual dyads        | 370        | 370                | 16      | 9       |
| Asymmetric dyads    | 719        | 779                | 303     | 237     |
| Total sample (students) |        |                    |         |         |
| Percentage of sinks \(a\) | 4% | 4%                | 24%     | 26%     |
| Percentage of sources \(a\) | 2% | 1%                | 19%     | 16%     |
| Percentage of isolates \(a\) | 6% | 6%                | 31%     | 40%     |
| Percentage of actives \(a\) | 88% | 89%               | 26%     | 18%     |

**Tie changes**

| Creation (0 → 1) | Dissolution (1 → 0) | Stable (1 → 1) | Jaccard index |
|------------------|---------------------|----------------|---------------|
| 355 (217.1)      | 332 (223.7)         | 91 (54.2)      | .38 (.06)     |
| 332 (224.5)      | 306 (177.2)         | 133 (86.0)     | .41 (.05)     |
| 405 (218.8)      | 441 (263.6)         | 36 (24.0)      | .14 (.04)     |

Note.  
1. **Sinks** are actors with zero out-ties and at least one in-tie; **Sources** are actors with at least one out-tie and zero in-ties; **Isolates** are actors with zero in-ties and zero out-ties; **Actives** are actors with at least one out-tie and as well as one in-tie.
ANALYTICAL STRATEGY (continued)

MODEL SPECIFICATION

Table A3.4 provides an overview of all effects, including graphical representations. All control effects were estimated freely in our models. Parameters were fixed and tested using a score-type test when configurations were absent in the observed networks.

Uniplex structural effects. Uniplex structural effects were added to the model to capture the basic tendencies of actors to form and maintain relationships. In friendship networks, actors generally have a tendency to form and maintain ties, but friendships come with certain costs; this is captured by the outdegree effect that is usually estimated negatively. Friendship networks are further characterized by high levels of reciprocity, or the tendency of actors to reciprocate friendships (actor $i$ nominates $\rightarrow$ actor $j$ which implies that actor $j$ $\rightarrow$ actor $i$). In addition, friendship networks are often transitive. Therefore, we included two transitivity effects in the friendship networks. First, we included the transitive version of the geometrically weighted edgewise shared partners (GWESP) effect which reflects the tendency that ‘friends of friends become friends’ (transitive closure; actor $i$ $\rightarrow$ intermediary $h$ $\rightarrow$ actor $j$; actor $i$ $\rightarrow$ actor $j$). Second, we added an interaction effect of this transitive version of the GWESP effect with reciprocity, resulting in an effect that reflects the tendency to reciprocate a tie that leads to transitive closure (reciprocated transitive closure; actor $i$ $\rightarrow$ intermediary $h$ $\rightarrow$ actor $j$; actor $i$ $\leftrightarrow$ actor $j$; Block, 2015). In addition, we added a cyclicity version of the GWESP effect which reflects the tendency toward anti-hierarchy, or in other words, generalized exchange in a non-hierarchical setting (cyclicity; $i$ $\rightarrow$ $j$ $\rightarrow$ $h$; $h$ $\rightarrow$ $i$).

We also included two degree-related effects to differentiate between actors who received or gave many (or few) ties in the friendship network. The indegree-popularity effect reflects the tendency of actors who receive many nominations to receive more nominations over time which expresses a reinforcing or maintaining process and leads to a dispersed distribution of the indegrees. The outdegree-activity effect expresses another reinforcing or maintaining process, namely that actors who give many nominations will give more nominations over time leading to a dispersed distribution of the outdegrees. Finally, we included the shared outgoing friendship $\rightarrow$ reciprocated friendship to enhance the goodness of fit of the models. This effect expresses the reciprocated tendency to nominate actors with similar outgoing ties.

Similar to the friendship model, outdegree, reciprocity, indegree-popularity, and outdegree-activity were added to the network model to capture the basic tendencies of actors to form and maintain bullying relationships. In addition, the zero-outdegrees effect was added which expresses the tendency to be an isolate with respect to outgoing ties. Another effect, namely shared-popularity, was added to the bullying model to capture basic tendencies. The shared-popularity effect expresses the tendency for children to nominate the same schoolmates as bullies. Due to low density of the bullying networks and a more centralized structure, the effects of transitive closure and cyclicity have not been included.
Uniplex actor covariate effects. To estimate how changes in the friendship and bullying networks depend on children's age, we included three selection effects: similarity, sender, and receiver effects. An effect for same class was included to control for the tendency of children to form ties within their classroom.

Multiplex structural effects. Multiplex effects were added to the model to control how changes in one dependent network are influenced by changes in the other dependent network. Two dyadic effects were added that controlled for the main effects of friendship on bullying and vice versa. These effects gave the likelihood that an outgoing bullying tie would result in a friendship tie in the same dyad at subsequent time points and vice versa (bullying → friendship and friendship → bullying). At the degree-level, cross-network dependencies were estimated for the outdegree (i.e., given nominations) of one independent network (friendship or bullying) that leads to an outgoing tie in the other dependent network (bullying outdegree → friendship outdegree and friendship outdegree → bullying outdegree). For example, nominating schoolmates for bullying leads to nominating (other) schoolmates for friendships. Comparably, indegrees (i.e., received nominations) for one relationship can lead to indegrees for the other dependent network (bullying indegree → friendship indegree and friendship indegree → bullying indegree). It was also tested whether children nominating many friends became nominated as bullies (by others) (friendship outdegree → bullying indegree), or whether nominating many others as bullies (i.e., being a victim) led to being a friend (of others) (bullying outdegree → friendship indegree).

Furthermore, two mixed triadic effects were added to the bullying model to control for mechanisms which correspond to the shared bullies and shared victims mechanisms. It was estimated whether being friends with a victim led to victimization by the bully of the friend over time (being friends with victims → being bullied). Also, it was estimated whether children would be bullied by friends of their bullies over time (being bullied → being bullied by friends of bully).

UNIPLEX RESULTS

Uniplex network descriptives. Table A3.3 displays means and standard deviations of the uniplex descriptive statistics for the seventeen school-level networks. Children nominated on average six schoolmates as their best friends and one schoolmate as their bully. On average, 21% of the friendships and 26% of bullying occurred outside the classroom. The Jaccard index indicates the amount of stability in the networks (Snijders et al., 2010). The proportion of stable relationship was low for bullying (a Jaccard index of at least .20 is recommended), but this had no consequences for model convergence in the seventeen schools.

On average, most children, 88%, were both nominated as friends and nominated others as friends (actives, children with both in-ties and out-ties). For bullying, only 20% of the children were actives. Whereas only 6% of the children were isolates (children with no out-ties and in-ties) in the friendship network, 38% of the children were not involved
in the bullying network. In addition, 17% of the children nominated others as bullies but did not receive bullying nominations (sources). For friendships, on average only 1% of the children were sources. On average, 4% of the children were nominated by schoolmates as a friend but did not nominate anyone as a friend themselves (sinks). For bullying, 25% of the children were sinks.

**Network results.** Table A3.5 presents the results for the uniplex structural and uniplex actor covariate effects. The first part of Table A3.5 presents the results for the friendship networks. Children tended to be selective in nominating schoolmates as their best friends (outdegree, \(PE = -3.03, p < .001\)). In addition, the positive reciprocity parameter indicates that friendship nominations were likely to be reciprocated (\(PE = 2.53, p < .001\)). Also, children were likely to become friends with friends of friends (transitive closure, \(PE = 1.68, p < .001\)). Nevertheless, these friendships were not likely to be reciprocated (reciprocated transitive closure, \(PE = -0.62, p < .001\)), given the main effect of reciprocity that captures these mutual friendships. The negative effect for cyclicity indicates that there was a tendency for the friendship networks to be hierarchically ordered (\(PE = -0.21, p < .001\)). In addition, the negative indegree-popularity effect shows that the more children were nominated by others as friends the less they attracted extra friendship nominations over time (\(PE = -0.27, p < 0.001\)).

For bullying, it was also found that children tended to be selective in nominating schoolmates as their bullies (outdegree, \(PE = -3.97, p < .001\)). In addition, bullying relationships were found to be reciprocated (reciprocity, \(PE = 0.47, p < .001\)). Bullying was found to be quite stable over time. This stability was characterized by children who were nominated as bullies to receive more nominations over time (indegree-popularity, \(PE = 0.62, p < .001\)). Nevertheless, children nominating others as bullies were not found to increase this tendency further over time (outdegree-activity, \(PE = -0.01, p = 0.92\)). In addition, the effect for zero outdegrees showed that many children did not nominate any schoolmates as their bullies (\(PE = -3.45, p < .001\)).

The results for the uniplex actor covariate effects show that children were more likely to befriend children from the same classroom (same class, \(PE = 0.38, p < .001\) and the same age (similarity age, \(PE = 0.73, p < .001\)). For bullying, it was found that boys were more likely to receive bullying nominations (receiver gender, \(PE = 0.36, p < .001\)) and were less likely to mention others as bullies (sender gender, \(PE = -0.11, p = .01\)) than girls. Furthermore, children were more likely to nominate same gender bullies (same gender, \(PE = 0.28, p < .001\), bullies from the same class (same class, \(PE = 1.05, p < .001\)) and the same age (similarity age, \(PE = 1.09, p < .001\)).

Table A3.5 shows that no relation was found between friendships and bullying on the dyadic level in the meta-analysis (bullying \(\rightarrow\) friendship, \(PE = -0.12, p = .48\); friendship \(\rightarrow\) bullying, \(PE = -0.14, p = .26\)). At the degree-level, it was found that both bullies and victims were less likely to attract friendship nominations (bullying indegree \(\rightarrow\) friendship indegree, \(PE = -0.10, p = .01\) and bullying outdegree \(\rightarrow\) friendship indegree, \(PE = -0.04, p = .01\)). Moreover, children mentioned by many classmates as friends were nominated less
as a bully over time \((\text{friendship indegree} \rightarrow \text{bullying indegree}, \ PE = -0.12, \ p = .03)\).

On the mixed triadic effects, we did not find that friends of victims were more likely to be bullied by the bullies of their friends over time \((\text{being friends with victims} \rightarrow \text{being bullied}, \ PE = 0.08, \ p = .15)\). We did find that children tended to be victimized by the friends of their bullies over time \((\text{being bullied} \rightarrow \text{being bullied by friends of bullies}, \ PE = 0.32, \ p < .001)\). This seems to suggest that bullies tend to bully the victims of their friends, but not the friends of their victims. Due to convergence problems in nine schools, the two mixed triadic effects were fixed. For the \text{being friends with victims} \rightarrow \text{being bullied} effect, the score-type test was non-significant, indicating that the parameter did not add significantly to the model. For the \text{being bullied} \rightarrow \text{being bullied by friends of bullies} the score-type test was significant. The results of the score-type tests indicated that including the effect would have added significantly to the model and that, in line with our results for the other eight schools, the parameter would have had a positive effect on the formation and maintenance of bullying ties.
### Table A3.4. Parameters in the network model

| Parameter | RSiena effect name | Explanation | Graphical representation |
|-----------|--------------------|-------------|--------------------------|
| **Uniplex structural effects** | | | |
| 1 Rate function (period 1) | ~ | The frequency with which actors have the opportunity to make one change | |
| 2 Outdegree density | | Basic tendency to have ties | |
| 3 Reciprocity recip | | Tendency towards reciprocation | |
| 4 Transitive closure gwespFF | | Transitive closure \((i \rightarrow h \rightarrow j; i \rightarrow j)\) | |
| 5 Reciprocated transitive closure gwespFF * recip | | Reciprocated transitive closure | |
| 6 Cyclicity gwespBB | | Tendency toward generalized exchange in a non-hierarchical setting | |
| 7 Indegree-popularity inPopSqrt | | Reinforcing or maintaining process: Actors with high indegrees will receive more nominations, leading to a dispersed distribution of the indegrees | |
| 8 Outdegree-activity outActSqrt | | Reinforcing or maintaining process: Actors with high outdegrees will give more nominations, leading to a dispersed distribution of the outdegrees | |
| 9 Reciprocated outbound shared partner gwespFB * recip | | Reciprocated tendency to nominate actors with shared outgoing ties | |
| 10 Shared popularity sharedPop | | Tendency to nominate the same actors | |
| 11 Zero outdegrees outTrunc(1) | | Tendency to be an isolate with respect to outgoing ties | |
| **Uniplex actor covariate effects** | | | |
| 12 Sender egoV | | Actors with higher values on \(X\) have a higher outdegree | |
| 13 Receiver altV | | Actors with higher values on \(X\) have a higher indegree | |
| 14 Same sameV | | Ties occur more often between actors with same values on \(V\) | |
| 15 Similarity simV | | Ties occur more often between actors with similar values on \(V\) | |
| **Multiplex structural effects** | | | |
| 16 \(W \rightarrow X\) crprod | | Effect of a tie in network \(W\) on a tie in network \(X\) (for same dyad \(i \rightarrow j\)) | |
| 17 \(W\) indegree \(\rightarrow X\) indegree inPopIntn | | Effect of indegree in network \(W\) on indegree in network \(X\) | |
Table A3.4 (continued)

| Parameter | RSiena effect name | Explanation | Graphical representation |
|-----------|--------------------|-------------|--------------------------|
| 18 W outdegree → X indegree | outPopIntn | Effect of outdegree in network W on indegree in network X | ![graph](image1) |
| 19 W outdegree → X outdegree | outActIntn | Effect of outdegree in network W on outdegree in network X | ![graph](image2) |
| 20 Shared outgoing W → X | | Shared outgoing W ties contribute to the tie X | ![graph](image3) |
| 21 Shared incoming W → X | sharedIn | Shared incoming W ties contribute to the tie X | ![graph](image4) |
| 22 Mixed W-X two-paths → X | | Mixed W-X two-paths contribute to the tie X | ![graph](image5) |
| 23 Mixed X-W two-paths → X | cLXWX | Mixed X-W two-paths contribute to the tie X | ![graph](image6) |
| **Multiplex actor covariate effects** | | | |
| 24 Same V * shared outgoing W → X | covNetNet | Tendency of shared outgoing W ties to contribute to the tie X for triad with actor i and j with same values on V | ![graph](image7) |
| 25 Same V * shared incoming W → X | covNetNetIn | Tendency of shared incoming W ties to contribute to the tie X for triad with actor i and j with same values on V | ![graph](image8) |

*Note.* Solid lines indicate friendship relationships, dotted lines indicate bullying relationships in the graphical representations of the parameters.
| Parameter | \( PE \) | \( (SE) \) | \( p \) | \( N \) schools |
|-----------|----------|---------|------|-------------|
| **Friendship** |
| **Uniplex structural effects** |
| Rate function (period 1) | 12.70 | (0.84) | <.001 | 17 |
| Rate function (period 2) | 11.80 | (0.89) | <.001 | 16 |
| Outdegree | -3.03 | (0.12) | <.001 | 17 |
| Reciprocity | 2.53 | (0.07) | <.001 | 17 |
| Transitive closure | 1.68 | (0.05) | <.001 | 17 |
| Reciprocated transitive closure | -0.62 | (0.13) | <.001 | 17 |
| Cyclicity | -0.21 | (0.02) | <.001 | 17 |
| Indegree-popularity | -0.27 | (0.03) | <.001 | 17 |
| Outdegree-activity | 0.02 | (0.02) | .22 | 17 |
| Reciprocated outbound shared partner | -0.44 | (0.09) | <.001 | 16 |
| **Uniplex actor covariate effects** |
| Class | 0.38 | (0.05) | <.001 | 17 |
| Age |
| Receiver | 0.003 | (0.001) | .01 | 17 |
| Sender | 0.00 | (0.001) | .75 | 17 |
| Similarity | 0.73 | (0.10) | <.001 | 17 |
| **Multiplex structural effects** |
| Bullying \( \rightarrow \) friendship | -0.12 | (0.18) | .48 | 15 |
| Bullying indegree \( \rightarrow \) friendship indegree | -0.10 | (0.04) | .01 | 17 |
| Bullying outdegree \( \rightarrow \) friendship indegree | -0.04 | (0.02) | .01 | 17 |
| Bullying outdegree \( \rightarrow \) friendship outdegree | 0.03 | (0.03) | .32 | 17 |
| **Uniplex structural effects** |
| Rate function (period 1) | 12.63 | (0.99) | <.001 | 17 |
| Rate function (period 2) | 12.76 | (1.25) | <.001 | 16 |
| Outdegree | -3.97 | (0.27) | <.001 | 17 |
| Reciprocity | 0.47 | (0.08) | <.001 | 15 |
| Shared popularity | -0.03 | (0.01) | .03 | 16 |
| Indegree-popularity | 0.62 | (0.05) | <.001 | 17 |
| Outdegree-activity | -0.01 | (0.08) | .92 | 17 |
| Zero outdegrees | -3.45 | (0.24) | <.001 | 17 |
| **Uniplex actor covariate effects** |
| Boy |
| Receiver | 0.36 | (0.05) | <.001 | 17 |
| Sender | -0.10 | (0.04) | .01 | 17 |
| Same gender | 0.28 | (0.05) | <.001 | 17 |

Table A3.5. **RSiena meta-analysis for friendship and bullying (model 2)**
### Table A3.5 (continued)

| Parameter | $PE$ | $(SE)$ | $p$ | $N$  |
|-----------|------|--------|-----|------|
| **Class** |      |        |     |      |
| Same      | 1.05 | (0.13) | <.001 | 17   |
| **Age**   |      |        |     |      |
| Receiver  | na   | na     |     |      |
| Sender    | na   | na     |     |      |
| Similarity| 1.09 | (0.18) | <.001 | 17   |
| **Multiplex structural effects** |      |        |     |      |
| Friendship $\rightarrow$ bullying | -0.14 | (0.12) | .26 | 17   |
| Friendship indegree $\rightarrow$ bullying indegree | -0.12 | (0.06) | .03 | 17   |
| Friendship outdegree $\rightarrow$ bullying indegree | 0.01 | (0.03) | .66 | 17   |
| Friendship outdegree $\rightarrow$ bullying outdegree | -0.02 | (0.02) | .45 | 17   |
| Being friends with victims $\rightarrow$ being bullied | 0.08 | (0.05) | .15 | 8    |
| Being bullied $\rightarrow$ being bullied by friends of bullies | 0.32 | (0.06) | <.001 | 8    |
GOODNESS OF FIT (GOF) STATISTICS

INTRODUCTION AND EXPLANATION

The goodness of fit for our models were calculated for four network indices: 1) the distribution of nominations received (indegrees), 2) the distribution of nominations given (outdegrees), 3) the geodesic distances in the networks, and 4) the triad census, all for both friendship and bullying for each school separately.

The goodness of fit of the models is estimated using the observed values for each network, summed over all waves except the first, and the values of the simulated network. The observed data should be within the range of the values of the simulated network to indicate an acceptable goodness of fit; this is confirmed by a p-value larger than .05.

The network index of geodesic distance represents the shortest path between two actors in a network. If actors are not connected (neither directly nor indirectly through others), the distance between them is infinite (or undefined). The bullying network is sparser with fewer network closure patterns than the friendship network, leading to less connected actors. Therefore, the geodesic distances are much larger in the bullying network than in the friendship network.

The triad census is a set of the different kinds of triads – relationships between three actors – that are possible in a network. Wasserman and Faust (1994, pp. 564–568) state that there are sixteen isomorphism classes for the sixty-four different triads that may exist. The possible triads can be labeled according to the following scheme: 1) the number of mutual (M) dyad in the triad; 2) the number of asymmetric (A) dyads in the triad; 3) the number of null (N) dyads in the triad; and 4) a character to distinguish further among the types: T is for Transitivity, C is for Cyclic, U is for Up, and D is for Down. This labeling scheme is also called the M-A-N-scheme.

RESULTS OF THE GOODNESS OF FIT STATISTICS

Table A3.6 gives the p-values of the network indices for both networks for each school separately. The graphical representations of the GoF, showing the observed values and the simulated values, are available upon request.

Overall, the goodness of fit of the bullying network seems to be acceptable for all four network indices, with a few exceptions. The indegree, outdegree, and geodesic distance of the friendship network also seem to fit well. The triad census of the friendship network had for many schools less acceptable GoF statistics. After adding the shared outgoing friendship → reciprocated friendship effect, the goodness of fit for the triad census increased slightly. Looking at the plotted observed and simulated values for the schools separately, there are no M-A-N-triads that are systematically under- or overestimated. If only one of the sixteen M-A-N-triads is not estimated sufficiently, the statistics indicate that the model is not acceptable. Given that we did not find systematic deviations, we considered the models as acceptable for our research purposes.
Table A3.6. Goodness of Fit statistics for the uniplex networks for the individual schools

|   | Friendship |   |   |   | Bullying |   |   |   |
|---|------------|---|---|---|----------|---|---|---|
|   | Indegree   | Outdegree | Geodesic distance | Triad census | Indegree | Outdegree | Geodesic distance | Triad census |
| 1 | .80        | .26       | .13               | .16         | .31       | .003       | .65               | .15         |
| 2 | .74        | .19       | .52               | .22         | .52       | .91        | .11               | .66         |
| 3 | .12        | .07       | .53               | .00         | .19       | .64        | .62               | .59         |
| 4 | .10        | .63       | .29               | .00         | .53       | .10        | .08               | .44         |
| 5 | .16        | .01       | .004              | .00         | .78       | .04        | .47               | .58         |
| 6 | .23        | .07       | .04               | .00         | .09       | .00        | .27               | .11         |
| 7 | .55        | .04       | .01               | .00         | .09       | .21        | .03               | .06         |
| 8 | .11        | .001      | .01               | .00         | .10       | .24        | .26               | .12         |
| 9 | .83        | .93       | .99               | .28         | .93       | .66        | .78               | .99         |
| 10| .68        | .31       | .01               | .00         | .21       | .64        | .45               | .66         |
| 11| .03        | .51       | .05               | .00         | .34       | .001       | .25               | .36         |
| 12| .18        | .01       | .76               | .10         | .84       | .16        | .98               | .81         |
| 13| .85        | .43       | .00               | .00         | .13       | .00        | .81               | .62         |
| 14| .46        | .94       | .45               | .23         | .23       | .03        | .65               | .86         |
| 15| .46        | .00       | .01               | .00         | .01       | .00        | .80               | .34         |
| 16| .80        | .02       | .72               | .01         | .52       | .84        | .59               | .33         |
| 17| .07        | .29       | .51               | .01         | .81       | .61        | .69               | .77         |