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EVOLUTION OF SOCIOLOGY FRESHMEN INTO A FRIENDSHIP NETWORK

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In this paper we both describe and analyze the meeting process and the evolution of a friendship network among sociology freshmen in the Netherlands. We develop a theory that explains how changes in the network structure depend on one or more of four main effects: proximity, visible similarity, invisible similarity, and network opportunity. We formulate expectations with regard to what factors are important at what stages of the friendship development, making a distinction between 'meeting' and 'mating.' To some extent, the results

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confirm our expectations. The proximity and visible similarity variables determine change in network structure in the early stages, whereas network opportunity is important during all stages. Unfortunately, no significant effects of invisible similarity are found.

Keywords: Evolution, Meeting, Friendship, Longitudinal networks, Similarity

1. INTRODUCTION

Friendships are an important source for the social well-being of individuals. Social well-being is produced by what an individual has (status), by what an individual does (behavioral confirmation), and by what an individual is (affection) (Lindenberg, 1984; Lindenberg, 1990). Friendships are particularly important for behavioral confirmation, people's need for confirmation of their behavior and opinions. Behavioral confirmation is easier obtained from those with similar behavior and opinions than from people who differ on these aspects. Most friendship theories stress similarity of behavior and invisible characteristics, rather than physical and other visible characteristics such as gender. Affection is often associated with later stages in friendships. Only if the basis of a friendship has evolved from behavioral confirmation to affection, friendships are able to survive growing dissimilarity and diversity between the individuals.

However, a friendship between two people can emerge only when their paths cross in the first place: they will have to "meet" before they can even "mate." That they actually meet is more likely if there is opportunity, by sharing, for example, the same living, school, or work environment, or if their social networks overlap (Fehr, 1996). Once two people meet, whether or not they decide to pursue a friendship, depends on many factors. The structural context not only determines whether individuals meet, but also influences other important factors such as visibility and propinquity: increased visibility and exposure increase the likelihood of becoming friends. Moreover, a friendship is more likely to come into existence if each individual perceives the other as attractive, responsive, and in particular, similar in a variety of ways (Cramer, 1998; Duck, 1991). Also, social skills of both individuals are necessary for building a friendship (Jew and Tienda, 1997). Other relevant factors that determine the actual development of a friendship are the probability of future interaction (people evaluate others more positively if they expect to interact with them on an ongoing basis), and availability of time and energy for new friends. Moreover, there should be reciprocity of liking and of self-disclosure. As Fehr nicely puts it, "Given the myriad factors that must coalesce, it seems remarkable that people are able to form friendships at all." (Fehr, 1996).

But people are! Especially in the relatively closed context of new social settings in which newcomers have to interact with each other for a certain

time, people always build new friendships, and thereby together (unconsciously) construct new friendship networks. It is in such a context that we try to explain changes in a friendship network.

Our main research question is: *What kinds of individual and network variables explain changes over time within a friendship network? At what stages, and why, are these variables important?* We do not consider structure per se, but we are interested in changes in this structure and the relevance of different kinds of variables in explaining these changes, i.e., in friendships that emerge and disappear. We expect that different factors play different roles at different stages of the friendship development. Little is known about what drives changes at different stages. Friendship structures have been analyzed extensively whereas changes over time rarely. In this respect our study can be regarded as an extension of the work by Van de Bunt (1999), who collected and analyzed longitudinal friendship network data of both freshmen students and of hospital workers. For the freshmen students he found that the opportunity effects were more, and longer, important, than similarity effects. His findings on structural effects were inconclusive.

Here, we try to fill in two major gaps in the study on friendship formation by explicitly distinguishing different stages in the friendship development process:

1. Little is known about the role of visible and invisible similarity at different stages of the friendship development, especially in relation with the effect of opportunity (or proximity) variables.
2. Little attention is given to the network structure itself. The development of a network of dyadic relationships provides opportunities for new relations to emerge.

In Section 2 we summarize the most important literature on friendship development and its embedding in networks. Since we study a population of university freshmen as our relatively closed setting of initially mutual strangers, we focus in particular on students' friendships. We present the data collection in Section 3, and describe the data in Section 4. In Section 5 we introduce the statistical method used to analyze longitudinal network data, implemented in the program SIENA, and present its results for our data. We discuss these results and give some conclusions in Section 6.

2. BACKGROUND AND EXPECTATIONS

2.1 University Freshmen

In many countries during the first year at college, most students experience enormous changes in their lives: going to college is a major life event (Hays and Oxley, 1986). Many students move from their parents' hometown to

the university town. If they do not move, their social life will still be subject to change because of the change in daily activities and the new people they meet. In both cases, going to college completely changes their social context, and as a result, students not only build up new friendships, but the character of their friendships is also likely to change. It can be assumed that there will be a considerable change in the composition and organization of the individuals' friendship networks. As such, friendships can play a significant role in forming their "new" identity. It has been found that for young and single adults, as most students are, friendships have maximal functional significance in this stage of the life cycle.[1] Probably because of the development towards "full" adulthood, friends are their number one companions and confidants.[2] College women for example, depend more often on friends than on family members as confidants for discussion of personal issues (Carbery and Buhrmester, 1998).

A large amount of research has been devoted to the development of friendships among students, but usually considers dyadic friendships only. Opportunity for contact is the most restrictive factor in the formation of friendships that was found already in the famous classic studies of Festinger, Schachter, and Back (1950) and Newcomb (1961).[3] Whereas it is generally recognized that context is quite important (Allan, 1998) because it creates opportunities and because it determines the possible functionalities of friendship, most studies do not go beyond the dyadic level.[4]

[1]Since attending college is on the other hand a very specific activity for young adults, the population of students consequently does not have to be representative for young adults in general. The meaning and content of friendship varies anyway over the life cycle. However, two elements, reciprocity and common activities, appear at all stages. Tesch and Martin (1983) asked university students what friendship meant to them and what they valued in their friendships. The most important aspect that came out is reciprocity in the form of dependability, caring, commitment, and trust. Second most important was compatibility, openness, acceptance, and similarity. In general, women place a greater emphasis on reciprocity and men value similarity more, in particular in the form of common activities (Weiss and Lowenthal, 1975).

[2]This decreases significantly during the marital stage and parenthood phase.

[3]In a population of graduate students, availability and visibility were the major determinants of friendship. As a result, it was not surprising that little evidence was found beyond these for value similarity in the development of friendships (Erbe, 1966).

[4]Those studies that do exist focus on the ego-centered networks of the students, and not on the social networks of a whole class or year of students (Salzinger, Antrobus, and Hammer, 1988). In these ego-centered studies (Antrobus, Dobbelaer, and Salzinger, 1988; Culbert, Good, and Lachenmeyer, 1988) it is found that students tend to be associated with other students who are similar to themselves in terms of gender, ethnicity and academic achievement. Network size does not relate to academic achievement or drop out. It may be that early in college life, students are more strongly affected by their prior ongoing friendships. Or in the first semester, the student may be more concerned with trying to find an appropriate social network to belong to than with using networks as source of support.

Some studies focus on new students on campus (Miell and Duck, 1986), others on dormitory room proximity in general and roommates in parti cular (Berg, 1984; Caplow and Forman, 1950; Hill and Stull, 1981; Holahan et al., 1978; Menne and Sinnett, 1971; Werner and Parmelee, 1979). Hays found that improvements in the convenience of getting together (due to schedule changes) were positively correlated with friendship development (Hays, 1984, 1985). Proximity is especially important in terms of class-rooms assignments (Clark and Ayers, 1992) and tracking (Kubitschek and Hallinan, 1998). Being part of the same social setting creates physical proximity and thereby leads to higher probabilities to meet and to mate.[5] On the extreme, when two individuals never meet, they will never become friends, however similar they may be. Thus, the more often and more regularly people meet, the easier it is to establish and maintain a friendship. Liking seems to emerge naturally from repeated exposure and visibility. But as "meeting" precedes "mating," proximity is expected to be more important for meeting than for mating and relevant only in the initial stages of the friendship development (Berndt and Perry, 1986; Duck et al., 1991; Fehr, 1996).

2.2 Not Just Dyads: Context and Network

Except transitivity studies (see below) and the studies by Newcomb (1961) and Van de Bunt (1999), hardly any studies exist that examine the process of friendship formation and maintenance between individuals within a broader context. This context, of which the complete friendship network is a part, is extremely important. Although friendship is due to individual choice, the influence of the social context on the initiation of new friendships and the course of existing friendships over time cannot be denied. Especially among students, but also in other populations, a lot of interaction takes place in "group-settings" such as classes, sports clubs, and student unions.

The ongoing character of a friendship and whether the friendship develops at all is thus determined by the structure of the network it is part of. This influence of the network may be unique and cannot be reduced to individual or dyadic factors because a friendship network is not made up of only pairs of friends. As soon as individuals deepen and strengthen their relationships, they influence each other's personal lives, thoughts, and actions and, moreover, they bring their friends together (as a result of restricted time, effort, and emotion). When one's friends know one another

[5]Important to note here is that some social settings in fact bring together similar individuals (Feld, 1981; Fischer et al., 1977; Leenders, 1995). Examples are a music concert, a soccermatch, and the specific major in college. That is, similar actors have higher probabilities to meet.

it is easier to relate closely and frequently with each of them. It is clear that the larger the number of friends that two individuals have in common, the higher the probability that these two will be introduced to each other and the more (conscious or unconscious) encouragement there will be for them to become friends (Hammer, 1979, 1980; Salzinger, 1982). Chances increase that these individuals get to like each other because they have common friends and consequently common interests. As such, proximity (or opportunity) together with similarity leads again to new friendships. In the literature, this process is often referred to as transitivity: if i and j are friends and j is friends with h, then i will also become friends with h (Hallinan, 1974; Holland and Leinhardt, 1970, 1976). However, intransitivity of friendship choices has also been observed (Hallinan and Kubitschek, 1990).

We postulate that it is not the pure transitivity process of friendship choices determining the presence of transitivity in friendships. Instead, it might be a combination of proximity and similarity effects explaining it. Only when change of the network is considered, it is possible to determine this.

2.3 Different Effects at Different Stages

Apart from Van de Bunt's study, little is known about the differential effects of the individual, dyadic, and contextual factors at the different points in time of the friendship development process. All dynamic theories (Altman and Taylor, 1973; Berger and Calabrese, 1975; Hallinan, 1979; Levinger, 1974; Levinger, 1980) that try to explain how a friendship develops over time focus on dyads and on similarity. They more or less consider the process of friendship formation to consist of several stages that build from an initially superficial interaction in narrow areas towards increasingly intimate interaction in broader areas. In the initial stages conversation focuses on demographic characteristics, in later stages more attitudinal issues and personal matters are discussed. The perceived background similarity gathered in the first stage might lead to assumptions of other similarities. Any suggestion of similar attitudes will encourage the individuals to conclude that similarity exists at other levels, making continuation of the friendship more likely.

Hence, a friendship between two individuals can emerge only if they see or feel that they are similar. Similarity should either be visible from the outside, or the individuals should know each other well enough such that similarity with respect to less visible characteristics can play a role. This relates to the fact that some kinds of similarities have been found to be more characteristic for acquaintances, whereas others have been found to be more characteristic for friends (Johnson 1989). Since friendship mostly develops out of acquaintanceship, these differences should also appear

when studying friendship formation over time.[6] Thus, in the early process of friendship formation, similarity with regard to visible characteristics is most salient. At later stages, at least if the individuals have had the opportunity to get to know each other, similarity with regard to invisible characteristics such as values and attitudes becomes more relevant (Urberg, Degirmencioglu, and Tolson 1998).[7]

2.4 Expectations

We claim that friendship is particularly important for behavioral confirmation. When individuals come in a group where they do not know any or many others, we expect that proximity and visible similarity initially strongly facilitate friendship formation. Getting to know one another (meeting) is a first prerequisite for becoming friends (mating) and in this process visible characteristics are often important cues for underlying attitudes and interests. If subsequently relationships are strongly confined within such proximity and visible similarity borders, the further fine-tuning of relationships occurs within these borders. In that case, proximity and visible similarity remain important determinants for the network structure at later moments, but are expected to be irrelevant to *explain changes* at later stages. We assume that common interests, behavior, and attitudes are more relevant at later stages as they are revealed only in longer lasting relationships and interactions. Moreover, we expect that the network structure itself creates new meeting opportunities with friends of friends and that these opportunities remain important causes for changes during all stages. On the basis of this reasoning, we distinguish four main factors that determine change in meeting and friendship networks over time.

1. (*Physical*) *proximity* is in fact a special kind of similarity. It is being in the same place at the same time and it has a large impact on meeting and, especially in the initial stages of the friendship network evolution, on friendship development. Proximity related variables are therefore

[6]Moreover, the rate at which relationships change or develop may depend on the stage the relationship is in.

[7]Especially for the initial stages, the following is important. Almost every individual has an 'implicit theory of personality' such that certain characteristics are expected from others on the basis of easily visible characteristics. This leads to a categorization of other individuals (Sherif and Sherif, 1964). Individuals in the extreme categories of a personality dimension of attraction are most restricted. If these individuals prefer similar individuals as their friends, they can rely on only one side of the dimension. In order to compensate, they choose even more from their own category, whereas individuals in the center of the dimension can choose from both (several) categories next to their own (Verbrugge, 1977, 1979).

expected to play a dominant role in the formation of networks that indicate meeting (getting to know one another) and, more moderately, in the very beginning of the friendship development process.

2. *Visible similarity* (*other than physical proximity*) is similarity based on characteristics that are visual from the outside or on which information is easily obtained. Examples are gender, ethnicity, and age. Usually, proximity and visible similarity variables function as clues to shared interests and behavior. These variables are expected to play a role in the beginning of the friendship development process (the "mating" process)[8] and to a lesser degree in the meeting process.
3. *Invisible similarity* is similarity on less visible characteristics, such as attitudes and activities outside the context in which the network develops. Usually these variables correct and strengthen friendships. We therefore expect that they will have effect only at later stages of the friendship development.
4. *Network opportunity* can be defined by proximity or opportunity variables as well. In small populations, meeting almost instantly implies knowing each other as a group. In such networks, network opportunity will hardly have a distinct effect. In larger populations, changes will be increasingly induced by network opportunity variables, where people meet each other through other people.

In the context of friendship formation, the most important network effect comes from friends bringing friends together. Two individuals who share more friends (they are more similar with regard to their friendships) have higher chances to meet and to become friends themselves. Since new friendships are established during the entire process, we expect this effect to appear at all stages.

We summarize our expectations in Table 1, distinguishing "meeting" (Table 1a) from "mating" (Table 1b). We assume three main stages in the friendship development process: the initial stage, the middle stage, and the final stage. The length of these periods is not necessarily equal because usually in the beginning things change at a much higher rate than in the end.[9]

[8]It should be noted that certain invisible characteristics may well be so strongly associated with certain contexts that they actually become visible characteristics. Religion, for example, will normally be treated as an invisible characteristic, but in the context of evolution of meeting and friendship networks around religious ceremonies, religion is a visible one. We therefore explicitly refer to invisible similarity in terms of attitudes and activities outside the context in which the network develops.

[9] We do not take into account different strengths of friendships, or strength development with a dyadic friendship because this would make this first elaboration of our theory too complex. When one would examine just developments within dyads, it is easier to examine different strengths, and feasible to focus on the rate at which strength changes.

TABLE 1a Overview of Expected Strengths of Different Effects at Different Stages of the Meeting Process

	Meeting stage		
Effect	Initial	Middle	Final
Proximity			
Visible similarity			
Invisible similarity			
Network opportunity			

TABLE 1b Overview of Expected Strengths of Different Effects at Different Stages of the Friendship Formation (Mating) Process

	Mating stage		
Effect	Initial	Middle	Final
Proximity			
Visible similarity			
Invisible similarity			
Network opportunity			

The darker the color of the variable in a certain stage, the stronger the effect of that factor for changes in the network in that particular stage.

In the meeting process, we expect proximity and, to a lesser degree, visible similarity to determine changes in the meeting network. In later stages, we assume network opportunity also to explain the changes in the meeting network. Invisible similarity does not play a role in changes in the meeting network in any stage.

For the mating process, Table 1b reflects different expectations. In the beginning, we mainly expect to find strong proximity, strong visible similarity and, to a smaller degree, network opportunity effects that drive the formation of new friendships. In the middle stage we expect to find still some visible similarity and network opportunity effects, but also some smaller invisible similarity effects that not only drive formation of new friendships, but also dissolution of existing friendships. At the end, we expect to find invisible similarity effects and network effects mainly.

In the next section we describe the data used to investigate the expectations.

3. DATA

When selecting a group of students with the same major, we can assume the group is relatively closed, the boundaries of the network to be developed are clear. Moreover, it can be assumed that most students are initially mutual strangers. This enhances the analyses of the different processes of friendship formation we have described above: Opportunity structures can be specified because some students (even with the same major) follow certain classes that others do not. Other forms of opportunity structures may also exist. A distinction between visible and invisible characteristics can be elicited by asking the students about their individual interests and activities that are important in student life. We have collected such data among sociology freshmen at the University of Groningen in the Netherlands.

3.1 Studying Sociology in Groningen

Groningen is known as a university city. The university is not located on a campus, but its buildings are spread out over the city, as are the bars, cheap places to eat, and the students. There are only few dormitories; most students live in houses together with about two to twelve fellow students. Even though the Netherlands is a small country, most students move to the city when entering college. Relatively few stay with their parents, if their parents live nearby. The vast majority of the students get state tuition. In order to keep the right to get this tuition students have to obtain half of the number of credit points that one is supposed to earn each year. The students are not extremely well off with the tuition, but their income is usually supplemented by parents and, often, a part-time job.

In contrast to the United States, freshmen in the Netherlands enroll immediately into a program that is focused on one discipline. In the first year, students have only limited opportunities to select their own courses, as most of the courses are obligatory for all. Whereas programs in the U.S. start very open and focus on specific disciplines only in later years, the situation in The Netherlands is just the opposite. Sociology freshmen can therefore be seen as a rather closed social system in contrast to freshmen in the U.S.

Sociology in Groningen is a relatively small discipline. Over the past five years, the number of freshmen each year has varied roughly between 30 and 50. In the Netherlands, in principle everyone with the highest high school certificate can enter university.[10] Students enter college right after

[10]At the age of 12, children already have to choose (or are assigned to) a specific high-school level. Four of such levels exist, and only the certificate of the highest level gives the right to enter college (it is possible however, to enter a new high school level, once you have finished a lower one). With the highest and second highest school level certificate, one can enter higher vocational training. Once one has finished higher vocational training, entrance to the university is possible.

high school (at the age of about 18 years), or after having finished higher vocational training first (at the age of about 22). The latter students follow a special program of two years instead of the regular four-year program. This means that these students follow different classes at different points in time than the regular students. The classes of these two programs overlap only partly. As a result, program can be considered to be a proximity variable. All classes take place in the same building, in which the classrooms, offices, and canteen are situated. During class breaks students drink coffee or tea, or have lunch in this canteen. The canteen is divided into a smoking area, and a non-smoking area upstairs. This provides us the second proximity variable, smoking behavior, because students, who want to smoke, need to use a different part of the canteen.

The two programs are more than a proximity variable because students who follow the same program are in general of about the same age. Those who follow the regular program will on average be 18 years old. Those who follow the short program will on average be 22 years old. Moreover, many of those who follow the short program have left their parents' home earlier, and have lived in the city of Groningen for a longer period. As such, their starting point differs tremendously from that of the "younger" students. The academic aspirations of the students of the short program will also be stronger in general. They are more mature and probably made a more deliberate choice to study sociology. As a result, the program variable captures not only proximity effects but also a number of similarity effects.

3.2 The Questionnaires

Questionnaires were presented to the students seven times during their first year at the university. In five questionnaires the networks were measured, together with, sometimes, other information; in two questionnaires only individual information was asked of the student related to the invisible similarity variables. At the very beginning of the school year, all information on proximity, visible and invisible similarity variables was gathered. We also asked about relationships present at that time. This questionnaire was filled out while most of the freshmen participated in the so-called introduction period. Students and staff members visited Schiermonnikoog (a Dutch Wadden island) to get acquainted with each other.

All subsequent questionnaires were handed out during lectures and the students were allowed to fill them out at home. They were encouraged not to discuss their answers with their fellow students. If possible, students were reminded during lecture times to return the questionnaires. If not, and time in between questionnaires permitting, we sent written reminders to the students. Each student that participated received a reward in the

form of a book token at the end of the academic year, the height of the reward depending on the number of times the student participated with a maximum of twenty-five guilders (about twelve dollars).

In the beginning of the year, we questioned the students more frequently than at the end, expecting more changes at the start of the school year. The five network measures are indicated by t_0, t_3, t_6, t_{13}, and t_{35}, where the index refers to the number of weeks after the start of the school year) with a total of 38, 25, 28, 18, and 18 students, respectively.

It is clear that the data suffer from attrition and we tried to find out whether this was related to dropout. Although there are some data about dropout, these were not very enlightening, since there was only one student who was registered to have stopped with the study during the first three months. Some others were registered to change after the first year, but we have no clear indication that this decision influenced their participation.

In the analyses, we do not use the last time point because the data are not quite reliable: some of the questionnaires were handed in before and some after an unexpected event with a great impact on the students. As a result, we have three transitions left and, in correspondence with the division in Table 1, attach the label 'initial' to transition t_0 to t_3, the label 'middle' to t_3 to t_6, and label 'final' to t_6 to t_{13}.

We took Van de Bunt's approach to measure friendships. He shows that for a closed group of students, the measurement of friendships as given in Table 2, where students are asked to rate their relationships with all other students in six categories, "best friend," "friend," "friendly relationship," "neutral relationship," "dissonant relationship," and "unknown relationship," is a representative and valid method. The questionnaire contained a list with names of all students with whom the type of relationship had to be indicated. The layout of this question is depicted in Table 2a. The six categories from which to choose are presented in Table 2b.

Choosing the Proximity, Visible, and Invisible Similarity Variables

Proximity variables are "program" and "smoking behavior." Program is a dichotomous variable. Smoking behavior is dichotomized such that those students who do not smoke and those who smoke only at parties are coded as non-smokers. Since the party-smokers will probably not use the smoking-section of the canteen, they are considered non-smokers for this proximity aspect.

Our choice of visible variables was initially derived from the literature mentioned in the previous sections and included gender and age. However,

TABLE 2a Lay-out Response Categories for Relationships with Fellow Students

Fellow student	Type of relationship					
Name 1	1[ ]	2[ ]	3[ ]	4[ ]	5[ ]	6[ ]
Name 2	1[ ]	2[ ]	3[ ]	4[ ]	5[ ]	6[ ]
Name 3	1[ ]	2[ ]	3[ ]	4[ ]	5[ ]	6[ ]
etc.	1[ ]	2[ ]	3[ ]	4[ ]	5[ ]	6[ ]

TABLE 2b Response Categories with Respect to the Type of Relationship

	Type	Description
1	'Real' friendship	People you would call 'real' friends.
2	Friendship	People with whom you have a good relationship but whom you would not (yet) call 'real' friends.
3	Friendly relationship	People with whom you regularly have pleasant contact during seminars and breaks. This contact could grow into friendship.
4	Neutral relationship	People who are fellow students, but with whom you do not have much in common further. However, when you meet each other or are involved in one way or another, the contact is pleasant. The chance is not very large that the relationship will develop into a friendship.
5	Dissonant relationship	People with whom you have an awkward relationship and with whom you certainly do not wish to develop further contact. The contact is uneasy and there is the risk of conflict or argument.
6	Unknown relationship	People you do not know at all, or only by face or name.

age is so strongly correlated with the program variable, that we do not consider age as a relevant variable. This leaves us with gender as the single visible variable.

The invisible variables are activities and interests important to students in general. Especially in view of the fact that for most students this period of their life is full of new experiences, happenings and changes towards maturity, we assume that these activities and interests are relevant for behavioral confirmation of freshmen. We asked the students to indicate how much attention she or he devoted to a certain activity by marking a 10-point scale.[11] In the first questionnaire, this was done for 22 activities, like doing/watching sports, going out for a meal/to see a movie, talking to others about study/personal feelings. Between the third and fourth networkmeasurement, in the ninth week, the same information was

[11]Besides, we have also asked the students directly how negative or positive it is when a friend pays special attention to this activity and how important it is to be able to perform the activity together with friends.

obtained via a questionnaire on 13 of these activities that were considered most important. Of these activities, we selected five that showed some change and that represent different aspects of an average student's life: going out, having dinner together, membership of a students' union/club, and talking, both about personal feelings as well as about the study.[12] We used these five variables in the analysis to reduce unwanted effects caused by high correlations between the activities.

Another variable that was included in the analysis records the use of soft drugs, that is, the smoking of marihuana, which we consider as an indicator of a certain "subculture" among adolescents and young adults. Van de Bunt (1999) found some effect of this invisible variable.

4. DESCRIPTIVE RESULTS

Since the composition of the set of students differs for the different points in time, we present this composition in terms of individual variables (opportunity and visible similarity variables) in Table 3.

The percentages of men and women and of the regular and short program are more or less stable. The percentage of smokers decreases from 34 percent to 22 percent over time.

As our focus is on network changes, we first show the transitions between four of the six original categories of Table 2b. These transitions are given in Figure 1 and Table 4. We disregard the transitions from and to

TABLE 3 Composition of Networks in Terms of Gender, Program, and Smoking Behavior of the Actors at Different Points in Time (Percentages in Parentheses)

		t_0	t_3	t_6	t_{13}
Gender	Men	14 (0.42)	10 (0.42)	10 (0.36)	7 (0.39)
	Women	24 (0.58)	15 (0.58)	18 (0.64)	11 (0.61)
Program	Regular	23 (0.61)	15 (0.58)	16 (0.57)	12 (0.67)
	Short	15 (0.39)	10 (0.42)	12 (0.43)	6 (0.33)
Smoking behavior	Non-smoking	25 (0.66)	18 (0.73)	21 (0.75)	14 (0.78)
	Smoking	13 (0.34)	7 (0.27)	7 (0.25)	4 (0.22)
N		38	25	28	18

[12]In an earlier version of the paper we reported the results of a factor analysis of 19 of the invisible variables. This resulted in a "serious" study-oriented dimension and a "fun" social-oriented dimension. Because of the restriction in the variables at the later time point, which we wanted to include in the analysis, we decided to make a more ad hoc but easier-to-interpret selection of the variables. We consider the variable "discussing the study" to represent the study-oriented dimension and the variable "going out" to capture the social-oriented dimension.

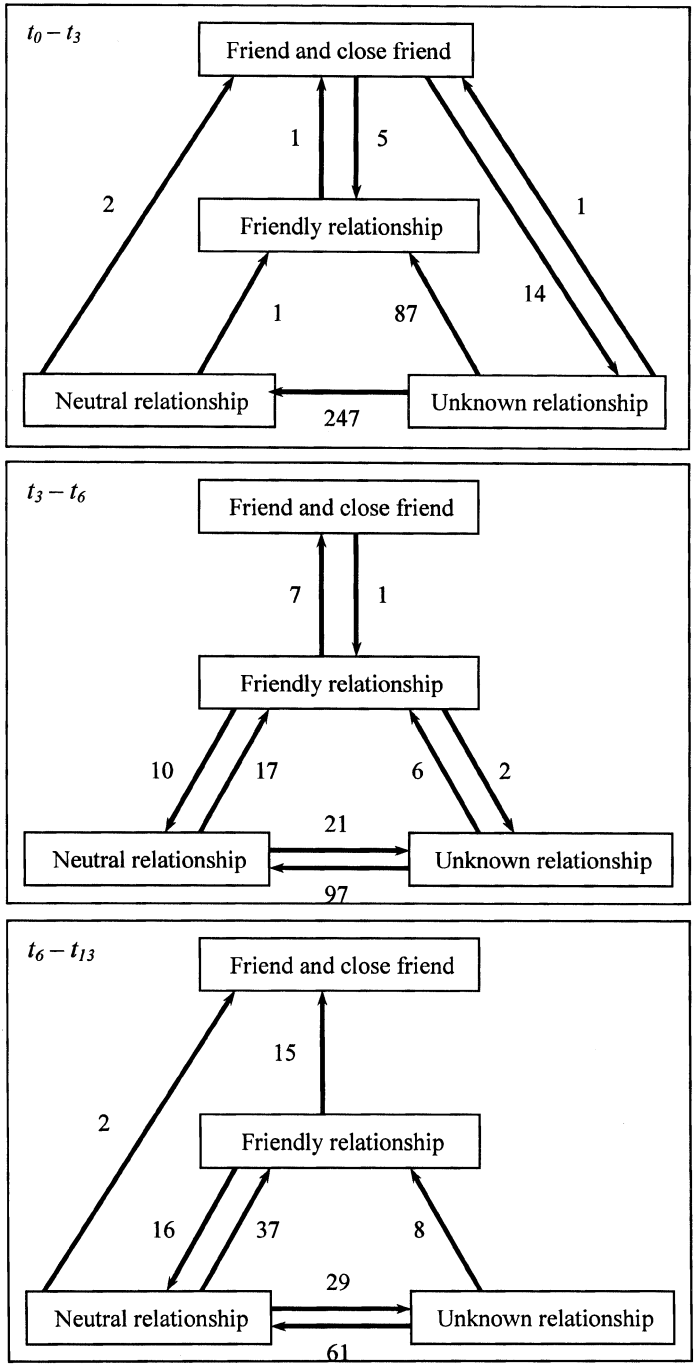

FIGURE 1 Transitions in the network from t_0 to t_3, t_3 to t_6, and t_6 to t_{13}.

TABLE 4 Transitions in the network from t_0 to t_3, t_3 to t_6, and t_6 to t_{13} (Percentages in Parentheses)

Transitions	$t_0 - t_3$	$t_3 - t_6$	$t_6 - t_{13}$
Neutral–unknown	247 (0.66)	118 (0.67)	90 (0.52)
Neutral–friendly	1 (0.00)	27 (0.15)	53 (0.30)
Other	129 (0.34)	32 (0.18)	31 (0.18)
Total	377	177	174

"dissonant relationships" as they are rare. Moreover, we lump together the categories "friends" and "close friends" because they are small.

The top picture of Figure 1 shows the transitions from t_0 to t_3. As almost none of the students knew one another at t_0, most transitions in the initial stage start at the unknown relationship category. Most of the transitions go to the neutral relationship category, but some students immediately become friends within the short period of three weeks. The middle and bottom pictures of Figures 1 give a fundamentally different picture for the middle and final stages. Friendships and close friendships almost exclusively develop from friendly relationships. Moreover, Table 4 shows that 82 percent of all transitions between the six categories belong to two transitions: on the one hand between unknown and neutral relationship and on the other between neutral and friendly relationships. For the initial stage only 66 percent of all transactions belong to these two categories. It means that the transactions in the initial stage are much more chaotic than later on (transitions to the category dissonant relationship occur also almost exclusively in the initial stage). Moreover, some initial friendships dissolve, whereas this hardly happens anymore in the middle and final stage. In these latter stages, the friendship categories become sink categories, where you stay once you are in.

The observed transitions facilitate the definition of meeting and mating. The high percentages of unknown-neutral and neutral-friendly transitions in the middle and final stages strongly justify the two dichotomizations for the meeting and friendship networks. Van de Bunt (1999) showed that the processes underlying the formation of friendly relationships (category 3) and those underlying the coming into existence of a friendship or "real" friendship (categories 1 and 2) differ significantly. Indeed, after the initial stage, almost all transitions towards the categories "friends" and "real friends" develop from relationships that were earlier indicated as "friendly relationship." Because of the limited availability of time for friendships to develop (13 weeks from the initial meeting), rather few friendship relations were observed. We therefore consider a friendship choice to exist from individual i to j as soon as i reports to have at

least a friendly relationship with j (categories 1, 2 or 3). To define meeting we use the dichotomization between category 6 (unknown relationship) and the other five categories. These dichotomizations allow us to use stochastic actor-oriented models (Snijders 1996) (Snijders 2001) to analyze the evolution of the meeting and mating networks, and to compare the two processes (see Section 5).

First, however, we examine and describe the graphs of the meeting and mating networks at the different observations times. The graphs are presented in Figure 2. For graphical purposes, we present symmetric choices only. The dichotomizations and the symmetric procedure result in a line (friendship) between two students if both students have mentioned the other in either one of the categories 1 to 5 (meeting) or 1 to 3 (mating). Note that they have not necessarily classified their relationships identically. For instance, if individual i names j as one of his best friends, and j mentions i as his friend, a line is drawn between i and j in the mating network. That line is not drawn, however, if i mentions having a friendly relationship with j, and j mentions a neutral relationship with i.

Figure 2a shows the network development over time of the meeting process, Figure 2b that of the mating processes. The figures were constructed using Pajek (Batagelj & Mrvar, 2002). Each figure consists of four graphs, representing the network at the different observation times, t_0 to t_{13}, beginning in the upper left graph and ending in the lower right graph, respectively. In the graphs, circles represent students who follow the regular program and boxes students in the short program. The white vertices represent female students; the male students are depicted by black vertices. Students who did not complete a questionnaire at some observation time have a label m (missing).

Both networks at time t_0 show a set of almost completely isolated individuals. At the beginning of the school year, in the initial set of 38 students, only few students know each other and only five friendships exist. Three of these are between male students having completed higher vocational training (in fact, the same type) and one is between two male students who follow the regular program and come from high school (possibly the same school because they previously lived close to each other). Only one friendship is between students of different gender.

The networks at time t_3 show that within 3 weeks all students have met and know some other students, at least well enough to label the (sparse) contact as pleasant. The isolates in the meeting graph are those students who did not hand in the questionnaire. There is one exception, a female student following the regular program who is never mentioned by the students she mentions. A number of reciprocal friendships have already developed, mostly among short program students with the same gender. The few students of the short program seem to constitute a kind of a bridge

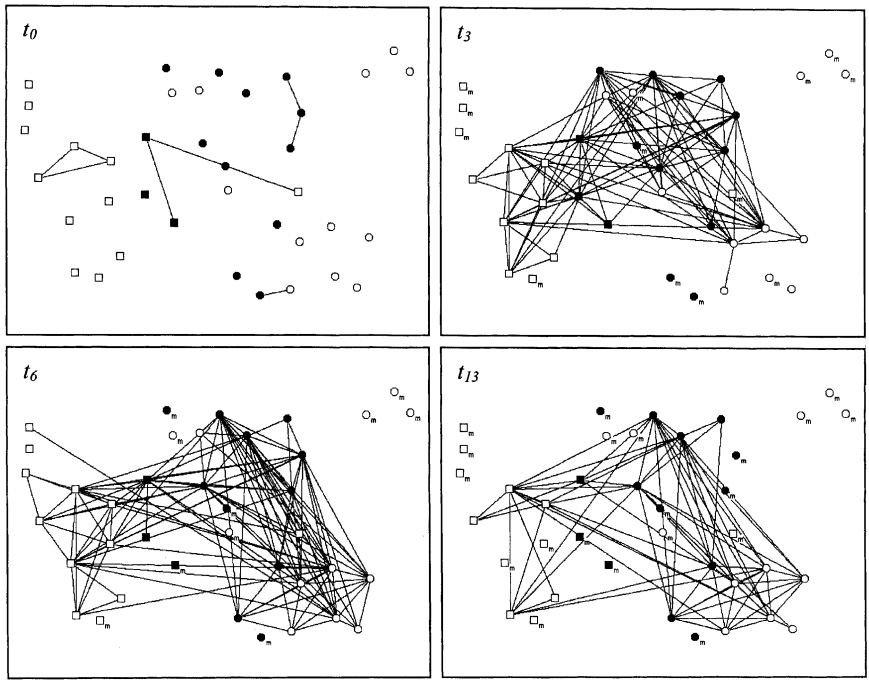

FIGURE 2a Friendship network development over time: MEETING (symmetric relations only). Female students are represented by white vertices, male students by black. Students following the regular program are represented by circles, students following the short program are represented by boxes. Students of whom the outgoing relations are missing at a certain observation time have a label m.

between the male regular students and the female students of the short program.

At time t_6, the networks show that still more students know each other than at t_3. Some students only know a few others, especially female students in the short program. There is again one—different—isolated student. The graph of the meeting process shows a rough division into two clusters or subgroups: students following the same program seem to know each other best. The graph of the mating process shows more clearly a division into three subgroups: female students of the regular program, female students of the short program, and male students of the regular program. At t_{13}, the number of missing respondents is unfortunately rather large, and causes the graphs to be less dense than at earlier observation times. The main dynamics in the mating process between t_6 and t_{13} concern the formation of the cluster among some of the female regular students. The density within this group of women increases tremendously during this period.

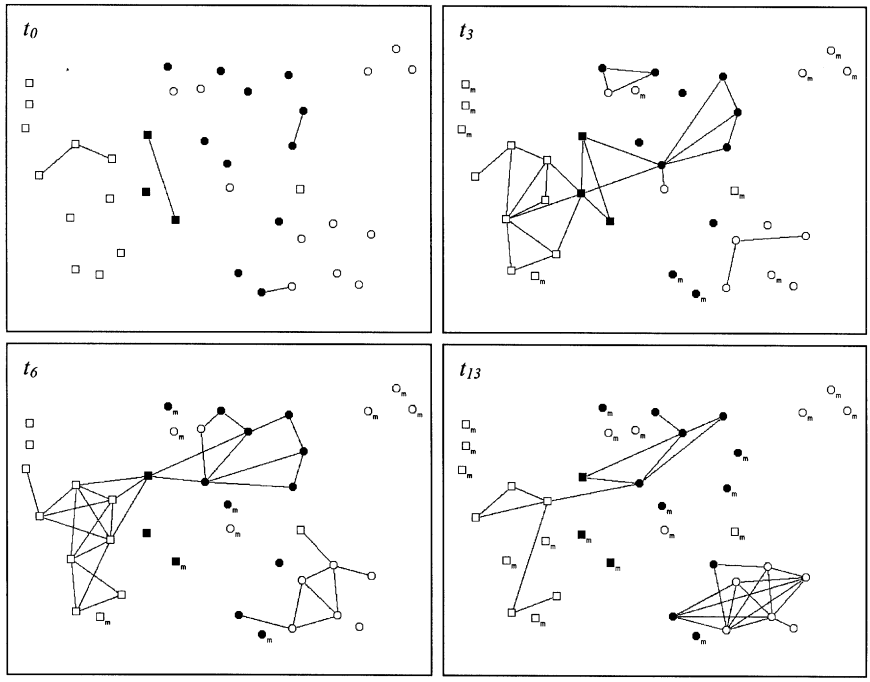

FIGURE 2b Friendship network development over time: MATING (symmetric relations only). Female students are represented by white vertices, male students by black. Students following the regular program are represented by circles, students following the short program are represented by boxes. Students of whom the outgoing relations are missing at a certain observation time have a label *m*.

From this visual inspection, we draw the general conclusion that opportunity is very important when it concerns the program that the students follow. Especially the female students have friendships only with fellow students of the same program. Male students seem to be less restricted in this regard, which may be caused by the fact that they are fewer in number. Male students of the regular program establish some (but few) friendships both with male students of the short program and with female students of the regular program. Male students of the short program similarly do establish some friendships with male students of the regular program and female students of the short program.

In Table 5 we present basic structural characteristics of the presented networks: the density, the degree of reciprocity, the degree of transitivity, and the degree of segmentation. The characteristics were calculated on the dichotomized, symmetric networks, except for the degree of reciprocity.

TABLE 5a Evolution of Network Characteristics Over Time for Symmetric Choices: MEETING

Network characteristic	t_0	t_3	t_6	t_{13}
Number of relations	8	104	121	71
Density	0.011	0.347	0.320	0.464
Reciprocity	0.593	0.712	0.727	0.785
Transitivity (norm.)	0.427	0.343	0.375	0.405
Segmentation (norm.)	0.297	0.251	0.280	0.109

TABLE 5b Evolution of network characteristics over time for symmetric choices: MATING

Network characteristic	t_0	t_3	t_6	t_{13}
Number of relations	5	28	36	28
Density	0.007	0.094	0.095	0.183
Reciprocity	0.526	0.615	0.655	0.718
Transitivity (norm.)	0.000	0.247	0.288	0.427
Segmentation (norm.)	0.021	0.285	0.427	0.548

The degree of reciprocity gives the fraction of the reciprocated friendship choices relative to all friendship choices made. For the meeting process it increases after the first observation time and stays fairly stable. For the mating process, it is pretty high and slightly increases over time. In all, about two third of the choices in the network is mutual, independent of the stage of development. Apparently, the chance that two students both perceive each other as friends at a certain moment does not vary much over time. Reciprocity is high and stable, except for t_0 when students met for the first time. This is in correspondence with findings in other studies (Doreian et. al., 1996).

Density, transitivity, and segmentation are all computed for the networks of mutual friendship choices, as given in Figure 2. Density is defined as the actual number of friendships divided by the maximal number of possible friendships given the number of individuals. A sharp increase is observed at the beginning of the meeting process when the group of strangers is transformed into a group of persons who know one another and start doing things together. This increase is smaller for the mating process, where increase in the number of relations is largest at the last time point.

The degree of transitivity counts the number of transitive and intransitive triplets from the perspective of the individuals within the triads. It is a normalized version of transitivity in the sense that it controls for the number of individuals and friendships (for its definition, see Zeggelink, 1993). In the meeting network, the transitivity is fairly high at the first

observation time, due to three female students who follow the short program and know each other already. As more relations are established, the degree of transitivity decreases at t_3, and gradually increases over the next observation times. In the mating network, transitivity also increases over time. This is in line with the results that were reported on the Newcomb data (Doreian et al., 1996).

For the friendship process, the degree of segmentation increases over time. Segmentation indicates the extent to which the network is segregated into subgroups. It is measured by the number of pairs at distance two relative to the number of pairs at higher distances. This number is related to the expected number given the number of points and lines (Baerveldt and Snijders, 1994; Zeggelink, 2000). The monotonic increase of transitivity and segmentation over time represents the process by which friends of friends become friends and as such form clusters within the larger network. In the meeting network the degree of segmentation is fairly stable over time, except for the last observation, where it sharply decreases. The decrease indicates that most students are acquainted, although it may also be partly caused by non-response of a number of central actors, so that fewer subgroups are identifiable. In the mating process, the effect of the missing actors on segmentation is compensated by the emergence of a strong subgroup of mostly female students in the regular program.

Before investigating what drives changes in friendship choices over time, we complete the description of structure at the different measurement moments with a summary of results obtained with the program FATCAT (Richards and Seary, 1993). FATCAT tests the association between certain relations and/or several categories of actors in a network, assuming independence between relations. Here, the association between the meeting and mating relations of the students categorized according to the variables program, smoking behavior, and gender was investigated. FATCAT produces square cross-tables of all observed (dichotomized) relations using the categories and computes a chi-square statistic. Thus, it tests the observed occurrence of relationships between certain categories against the null hypothesis of equal distribution of relationships over categories. Because the variables all have two categories, the number of degrees of freedom of the chi-square statistic is always one. The results are reported in Tables 6a and 6b.

For the variable program, a significant chi-square statistic was found at all time points for both types of relationship. This means that there were more relationships between students from the same program. For gender, the same was found for the friendship relation, whereas for the meeting relation the chi-square test was only significant for the first two time points. There is no significant association found for smoking, except for the mating relation at t_3.

TABLE 6a Chi-square Statistics from FATCAT Analyses Testing the Association between Several Categories of Students: MEETING

Variable	t_0	t_3	t_6	t_{13}
Gender	8.6**	4.2*	0.21	0.03
Program	27.0**	40.0**	35.6**	25.1**
Smoking behavior	0.82	0.005	0.004	0.16

TABLE 6b Chi-square Statistics from FATCAT Analyses testing the Association between Several Ctegories of Students: MATING

Variable	t_0	t_3	t_6	t_{13}
Gender	9.0**	24.9**	23.1**	11.5**
Program	19.0**	61.7**	71.2**	64.4**
Smoking behavior	0.60	5.14*	0.21	0.007

Note: $df = 1$, *: $p < 0.05$, **: $p < 0.01$.

These results suggest that at least some of our expectations might be right with respect to the importance of gender and program, and their possibly different effects at different stages. However, these findings result from the observed networks at each time point and not from the observed changes in the networks. Thus, they test the static networks and not their dynamics. If for example, choices are gender specific from the very beginning, gender explains only evolution in the beginning, and not later, even though separate, static, analyses may show a gender effect all time points. A much more complex analysis is needed for the analysis of the differential effects. In the next section, the SIENA model developed by Snijders (Snijders, 1996; 2001), and the results obtained with the accompanying software are presented.

5. STATISTICAL RESULTS: SIENA

In this section we present the results that were obtained with the software program SIENA (Snijders and Huisman, 2001).[13] The workings and underlying principles of SIENA will first be described in Section 5.1. The design of the analysis is given in Section 5.2, and the corresponding results are presented in 5.3.

[13]A windows version of SIENA is implemented in the program StOCNET which can be downloaded from http://stat.gamma.rug.nl/stocnet.

5.1 Siena

The program SIENA for Simulation Investigation for Empirical Network Analysis carries out the statistical estimation of models for the evolution of social networks according to the dynamic actor-oriented model of Snijders (Snijders, 1996, 2001). The basic idea of the model is that individuals in the network evaluate their position in the network and try to obtain a "better" configuration of relationships, a configuration that increases their social well-being.

Two or more consecutive observations of the network are supposed to be available. Between two observation moments, time flows on continuously, and the actors may change their relations at random moments during this period. It is assumed that each actor controls his outgoing relations and the network only changes one tie at a time. Such a single change by one actor is called a ministep. In each ministep, the structure of the network and attributes of the actor and of the dyads determine which outgoing tie is changed and the moment at which the ministep is made. Making one change means that an actor creates a new tie, or that an existing tie is withdrawn.

First, we discuss in which way it is determined which tie will be changed in a ministep. The network at the second time point is considered the dependent variable in the model, that is, the state of the network that has to be reached from the starting position of the network. Both observations of the network influence the tie changes made by the actors, because the actors evaluate the network structure (at the first time point) in order to obtain a rewarding pattern of relationships (as represented by the network at the second time point). The evaluation takes place on the basis of a so-called objective function and a gratification function. The objective function relates different characteristics of the network and of the connected individuals to their overall utility. It is defined as a sum of weighted effects, where the weights are unknown and will be estimated from the data. Three groups of effects can be distinguished. First, standard network effects, reflecting well-known structural tendencies like density, reciprocity, or transitivity. Second, actor attribute effects, reflecting attribute-related popularity, attribute-related activity, and attribute-related dissimilarity (Snijders, 2001). Third, dyadic attribute effects, modeled as covariate-related preference. We consider only effects from the former two groups. The actor attributes are assumed constant between two observation times.

The preferences expressed by the objective function treat the creation of new ties in a similar way as the deletions of existing ties. However, it is conceivable that some effects (e.g., reciprocity or an attribute effect like gender) operate differently for initiating new relations than for breaking

existing relations.[14] Such effects operating differently for creation and breaking of ties cannot be represented by the objective function and are therefore represented by the gratification function, indicating the instant gratification experienced by an actor when changing the relation with another actor, given the current state of the network.

The objective and gratification functions are combined in the model for the ministep. A random component is added to the functions to account for the deviation between theoretical expectation and observed reality (it represents the actor's drives and limited foresights that are not, and cannot be, explicitly modeled). For each ministep, it is assumed that the actor who makes the change maximizes the sum of the objective function given the new state, the gratification inherent in the change and the random component. The random term is assumed to have a Gumbel distribution with mean 0 and scale parameter 1, which means that the actors behave according to a discrete choice model (Maddala, 1983). An actor considers the value of the objective function that would be obtained after each possible change in one of his ties and makes a stochastic choice, in which the probability of change in a particular tie is larger when this change would lead to a greater increase in the objective function (discrete choice model). Every individual has the same objective and gratification function, but differs of course in individual characteristics. Given the present state of the network, all actors are assumed to behave independently and are assumed to have full knowledge of the network.

Next, we discuss the moment that a ministep is made. It is assumed that at stochastic times a randomly chosen actor makes a ministep. All actors have a rate of change $\lambda_i(x)$ of their ties. The rate can be constant between two observation moments, but can also be modeled as a function of actor attributes and degrees. Given the individual change rates $\lambda_i(x)$, the times between the ministeps are independently and identically distributed with the exponential distribution with parameter $\Sigma_i\lambda_i(x)$. The probability that, if a ministep is made, this step is made by a specific actor i equals $\lambda_i(x)/\Sigma_i\lambda_i(x)$.

The specification of the stochastic actor-oriented models given above results in the following parameters: the constant change rate and the weights that indicate the influence of attributes and degrees on the change rate, the weights of the objective function, and the weights of the gratification function. Classical maximum likelihood estimation methods cannot be applied to estimate the parameters from the data. Instead, the Robbins-Monro approximation method and Monte Carlo simulation methods (to

[14]See Van de Bunt (1999), or Van de Bunt, Van Duijn, and Snijders (1999), for examples of gratification inherent in reciprocated relations, where actors are reluctant to break off reciprocated relations, but like starting an as yet unreciprocated relation.

repeatedly simulate the evolution process of the network) are used to obtain approximate expected values of relevant statistics and parameters.[15] Methods for testing the significance of these parameters have not been developed to a satisfactory degree. Since both parameter estimates and estimated standard errors are obtained with the Robbins-Monro method, the corresponding t-statistics are used to determine approximate significance.

As such, the program is perfectly suitable to test our hypotheses because it can estimate all possible effects simultaneously (controlling for the others).

5.2 Design of the Analyses

In the previous section, we showed how network characteristics changed over time for symmetric friendship choices. However, here the analyses here will focus on *all* choices to detect details of the choice process.

In total, the network consists of 38 students. However, only at the first observation time all students were completely observed. At the other times, missing values were encountered due to item and unit nonresponse and composition change. Item nonresponse occurred when students did not provide data on a specific tie, and unit nonresponse occurred when students did not hand in the questionnaire, resulting in missing values for all outgoing relations of that actor. These missing ties are treated in SIENA by setting their values to 0 at the beginning and ending of each time period whenever at least one of the two observations is missing. In this way, their influence on the estimation results is minimized (for details about handling missing data in SIENA see Snijders and Huisman, 2001).

Changes in the composition of the network occurred only in the period from t_6 to t_{13}, where 1 student left the network. The simulation algorithm implemented in SIENA handles networks of changing composition by modeling the composition changes as exogenous events that occur at given time points, as proposed by Huisman and Snijders (2002). In this specification, actors who leave the network influence the estimation of the parameters up to the time of leaving the network and actors who join the network influence the estimates from the time of entering the network.

In Table 7, we show how the effects of Table 1 are operationalized. The variables for proximity, visible and invisible similarity were extensively introduced in Section 3. For reasons of simplicity, the invisible similarity variables as measured at t_0 were used for all transitions, although it is possible in SIENA to use changing covariates. These variables were

[15]See Snijders (2001) and Snijders and Van Duijn (1997) for technical details.

TABLE 7 Operationalization of Effects in Empirical Variables

Effects	Variable name					
General control variables	Change rate λ	Density	Squared density	Reciprocity		
Network opportunity	Transitivity	Balance, Popularity	Indirect relations	Activity		
Proximity	Program	Smoking behavior				
Visible similarity	Gender					
Invisible similarity	Club membership	Dinner at home	Going out	Talk about personal feelings	Talk about study	Using soft drugs

measured again during the final stage, but the observed changes were few, and therefore do not influence the results to a great extent.

The other types of variables mentioned in Table 7 are explained here. These structural effects have to be derived from the network itself. We consider two kinds of network variables, that is, general control variables and network opportunity effects. As general control variables SIENA automatically includes density, the mean number of friendships (the intercept) and the constant change rate λ, the amount of change between the two measurement moments. In addition to density, a parameter related to squared density (i.e., squared outdegree) is included. This parameter represents the variance of the number of friendships of an actor, indicating the marginal returns of initiating new ties (Van de Bunt, 1999).

The reciprocity effect is also included in all of the analyses, because it is well known from the literature that people prefer to be friends with those who want to be friends with them. Since we have already seen that the degree of reciprocity in the data over time is high at all time points, we expect the reciprocity effect to be high and large at all transactions. This is due to the fact that also new friendship choices tend to be reciprocated or disappear soon. This means that the probability of choosing someone else as a friend is larger if, ceteris paribus, one is chosen by the other individual as well. Moreover, it implies that the probability of removing a friendship choice is larger if one is not chosen by the other (anymore).

Network opportunity effects can be oriented toward either transitivity or balance. These effects are different mathematical specifications of the same intuitive idea: an individual i has a closed or transitive personal network, that is, the others to whom i is related tend to have

comparatively many friendships among themselves. Verbal theories are often not detailed enough to distinguish between structural effects (see also section 2.2). Empirically, however, it is possible to determine which one of these effects succeeds better in accounting for the degree of transitivity in the data.

Let the matrix $x = [x_{ij}]$ be the network at a given point in time, with x_{ij} the tie from actor i to j. From the viewpoint of i, $s_i^T(x)$ represents the corresponding transitivity effect, and $s_i^B(x)$ represents the balance effect. Other individuals are represented by j and h, and the total number of individuals is n. If actor i chooses j, the element $x_{ij} = 1$, and if i does not choose j the element equals $x_{ij} = 0$. The transitivity effect is defined by the number of transitive patterns in individual i's relations, that is, the number of ordered pairs (j, h) to both of whom i is related, while also j is related to h:

$$s_i^T(x) = \sum_{j=1}^{n} \sum_{h=1}^{n} x_{ij} x_{ih} x_{jh}. \tag{1}$$

The balance effect is defined by the likeness between the out-relations of individual i to the out-relations of the other individuals j to whom i is related:

$$s_i^B(x) = \sum_{j=1}^{n} x_{ij} \sum_{\substack{h=1 \\ h \neq i,j}}^{n} (b_0 - |x_{ih} - x_{jh}|), \tag{2}$$

where b_o is a constant included for convenience.

At first sight, it seems as if transitivity and balance are the same things, but they are not. A triad is transitive from the viewpoint of i if i chooses j, j chooses h, and i chooses h. A triad is balanced from the viewpoint of i either if i chooses j, j chooses h, and i chooses h, or if i chooses j, j does not choose h, and i does not choose h. Moreover, the transitivity effect counts pairs of individuals, and the balance effects counts individuals. Van de Bunt (1999) shows the formal relationship between balance and transitivity: when an individual strives after balanced relationships this is the same as a mixture of striving after transitivity and a preference for others with a high outdegree.

We find balance theoretically more appealing because it captures the idea that individuals get to know each other through common friends, and they want to be friends with those who are similar on friendships with others (they think alike about others). Another interpretation of the balance effect is that it is similarity with regard to preference for the same others.

Since we have demonstrated that the balance effect is a combination of the transitivity effect with a popularity effect, we always include the popularity effect as a control variable in the SIENA analyses together with the balance effect. As such, we can examine whether popularity plays a role by itself in the process of friendship formation among students, that is, whether there is a tendency to choose more often those who are already chosen by many. With SIENA we can even examine whether the choice probabilities depend on a student's popularity, based on measured individual variables. Likewise, we investigate an activity effect (are students who make many choices themselves preferred), and we examine whether there are preference differences between students' activity, based on individual characteristics.

A forward stepwise model selection procedure is used, with the aim of including only important parameters in the model. The general order in the procedure is that first the structural effects (and control variables) are included, and then the covariate related effects. In this procedure, simulations of the network evolution are used to select effects that may be candidates for inclusion. The network evolution is simulated for fixed parameters from earlier model estimations, and t-statistics are calculated which can be regarded as tests for the simple null hypothesis that the model specification with the current parameter values is correct. However, care should be taken with this procedure, because the t-values do not take into account that the parameter values are estimated and it entails the risk of capitalizing on chance. For details on the simulation procedure in SIENA, see Snijders and Huisman (2001), for another application of a stepwise procedure see Snijders and Baerveldt (2002).

In the consecutive steps of the stepwise procedure, the following effects are inspected and included when 'significant', that is, when having a t-statistic, defined as the ratio of parameter estimate and its standard error, larger than 2:

1. *General control variables*. Constant rate, density and reciprocity. We always start with estimating a model in which these effects are included because of their fundamental nature.
2. *Network opportunity effects*. Transitivity, balance, indirect relations, and popularity. All four effects are included, the model estimated, the significance and relevance of the effects evaluated. If necessary, the model is estimated again with one or more effects removed.
3. *Other network effects*. Squared outdegree and activity. Simulations are used to determine which effects are to be included in the model. For all effects, the t-statistics are evaluated and those effects with large (absolute) t-values are included. Next, the model is re-estimated. If

necessary, the model is estimated again with one or more effects removed.

4. *Network gratification effects* and *network rate effects*. Simulations are used to determine relevant network gratification and rate effects, as in the previous step.
5. *Actor attribute effects*. The inclusion of actor attribute effects is evaluated separately for all three groups introduced in Section 2.4: proximity, visible, and invisible variables. For each group of attributes five effects are inspected: attribute-related popularity, activity, and dissimilarity, the gratification effect of dissimilarity, and the rate effect of the attribute. Simulations are used to determine t-values of the effects per group. The effects with the largest (absolute) values are included one at a time, that is, the effect with the largest value is included, and the model re-estimated. Then again simulations are performed, the effect with the largest (absolute) t-value included, and so on. If necessary, non-significant effects are removed. In all, 9 actor attributes are evaluated:

   A. *Proximity variables*: program and smoking.
   B. *Visible variable*: gender.
   C. *Invisible variables*: club membership, dinner at home, going out, talking about personal feelings, talking about study, and using soft drugs.

The order of evaluating (and including) attribute effects depends on the observation times and is based on the hypothesized importance of the effects in the different stages of friendship formation in section 2.4 (see Table 1). For the initial period, the order is proximity, visible, invisible variables. For the middle stage, the order is visible, invisible, proximity variables, where the first two are considered most important. For the final period the order is invisible, proximity, visible variables, with the first group of variables considered most important. For the meeting process, the invisible variables are excluded from the analysis. The proximity variables are included first and then the visible variables.

5.3 Results

In Tables 8a and 8b, we present the results for all three meeting and mating transitions together. In the first column, we show the name of the effect such as it was introduced in Section 2 and Table 1. In the second column, its operationalization is shown, and the third, fourth, and fifth column show the effect sizes for significant effects in the initial, middle and final stage of the meeting and mating network development, respectively. Estimated

TABLE 8a Estimated Effects and Standard Errors Within Parentheses: MEETING. For the Proximity Variables and the Characteristics, Only Significant Effects Are Presented

	Effect	Initial t_0 to t_3	Middle t_3 to t_6	Final t_6 to t_{13}
Control variables	λ	15.74 (0.64)	8.50 (0.74)	7.77 (0.85)
	Density	−1.84 (1.24)	−0.91 (0.35)	1.01 (1.05)
	Reciprocity	3.77 (3.29)	0.82 (0.37)	0.38 (0.35)
Network opportunity	Balance			2.75 (1.11)
	Popularity	8.15 (2.85)	2.98 (0.56)	−0.42 (1.50)
Proximity	Program-similarity	1.04 (0.24)	0.97 (0.23)	
	Program-popularity		0.45 (0.23)	
	Program-activity		−0.54 (0.24)	
	Program-rate		−0.77 (0.23)	
Visible characteristics	Gender-activity			−0.95 (0.42)
	Gender-rate		−0.47 (0.23)	
Possible covariate effects	Program-activity	+		
	Program-rate	+		
	Smoke-activity		+	
	Smoke-rate		+	
	Gender-activity		−	
	Gender-gratification	+		

standard errors are given in parentheses. At the bottom of the table, we included a list of "possible" covariate effects, indicating effects that were included in step 5 of the estimation procedure (on the basis of their simulated t-statistic) but had an estimated t-statistic between 1 and 2, and were excluded from the final model. Especially for the invisible variables, used in the estimation of the friendship networks, it provides some indication of the importance of some of these variables.

The random change parameter λ indicates the expected number of changes of relationships with another individual per time period per person. Note that the number of weeks is different in the three transition periods which means that the effects in different stages have to be interpreted on a slightly different time scale, adjusting for the length of the stage.

Two main observations can be made with respect to the change parameter. The first is that, when taking into account the different time scale, the number of changes decreases over time. In the initial stage is much larger than the number of changes at later stages, which is of course due to the fact that the point of departure was an almost empty network for both meeting and mating. Second, the amount of change is much lower in the

TABLE 8b Estimated Effects and Standard Errors Within Parentheses: MATING. For the Proximity Variables and the Characteristics, Only Significant Effects Are Presented

	Effect	Initial t_0 to t_3	Middle t_3 to t_6	Final t_6 to t_{13}
Control variables	λ	5.37 (0.56)	3.09 (0.56)	5.35 (0.77)
	Density	2.49 (1.16)	−1.44 (0.70)	−2.25 (0.82)
	Squared density	0.66 (0.04)		
	Reciprocity	3.86 (1.48)	3.46 (1.19)	3.37 (1.17)
Network opportunity	Balance	13.99 (3.76)	8.29 (3.11)	9.40 (2.48)
	Popularity	9.77 (2.27)	0.46 (4.07)	6.81 (1.59)
Proximity	Program-similarity	1.13 (0.22)		
Visible characteristics	Gender-similarity	0.68 (0.27)		
Invisible characteristics				
Possible covariate effects	Program-popularity			−
	Smoking-similarity	+		
	Smoking-activity			+
	Soft drugs-similarity	+		
	Soft drugs-popularity		+	
	Feelings-similarity			+
	Feelings-gratification		−	
	Going out-activity			−

mating network than in the meeting network, which implies that the process of meeting is faster than the process of mating. This was also found by Van de Bunt (1999).

The density parameter is hard to interpret by itself, since it is dependent on the other effects included in the model (see Snijders, 2003, for a discussion on parameter interpretation). The same holds for the reciprocity parameter, although it can be observed that reciprocity is—not surprisingly—always positive and larger in the mating network than in the meeting network in the middle and final stages. The squared density effect that is found in the initial stage of the mating process indicates the marginal effect, whose positive sign denotes an increased desire for friendships for students with few established friendships yet.

Balance plays an important role in all three stages of the mating process, especially in the initial stage. The role of balance is very modest in the meeting process, only in the final stage a small effect of balance is found. Popularity is always included in the models (for a correct interpretation of the balance effect), and is especially important in the initial stages of both

meeting and mating. This implies a preference for "popular others" in these stages. Apparently, students who have received relative many choices already are "attractive." In this sense, popularity could be regarded as a "visible" (that is, observable) individual attribute in these first stages. Transitivity is never included in the models. Van de Bunt (1999) chose to include transitivity instead of balance and did not find an effect of transitivity either.

As expected, the proximity parameter "program" turns out to be important. In the initial stages of both meeting and mating, there is a rather strong and significant similarity effect: students tend to get to know and become friends with students in the same program. For the friendship process, the effect of "program" is not important anymore in the middle and final stages (although an almost significant effect was found in the middle stage). The effect of "program" in the meeting process, however, increases in the middle stage. Not only a similarity effect is found, but also popularity and activity effects, implying that popular students in the short program and active students in the regular program have higher probabilities of being met. Moreover, a significant effect of program on rate is found, implying that students in the regular program make on average more choices than students in the short program, that is, are more active in meeting other people. This corresponds with our earlier idea that students in the regular program are starting a new phase in their lives, whereas students in the short program are a few years ahead and probably have established a lot of (meeting and mating) relations already. Conform our expectations no effect of program is found in the final stage.

The proximity parameter smoking turns out not to be important at all, although a possible similarity effect is found for the initial stage in the friendship process and possible rate and activity effects are found in the middle stage of the meeting process. This is contrary to the findings by Van de Bunt (1999).

The visible similarity parameter gender is significant only in the initial stage of the friendship process. In the meeting process, we do not find a similarity effect in any of the stages. There is an effect of gender on rate in the middle stage, expressing that men change more relations than women. The activity effect of gender in the final stage of the meeting process implies that the probability of meeting a male student is higher than meeting a female student. Thus, the visibility effect is somewhat different from what we expected. The similarity effect lasts shorter, and is not found for the meeting process. The rate and activity effect of gender in the later stages cannot be regarded so much as visibility effects, but may capture other—invisible—male characteristics as well.

Unfortunately, no other effects of invisible characteristics are found in the meeting and mating processes. Some possible effects are found for

personal feelings in the later stages of both meeting and mating, for club membership in the middle stage of the meeting process, and for going out in the final stage of the friendship process.

When we now combine the results with our expectations (Table 1), we obtain Table 9. In this table, ** indicates that the expected effect is found and significant in the specific stage of development, *? indicates a possible effect, and * indicates that we have both a confirmation and a rejection of the expectations in that stage. If the distinction in initial, middle, and final stages seems reasonable (which is of course debatable) we have obtained quite good results. Proximity is important initially, where initially may mean a somewhat longer period than we thought at first. Visible similarity determines friendship choice in the initial and middle stage of network development. Although the effect of invisible similarity is weak, we found that it does not play a role until the final stage of the development process.

TABLE 9a Overview of Expected (Bars) and Observed (Stars) Strengths of Different Effects at Different Stages of the Meeting Process

	Meeting stage		
Effect	Initial	Middle	Final
Proximity	**	**	
Visible similarity		**	**
Invisible similarity	**	**	*
Network opportunity			

TABLE 9b Overview of Expected (Bars) and Observed (Stars) Strengths of Different Effects at Different Stages of the Friendship Formation (Mating) Process

	Mating stage		
Effect	Initial	Middle	Final
Proximity	**		*
Visible similarity	**		
Invisible similarity		*?	*?
Network opportunity	**	*	**

Network opportunity effects come into play at all stages, but may disappear when proximity or similarity effects are very large in a specific stage (here, the middle stage).

6. CONCLUSION AND DISCUSSION

What kinds of individual characteristics and network variables explain the changes over time within a friendship network? At what stages, and why, are these variables important? This was the main research question of the paper. From this research question, it follows that we were not primarily interested in the explanation of network structure at a certain point in time or in the differences in network structures at consecutive points in time, but in the underlying process that drives changes in the network. Realizing that systematic changes in networks necessarily lead to changes in network structure, we specifically aimed at researching the influence of network characteristics on the network evolution. The other goal of the study was to investigate the role of similarity with respect to visible, and especially invisible actor characteristics.

We focused on the development of a friendship network in a relatively closed setting of initially mutual strangers: a population of university freshmen. We argued that friendship is particularly important for behavioral confirmation, expecting that proximity and visible similarity initially strongly facilitate friendship formation. Meeting one another is a first prerequisite for becoming friends (mating) and visible characteristics are often important cues for underlying attitudes and interests. Therefore, we distinguished the meeting process and the mating process.

Proximity and visible similarity were expected to be irrelevant at later stages in the sense that those variables do not explain the changes at these stages, although they might serve to explain the network structure itself. During later stages, common interests, behavior, and attitudes were assumed more relevant, as they are revealed only in longer lasting relationships and interactions. Moreover, we expected that the network structure itself creates meeting opportunities with friends of friends and that these opportunities remain important causes for changes during all stages. In the friendship process, similarity with respect to certain characteristics, were expected to be the most important variables, whereas in the meeting process individual characteristics were also considered relevant.

We indeed found that proximity and visible similarity are important explanatory variables for friendship formation, that is, the mating process in the initial stage of the group formation and disappear as explanatory factors in the middle and final stages. For the meeting process, we found that proximity is important in the initial and middle stages, and that the role of visible characteristics is much less clear.

We also established that balance is an important network proximity factor in the mating process, more important than transitivity for which no effect was found. As explained previously, balance and transitivity are related. Here we empirically showed that balance seems most relevant. This means that similarity of positive and negative friendship choices of one's friends remains an important cause for changes in friendship choices. In the meeting process, balance does not start to play a modest role until the final stage.

Thus, we found evidence that the meeting process is indeed different from the mating process. Apart from differences in rate, network opportunity effects, and proximity effects, we also found that actor characteristics are important for the development of the meeting network. Thus, individual differences are identified, in our study with respect to the variables gender and program. These characteristics influence the rate of change, and the attractiveness (or availability) of the actors in the network.

The results with regard to the effects of invisible similarity were only weak. Although we did find some possible effects of invisible actor characteristics, especially in the final stage of the mating process, none of them were significant. We can think of several reasons, however, for not finding similarity effects of the invisible variables.

In our study, program was the most important proximity variable as students had many more meeting opportunities with other students in their program than with students of the other program. Gender was the most important visible similarity variable. The two variables are at the same time a proxy for many of the aspects represented in the invisible variables, which probably also explains why their effects are so strong (recall that in general the students in the short program are older than the students in the normal program).

The importance of program and gender could also be attributed to the observation in other studies that perceived similarity may be much more important than actual similarity (Curry and Kenny, 1974; Hill and Stull, 1981; Newcomb, 1961). Moreover, certain values (of invisible variables) may be important only to those whose values differ markedly from the mainstream (Jew and Tienda, 1997). The low importance of actual similarity may also be due to the finding that friends seem to assume that their attitudes are more similar and that their activities are less coincident than is actually the case (Werner and Parmelee, 1979). Framing could be another reason why actual dissimilarities may remain hidden for quite a while. It is well known that individuals behave differently in strong solidarity settings, like friendships, than in other settings (Lindenberg, 1998). Large dissimilarities between friends may remain hidden as they meet only in one setting, doing quite different things when they are alone or when with others.

Finally, we question whether our phrasing of the questions is sufficiently specific to tap common interests, activities and behavior. Questions about students' clubs, going out etc. are not specific about, for instance, the type of club or the type of bar. We should reflect about possibilities to ask in more detail, specific questions about common interests, activities and attitudes without lengthening the questionnaire.

To summarize, our results clearly show that the usual proximity and similarity variables in friendship research explain changes in friendship choices only in the beginning of friendship formation. Because of their importance as constraints for later friendships, they do not contribute to the explanation of further fine-tuning of friendship relations at later stages. The results also show that network opportunity is important throughout, both in the meeting and the mating processes. The results are not conclusive about the influence of invisible similarity in friendship formation.

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