

Dynamics of Adolescent Friendships:

The Interplay between Structure and Gender

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Abstract- This study investigates the network characteristics of adolescent friendship networks and the interaction between network characteristics and gender. Two competing hypotheses for closure and openness are derived and tested. Adolescents might strive for network closure, because this facilitates trust and trustworthiness among their friends. However, openness can also be beneficial because it facilitates establishing multi-layered identities and finding novel ideas for school tasks. The hypothesis for interaction between structure and gender is derived from the argument that gender influences the criteria for seeking and making friends during adolescence. SIENA is used to estimate the effects of network and individual characteristics on friendship formation. The data consists of longitudinal friendship nominations of 410 Taiwanese adolescents. We find that adolescents have a tendency to establish friendships that increase network closure. This tendency is stronger for male than for female adolescents in single-gender classes. On the contrary, the tendency towards network closure is stronger for female than for male adolescents in mixed-gender classes.

Keywords- Dynamics of Friendship; Social Networks; Gender; Adolescence

I. INTRODUCTION

Making friends is an essential part of life for adolescents at school. Adolescent friendships have received a great deal of attention in interdisciplinary research as an important component in adolescents' relationships [1]-[3]. Studies from education science have shown the effects of friendship on learning, adaptation, and psychological health [3]-[5]. Sociological studies have shown how friendship influences deviant behavior, substance use, and sexual relationships [6]-[8]. These studies indicate that friendships substantially impact adolescents' lives.

The relevance of the impact friendships have on extensive aspects of an adolescent's life gives credence to investigating what factors influence the formation of those friendships. Friendship theories broadly stress that friendship choice is affected by two factors – preferences and contact opportunities [2], [9]-[11]. The preference argument postulates that people feel attracted to others if they have attractive socio-economic

resources, such as a good income, or have compatible cultural resources, such as similar opinions or values. Empirical findings indicate that a preferable cultural resource for adolescents is same-gender adolescents holding similar attitudes towards life and interpersonal relationships [12]. Simultaneously, the contact opportunity argument states that people are more likely to make friends in social settings where they repeatedly interact with the same people, such as at churches, schools, and places of work [9]. Empirical research reveals that adolescents are more likely to make friends if they perform similar group activities [13].

However, adolescent friendships change over time [14], [15]. Preferences and contact opportunities often cannot explain changes of friendship as they only suggest static similarity of two parties and frequencies of joint settings. For instance, similar socio-economic resources cannot explain why a friendship between two people is created at this time point while it is terminated at the next time point. This shows that in reality people make different friendship choices as time changes. We conjecture that these changes in friendship choices over time might be related to changes in the structure of the network in which adolescents are embedded.

Through various structural characteristics of networks, individuals benefit from support, information, or resources [16]-[19]. Based on this perspective, friendship choice is influenced by the structural positions of potential friends in the larger friendship networks [13]. Theories about adolescent friendship often claim that adolescents seek friends' support and also make friends that provide different ideas and resources. Hence, we postulate that network closure, which is measured by the extent to which someone's friends are connected among each other as well as the converse characteristic network openness, which can be recognized by relatively few connections among someone's friends, might both be preferable network characteristics [16], [17], [19]. We examine which one is the more preferred network characteristic that influences adolescent friendship choice. This leads to the first research question: "*Does closure or openness in friendship networks drive adolescent friendship formation?*"

In addition, empirical studies have shown that gender plays an important role in friendship [20]-[22]. Males and females are taught and encouraged to manage friendships differently beginning in childhood [23], [24]. Female adolescents put emphasis on more intimate interaction with

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friends by sharing feelings, while male adolescents sustain and make friends in joint activities [20], [23]. The gender difference in friendship reveals that gender may differentiate the tendency to which adolescents strive for either closure or openness. Male and female adolescents may focus on different aspects while making friends, which can lead to a preference for different network characteristics in friendship networks. Hence, the second question: “Does gender differentiate the tendency to which a specific network characteristic (closure or openness) determines dynamics of friendship networks?”

This study is expected to contribute to the literature in two aspects. First, it provides theoretical explanations for friendship networks in terms of the two relevant network characteristics, closure and openness. Adolescent research rarely focuses on dynamics of friendship networks, and network studies often neglect adolescent theories to explain the factors of dynamic networks. This study bridges friendship theories and network studies, providing a new understanding of how network characteristics matter to adolescents’ friendships. Second, analyzing friendships at single-gender schools allows for disentangling the pure effects of network characteristics from the effect of gender within classes and for testing whether these network effects differ between classes of different gender. Simultaneously, the mixed-gender classes allow for testing of whether effects of different network characteristics vary with gender within classes.

II. THEORY AND HYPOTHESIS

This section is organized as follows: Subsection A stresses the relevance of closure in friendship networks, while subsection B considers reasons why openness is a valuable network characteristic. Subsection C discusses why we expect that gender, as the most relevant individual characteristic affecting adolescent friendship, moderates the effect of closure and openness. Subsection D introduces two additional factors that are considered to be relevant in previous studies on adolescent network formation.

A. Explaining Closure in Friendship Networks

Closure is defined as the extent to which friends of a focal individual are connected [16]. For individuals who strive for closure, choosing friends of friends as new friends is more attractive than choosing other people as friends. Thus, the likelihood of forming friendships with friends’ friends is relatively higher for individuals who strive for closure in their network than the likelihood of establishing friendships with more remote others.

Adolescent development theory provides an explanation as to why they strive for closure. Adolescents attempt to develop self-identity as they gain independence from their parents. As adolescents seek for specific values and ideas that they can believe in and integrate into their lives, friends’ recognition and confirmation are essential [9], [13]. Friends are the sources of support for adolescents in their self-defining process [2], [6], [27]. However, it is not the case that all friends are able to provide support for adolescents during the self-defining process. Empirical findings have shown that adolescents prefer friends who keep their promises and

provide steady support [27], [28], revealing that adolescents seek reliable friendships. Through the interaction with trustworthy friends, adolescents are able to believe and internalize friends’ ideas and values as their own and feel secure since their friends will not easily do something, such as talking behind their backs, to hurt their friendship. Hence, only by relying on friendship networks that provide trust can adolescents feel friends are reliable and construct self-identity from those friends.

Closure facilitates trust in the connections of the actors. By the common connections among actors, trust within more closed networks develops as actors keep an eye on each other [16]. Empirical findings have shown that closure enables the emergence of trust in transactions in business [16], [29]. For adolescents, friends in closed networks will be more likely to keep a promise or keep important information to themselves than in more open networks. In a closed network, friends’ behavior and opinions are spread easily and known quickly by others. If a friend does anything inappropriate, such as telling secrets to other adolescents outside his/her network, it will soon be known by other friends and cause negative interactions with that friend, such as refusal to talk to that friend anymore. It will be an unwanted situation for adolescents since friendship with peers is important during that stage in life. Therefore, adolescents will strive for closure in their networks, seeking trustworthy friendships. In conclusion, since closure can be reached by establishing friendships with friends of friends, the first hypothesis is formulated:

H1: Adolescents are more likely to choose friends of friends as friends than to choose other classmates as friends.

An alternative mechanism is that there are greater contact opportunities with friends’ friends [13]. Adolescents’ interact with friends’ friends more than with other classmates, increasing the probability that they will choose friends’ friends as friends. Because this mechanism also leads to Hypothesis 1, if Hypothesis 1 is confirmed, we cannot exclude that the effect is caused purely by interaction opportunities rather than by the idea that adolescents genuinely search for trusting relations in their networks.

B. Explaining Openness in Friendship Networks

An open network is a means by which actors are able to get diverse information because this type of network features ties among unconnected others. As a consequence, these others are more likely to belong to different groups [17]-[19]. These diverse connections enable actors to access non-redundant information, which in turn inspires new ideas for their work [18]. Openness in the network is measured as the extent to which friends of a focal individual are not connected to each other. This implies that openness is actually the opposite of closure in the network. Hence, in order to create openness, actors may resist making ties with friends’ friends.

There are two explanations for the creation of open networks by adolescents. First, as they gradually mature, they open their minds to other ideas and realize that they do not want to define themselves as belonging to one particular group [2], [30]. Thus, the desire to belong to a certain clique loses

strength. The boundaries of the different groups are no longer well defined, and the members are not as self-conscious about interaction with peers from previously considered “outside” crowds. That is, adolescents prefer to establish multi-layered identities from their multiple memberships in diverse crowds [30]. Brown et al. [31] found, while tracking adolescents’ wider networks, that adolescents in high school shift from single-crowd affiliation in lower grades to ties with several crowds at the same time in upper grades. Haynie [32] also reports that by their late teens, most students with no delinquent behavior list others who have delinquent behavior as friends, indirectly supporting the gradual change to make friends even with extremely different adolescents. Therefore, incorporating the concept of multi-layered identities with preferred friendship networks, adolescents may wish to establish an open network through its diverse links with different clusters.

The second explanation is borrowed from learning theory in educational science [3], [33]. This theory emphasizes collaboration between students via seating arrangements that expose students to different groups (and hence, different ideas) in order to foster better learning [3]. That is, students learn from other partners via brainstorming on projects in the assigned group. Though the theory emphasizes the teachers’ strategies for the makeup of the groups, the underlying idea can be rephrased as resource exchange through teamwork [3], [4]. Epstein [34] in a review of the effects of peer groups, points out that adolescents’ relationships may change as the result of school-organized events and teams. Because it has been found that creativity is often inspired by diverse resources [18], the mixing of groups encourages adolescents to work creatively through exposure to different opinions and ideas. Adolescents may realize that diverse ties that bring diverse information and resources are helpful for their academic performance. Conversely, relying on friends from a closed network is not always beneficial because the resources and ideas of each member are too similar.

In sum, seeking diverse resources and multi-layered identities, adolescents may find open networks, featuring diverse ties, more desirable because they enable the individuals to access diverse information [17], [19]. As data used in this study were collected from 17-year-old adolescents, it is possible that these adolescents were searching multi-layered identities. Also, incorporating the arguments on seeking diverse resources, it is suggested that adolescents are less likely to think that establishing friendships with friends of friends is an interesting option. The foregoing arguments lead to Hypothesis 2:

H2: Adolescents are less likely to choose friends of friends as friends than to choose other classmates as friends.

It is important to realize that Hypotheses 1 and 2 are competing hypotheses, because openness is the opposite of closure, and both network characteristics are based on the absence or presence of relations between friends’ friends. We still chose to present both hypotheses because the theoretical arguments for both hypotheses are plausible and part of the

aim of this study is to establish for which of these theoretical arguments we find empirical support.

C. Explaining the Interaction between Gender and Network Characteristics

The aim of our study is not only to investigate which network position adolescents strive for. Our second research aim is to test whether gender differentiates the effects of closure and openness. We argue that female and male adolescents have different ways of forming friendships, so they have different likelihoods of choosing friends’ friends as friends.

Defining themselves by their relationships with others, girls interpret intimacy as sharing feelings with friends. To enhance and sustain friendship is telling true feelings to friends [20]-[24]. Additionally, female adolescents think that revealing feelings to trustworthy friends is better than to acquaintances because trustworthy friends would respect the secrecy if asked to. As this paper argues in subsection A that friends’ friends usually are given credit for trustworthiness by the intermediates, it is reasonable for females to have a higher likelihood than males of establishing friendships with friends of friends.

In contrast, male adolescents develop their self-identity more based on achievements in which they also define their relationships with others [20]. They form friendships through the accomplishment of activities with other males. If the joint activities are related to performance, it is probable that they will welcome others with different backgrounds into their circle. Then, by working with people outside their own circle, they are more likely to glean good ideas and perform better. Related to the argument in subsection B, this implies that the likelihood of establishing friendships with friends of friends is relatively lower for male than for female adolescents.

To sum up, female adolescents are more likely to strive for network closure in which friends’ friends are friends than male adolescents. Contrarily, male adolescents are more drawn to network openness. This leads to the third hypothesis: *H3: Female adolescents are more likely than male adolescents to choose friends of friends as friends compared to choosing other classmates as friends.*

The argument in subsection B also suggests that older adolescents tend more towards openness than younger adolescents. Because we have data only on 17-year-old students, we cannot test this hypothesis.

D. Explaining Other Dyadic Factors in Friendship Networks

This subsection discusses two additional factors that have been found to be influential for friendship networks in previous findings. Though those factors are not the research focus, they maintain value for us to be reconfirmed and to be controlled for in our analysis.

Gender homophily is a relevant factor in interpersonal relationships as it refers to the pattern in which same-gender relationships are more likely to occur than opposite-gender relationships [11], [12], [35]. During the socialization process throughout childhood, parents and schools indirectly tend to segregate activities and behaviors of girls and boys,

encouraging ties to same-gender friends [12], [36], [37]. Empirical studies show that latent segregations from socialization influence the tendency of same-gender friends from childhood to adolescence [13], [14], [36], [38], [39]. Therefore, female and male adolescents will gradually have more same-gender friends as gender homophily continuously influences friendship networks. This leads to the following hypothesis:

H4: Adolescents are more likely to choose same-gender adolescents than opposite-gender adolescents as friends.

Another factor that influences friendship is popularity. There are several elements contributing to the popularity for high school students, including being on a sports team for boys, participating in cheerleading for girls, or having a desirable personality [1], [38]. Popularity is an important determinant for adolescents' status in classes. Hence, those who are not part of the popular group try to be friends with popular adolescents in order to improve their status [38]. Eder [38] shows that girls outside the popular groups try to have more contacts with popular girls via joint activities. Brown et al. [30], [31] show that popular adolescents at school receive more friendship nominations from peers outside the popular groups than unpopular adolescents. Those popular adolescents usually are reluctant to make friends outside their own circles, nominating friends from within their groups [30], [38]. However, if they decide to sustain their popular circles by refusing making friends outside circles, the peers will regard them as arrogant and soon dislike them [38]. Overall, those findings reveal that friendship choices are influenced by adolescents' popularity in classes. Because the precise effects of popularity have not been completely consistent in earlier research, we do not specify a prediction for popularity as we do for gender homophily.

In conclusion, gender homophily and popularity are found to influence adolescent friendships in empirical findings, so these effects will be included, though they are not the main research focus. Moreover, by controlling for these factors, we avoid the possibility that other relations we find can be due to spurious correlations based on these determinants of adolescent friendship relations.

III. METHOD AND DATA

A. Sample and Questionnaire

The dataset used is from the "Taiwan Youth Growth and Life Course Survey" conducted by Academia Sinica, Taiwan in 2009. The survey targets high schools in three counties in southern Taiwan. In each county, a multistage sampling method was deployed in randomly selecting one school from mixed-gender and single-gender high schools (female and male senior high schools). Then, one class was randomly selected from each school. Consequently, the dataset contains nine classes from five single-gender senior high schools (three male and two female high schools) and four mixed-gender senior high schools. In total, it consists of 410 17-year-old adolescents in the first semester of their second year of high school.

The dataset contains nominations and demographic information from two questionnaires. The short version collected adolescents' friends in class using friend nominations from the question: "Please list your good friends' names, ranked according to closeness (not including your boyfriend or girlfriend) with a maximum of 16 names." The short version questionnaire was given to the same classes five times between September 2008 and February 2009. The long version was used once at the end of 2008, and it collected adolescents' demographic information, adjustment to school life, perception of school performance, and attitude toward classmates. Adolescents' gender is thus accessed from this questionnaire.

This is a suitable dataset for two reasons. First, as we want to investigate the dynamics of friendship networks, we have to rely on longitudinal complete social network data. The friendship nominations were collected in five waves, which enable us to construct the network matrices in consecutive waves. Second, we expect the networks to show a certain extent of friendship change within the same classes enabling us to analyze the relevant changes of friendship in observation time. The adolescents in the sample had recently been reassigned according to different classes when the survey was conducted.¹ Hence, it is expected that friendships are quite dynamic during the waves of this study. It ensures that we can estimate relevant effects.

B. Variables

Changes of ties. The dependent variable is the changes of ties from a current wave to a subsequent wave. A tie exists if an adolescent nominates his/her classmate as a friend on a wave of the short questionnaire. By coding ties from friend nominations, the matrices are constructed as directed networks. As mentioned above, there will likely be certain changes in friend nominations. Here, the Jaccard index is given to provide information on the extent of changes. The Jaccard index is calculated based on the number of ties present at both the current as the subsequent wave, divided by the sum of the number of ties present at both waves, newly created ties in the next wave, and existing ties in the current wave that were terminated in the next wave [26]:

$$\frac{N_{11}}{N_{11} + N_{01} + N_{10}} \quad (1)$$

Table I shows that the Jaccard index between each wave transition ranges from 0.47 to 0.52. This amount of change is considered to be sufficient for analysis because according to Snijders et al. [26], an index that is above 0.3 is preferable.

Transitive triplets and transitive ties. The investigation of whether adolescents strive for network closure or openness and are more or less likely to become friends with friends' friends refers to the concept of transitivity. That is, transitivity represents that given three actors (actor i , j and k) in a triad, when i is friends with j and j is friends with k , i is more likely to become friends with k in the end. We specify two indicators

¹ Taiwanese high school students must choose between three tracks - "humanities and social sciences", "engineering, physics, and chemistry", or "medical sciences" at the end of the first year.

available in SIENA – a *transitive triplets* variable and a *transitive ties* variable, as both refer to the likelihood of becoming friends with friends’ friends. *Transitive ties* measures the effect on establishing a transitive tie based on whether at least one friend of a friend exists for this new tie. In addition, *transitive triplets* measure the effect of the number of friends of friends related to a new tie to be established. Hence, the difference is that *transitive ties* measure whether, if we consider two actors, there exists at least one friend of a friend, while *transitive triplets* measures the number of friends of friends [13], [41]. By including both effects in the model, we can distinguish whether the effect of the first friend of a friend differs from subsequent friends of friends.

Gender. Adolescents’ gender was collected in the long questionnaire mentioned above. We include “female” as a dummy variable, leaving male adolescents as the reference group. The interactions between gender and transitive triplets as well as between gender and transitive ties are specified. They are estimated only for the four mixed-gender classes because only in those classes we can directly test for gender difference in transitivity.

Gender Similarity. Gender homophily is operationalized by the gender similarity effect, which refers to the higher likelihood of same-sex adolescents having a tie. This effect controls for the well-known gender similarity effect related to Hypothesis 4.

Control variables. The following control variables are specified: *3-cycles*, *outdegree popularity*, *indegree popularity*,² *reciprocity*, *outdegree*, *outdegree time dummies*, *class dummies and class dummies on rates*. *3-cycles* refers to the instance that an intransitive tie occurs in a triad, this is the likelihood that if i nominates j as a friend and j nominates k that then k nominates i as a friend. *Outdegree popularity* indicates whether a respondent who reports more ties to others will receive more ties from others, while *indegree popularity* indicates whether a respondent who had more receiving ties from others at a previous time point will receive more ties from others at the next time point. *Reciprocity* and *outdegree* are controlled in the models because they influence the model fit and control for individual and dyadic baseline effects [26], [41]. We also consider heterogeneity effects between time transitions and classes in longitudinal network data. By specifying variables *outdegree time dummies (between wave 2 to 3, wave 3 to 4 and wave 4 to 5)*, we allow the baseline individual tendency to nominate others to vary over time. By specifying *class dummies* and *class dummies on rates*, we control for the differences between classes in tendencies to nominate others and between classes on rates of changing ties.

Table II provides descriptive statistics for tie changes. Table II provides information about the respondents such as sample size, how many friendship nominations they reported in each wave, gender, and age. Several variables, such as *transitive triplets*, *transitive ties*, *3-cycles* and others are not

² Snijders et al. [26] show that effects of degree related indicators are mostly better estimable using the square root of the degree. This also turned out to be the case for our data. Therefore, we use the version that implements the square root of the degree.

provided, because they are not readily available, but only constructed within the SIENA estimation procedures.

C. Stochastic Actor-Based Models for Friendship Network Dynamics

We apply stochastic actor-based models for network dynamics in longitudinal network data. Other network models might lead to biased estimates due to neglecting dynamics over time or assuming independent networks between waves [13]. Stochastic actor-based models for network dynamics eliminate the possibility of these biases by estimating the effects of changing relations over time [26]. In the assumptions, actors’ (adolescents in our study) ties are dichotomous or discrete variables [26]. Actors have full information about the networks, and they seek to obtain a better network position. Hence, actors change ties according to the current networks in order to improve their network positions in the next wave [26].

Estimating the effects of network indicators on the likelihood of tie change (creation or termination) relies on an objective function [26], [41]. For example, an effect for reciprocity is estimated in the objective function to show whether a tie is less or more likely to be established if it is a reciprocal tie with another actor. The variables mentioned in the previous section are specified in the objective function. We employ SIENA version 4.0 (Simulation Investigation Empirical Network Analysis) to estimate our models [41].

We deal with missing data in two different ways. First, for those adolescents who did not nominate others, but who were nominated and whose gender was known, we coded the outgoing ties as missing in the network matrices. Second, those adolescents who did not nominate others, did not receive nominations until the last wave, or their gender information was not collected were removed from data. Four cases are deleted (406 remain). Table I shows that percentages of missing values are below 5%, far less than the 20% that would likely lead to a concern of disturbance of model estimation [41].

TABLE I. DESCRIPTIVES OF TIE CHANGES

Transitions	Mean ^a	Jaccard index
Wave 1 to Wave 2	196	0.487
Wave 2 to Wave 3	177	0.516
Wave 3 to Wave 4	174	0.514
Wave 4 to Wave 5	182	0.476

a. Mean number of the changes per class.

TABLE II. RESPONDENT LEVEL DESCRIPTIVE STATISTICS

		N	Mean	S.D.	Missing ties (%) ^a
Friend nominations	Wave 1	406	6.89	1.23	1.27
	Wave 2	406	6.08	0.62	1.73
	Wave 3	406	6.59	0.65	1.01
	Wave 4	406	5.89	1.05	1.57
	Wave 5	406	5.78	0.79	3.50
Gender	Male	230	0.57		
	Female	176	0.43		
Age			17.33	0.49	

a. The percentage of missing ties = (missing ties) / (maximal possible number of ties) * 100%.

IV. RESULTS

A. Explanatory Analysis

Three groups of classes (mixed-gender, female, and male) are distinguished in order to estimate the effects of network indicators and other dyadic effects mentioned in the method section. The combined networks give us better and more stable estimation of effect size than if we would estimate effects for each class separately (Ripley and Snijders 2010). “Structural zeros” are assigned to relations between classes within the three groups to indicate that relations from different classes could not nominate each other. This implies that these dyads are not included in the estimations. Tables III through V show the models for each of these three groups of classes. In Table III, Model 1 shows the model with *transitive ties*, *transitive triplets*, *gender similarity*, *3-cycles*, *outdegree popularity*, *outdegree*, *reciprocity*, *gender of ego*, *gender of alter*, *outdegree time dummies* (wave 2 to 3, wave 3 to 4 and wave 4 to 5), *class dummies* and *class dummies on rate*. Model 2 adds the interaction effects with gender. Tables IV and V only present Model 1 and not the model with gender interaction effects, because these tables analyze single-gender classes.

The results reveal that for the mixed-gender group, the *transitive triplets* (coeff. = 0.261, $p < 0.001$) and *transitive ties* (coeff. = 0.611, $p < 0.001$) effects are significantly positive. Therefore, Hypothesis 1 is supported, while Hypothesis 2 is rejected. Adolescents clearly prefer to establish friendships with friends’ friends, and that tendency leads to network closure in their friendship networks rather than openness. The interpretation of coefficients is the same as for coefficients in logistic regression as the coefficients are the log odds ratio of the probability [41]. For the *transitive ties* effect, an adolescent is 1.84 times ($e^{0.611}$) more likely to make friends with a friend of a friend than with other classmates when that adolescent has at least one indirect tie with a friend of a friend. For the *transitive triplets* effect, an adolescent is 1.3 times ($e^{0.261}$) more likely to make friends with friends of friends than with other classmates for every additional friend of a friend. This finding is consistent with previous findings based on friendship studies of children and young adults [12], [13].

Regarding the interaction effect (female x transitive triplets and female x transitive ties in Table III), the interaction effect between female and transitive ties is significant (coeff. = 0.424, $p < 0.001$), while the interaction effect between gender and transitive triplets is not significant. This still provides support for Hypothesis 3 in the sense that it is more important for females to have an indirect relation with someone else to establish a new relation than it is for males. Interpreting the effects for female adolescents (in comparison to male adolescents) requires looking at coefficients for the interaction effect (female x transitive ties). Female adolescents are 1.53 times ($e^{0.424}$) more likely to make friends with friends of friends than male adolescents are if there is at least one friend of a friend. The effect of the number of friends’ friends (*transitive triplets*) does not differ between males and females.

TABLE III. RESULTS FOR MIXED-GENDER CLASSES

	Model 1		Model 2	
	Coeff.	Std. err.	Coeff.	Std. err.
Transitive triplets	0.261***	0.011	0.260***	0.011
Transitive ties	0.611***	0.061	0.647***	0.059
Female x transitive triplets			-0.005	0.016
Female x transitive ties			0.424**	0.126
Gender similarity	0.361***	0.043	0.346***	0.041
3-cycles	-0.178***	0.025	-0.169***	0.023
Outdegree popularity (sqrt)	-0.455***	0.047	-0.480***	0.047
Outdegree	-1.588***	0.102	-1.573***	0.101
Reciprocity	1.662***	0.060	1.667***	0.060
Ego is female	0.107*	0.044	-0.269*	0.112
Alter is female	-0.064	0.046	-0.089	0.046
Outdegree time 2-3	0.272***	0.050	0.270***	0.053
Outdegree time 3-4	-0.038	0.052	-0.042	0.054
Outdegree time 4-5	0.278***	0.052	0.275***	0.053
<i>Class dummies (class 1 as ref.)</i>				
Class 2	-0.084	0.056	-0.085	0.057
Class 3	-0.080	0.053	-0.074	0.055
Class 4	-0.038	0.060	-0.036	0.063
Class 2 on rate	-0.089	0.072	-0.095	0.076
Class 3 on rate	0.180*	0.075	0.174*	0.075
Class 4 on rate	-0.081	0.086	-0.082	0.087

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Comparing the coefficients of *transitive ties* and *transitive triplets* in the male-class group with those effects in the female-class group, we find that the *transitive ties* effect for the male-class group (coeff. = 0.583) is larger than that in the female-class group (coeff. = 0.346), and *transitive triplets* for the male-class group and the female-class group are similar, though the *transitive triplets* effect in the female-class group is slightly higher (coeff. = 0.285) than in the male-class group (coeff. = 0.236). Additional *t*-tests show that both differences between the two coefficients are significant.³ However, these findings contrast with the finding in the mixed-gender classes. For *transitive ties*, the effect for females is larger than for males within mixed-gender classes, while the effect is smaller for females in the single-gender classes. For *transitive triplets*, there is no difference for female and male adolescents in the mixed-gender group, while the effect is slightly larger for females in the single-gender classes.

With respect to *gender similarity*, we find a significant and positive effect (Table III). Hypothesis 4 is supported. An adolescent is 1.41 times more likely to make same-gender friends than to make opposite-gender friends. This finding confirms previous findings [11], [36], [37]. Regarding additional control variables, first, *3-cycles* have a significant

³ The test statistic to compare of two estimated parameters in independent networks is: $(\hat{\beta}_a - \hat{\beta}_b) / \sqrt{s.e._a^2 + s.e._b^2}$. The null hypothesis states the parameters are equal [41].

negative effect across the three groups, indirectly providing evidence that transitive closure is more likely to happen than intransitive closure of triads, because, as we mentioned in the method section, *3-cycles* predict a cyclical, intransitive relation in a triad. Regarding *outdegree popularity* in the models, in all three groups it is significantly negative, showing that adolescents are less likely to make friends with those who indicate many others as friends. We do not include *indegree popularity* in the final models because its inclusion affects the convergence of *outdegree popularity* effects.⁴ The results show that the *indegree popularity* effects are found to be significant in the male-class group and female-class group, though they are not significant in mixed-gender group. Male adolescents and female adolescents are more likely to make friends who receive many nominations from others in single-gender classes. However, it is not the case in mixed-gender classes. Concerning the tested differences between classes and over time, we see that there are no differences in the amounts of friends nominated between the classes (*class dummies*). In the mixed-gender classes there are somewhat more changes in class 3, while in the male class there are more changes in the reference class 5 (*class dummies on rate*). The negative effects of outdegree are smaller going from time 2 to 3 and from time 4 to 5 in the mixed-gender and male classes as can be seen from the positive effects on the *outdegree time dummies*.

TABLE IV. RESULTS FOR MALE CLASSES

	Model 1	
	Coeff.	Std. err.
Transitive triplets	0.236***	0.011
Transitive ties	0.583***	0.058
3-cycles	-0.160***	0.025
Outdegree popularity (sqrt)	-0.361***	0.044
Outdegree	-1.475***	0.095
Reciprocity	1.409***	0.054
Outdegree time 2-3	0.316***	0.051
Outdegree time 3-4	0.057	0.050
Outdegree time 4-5	0.124*	0.046
<i>Class dummies (class 5 as ref.)</i>		
Class 6	-0.012	0.043
Class 7	0.005	0.042
Class 6 on rate	-0.434***	0.070
Class 7 on rate	-0.547***	0.068

*p<0.05; **p<0.01; ***p<0.001

⁴ The *t*-ratio which is estimated for model convergence for each variable shows that when *indegree popularity* is included with other controls, it increases the *t*-ratio for *outdegree popularity* to above the value of 0.1, suggested to be the upper limit of excellent convergence by Ripley and Snijders [41]. Therefore, we decide to exclude it to sustain good convergence for the remaining variables in the final models. Still, including *indegree popularity* did not substantively change other estimates.

TABLE V. RESULTS FOR FEMALE CLASSES

	Model 1	
	Coeff.	Std. err.
Transitive triplets	0.285***	0.018
Transitive ties	0.346***	0.063
3-cycles	-0.207***	0.036
Outdegree popularity (sqrt)	-0.430***	0.062
Outdegree	-1.258***	0.130
Reciprocity	1.715***	0.072
Outdegree time 2-3	-0.008	0.061
Outdegree time 3-4	-0.079	0.061
Outdegree time 4-5	-0.060	0.063
<i>Class dummy (8 as ref.)</i>		
Class 9	-0.081	0.047
Class 9 on rate	-0.018	0.075

*p<0.05; **p<0.01; ***p<0.001

B. Additional Analysis

We report two sets of additional analyses. These analyses confirm the robustness of our results.

First, we performed an additional analysis in which only *transitive ties*, *transitive triplets* and the baseline effects (*reciprocity* and *outdegree*) were included, while all additional control variables were excluded. The results show that the effects of *transitive ties* and *transitive triplets* remain significant and positive also without those additional control variables.

Second, we estimated models for each class separately to check whether the directions of estimating effects are the same as the ones we obtained in the mixed-gender group, female-class group, and male-class group. In sum, we find the same directions and significance in separate classes, revealing that the predicting effects are consistent across mixed-gender and single-gender classes.

V. SUMMARY AND CONCLUSION

Our findings answer the research questions: first, more closed networks seem to have greater attraction for adolescents than more open networks. Second, in mixed-gender classes, female adolescents' tendency to establish closed networks is stronger than that for male adolescents, while the opposite is the case in single-gender classes.

This study has disentangled the factors of dynamics of friendships in adolescents. It provides new understanding on friendship formation beyond the theories of preferences and contact opportunities. Moreover, our comparison of mixed-gender classes and the single-gender classes points out the differences in friendship formation for females and males. We did not anticipate the discrepancy between the two types of classes. One possible explanation might be related to the differences in setting: the competition among male adolescents and female adolescents in mixed-gender classes might lead to different networks compared to the single-gender classes in which this competition element is absent. Further work is suggested to focus on investigating whether types of classes influence friendship network formation.

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