

Relationship patterns in the 19th century: The friendship network in a German boys' school class from 1880 to 1881 revisited



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ABSTRACT

The article presents a friendship network from 1880 to 1881 in a school class, which goes back to the exceptional mixed-methods study of the German primary school teacher Johannes Delitsch. The re-analysis of the historic network gives insights into what characteristics defined the friendship networks in school classes in Germany at the end of the 19th century. ERGMs of the so far unmarked data show structural patterns of friendship networks similar to today (reciprocity, transitive triadic closure). Moreover we test the influence of the class ranking order (Lokationsprinzip), which allocates the pupils in the class room according to their school performance. This ranking order produces a hierarchy in the popularity of pupils, through hierarchy-congruent friendship ties going upwards in the hierarchy. In this respect, concerning the effect of school achievement on popularity, we find a strong stratification, which is not always prevalent today.

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1. Introduction

A look at the history of social network analysis shows that the first attempt to find structural principles goes back to the 30s of the 19th century: worthy of mention are e.g. Auguste Comte (1830–1842) and Alexis De Tocqueville (1835–1840). The decisive conceptual step is often attributed to the sociologist Georg Simmel (1908), who provides network thinking in the center of his theoretical approach.¹ The first big wave of "network" studies were chronologically and geographically located in the middle of the 20th century in the Anglo-American region (for a historical overview see Freeman, 1996, 2004; Gamper and Reschke, 2010). However "Child Study", and later on "Sociometry", deserve a special mention, since they represent precedent empirical approaches to social networks. In these early studies² e.g. made by Almack (1922), Wellman (1926), Bott (1928), Hubbard (1929) and by Moreno (1934) friendship relations between pupils in schools were the subject of interest. A look at these early studies shows, that the

meaning of friendship can shift within sociocultural and historic boundaries. However friendship ties have been always regarded as essentially meaningful especially for the development of a sense of identity and for a positive primary socialization (DuBois and Hirsch, 1993; Douvan and Adelson, 1966). Therefore it is not surprising that social network research tends to this day to focus on friendship networks of pupils.³ Nowadays questions revolve around the effects of school performance (Kandel, 1978; Lubbers and Snijders, 2007; Knecht, 2008), of social status (Adler and Adler, 1995), of gender (Goodreau et al., 2009; Lubbers and Snijders, 2007), of ethnic affiliation (Snijders and Baerveldt, 2003; Knecht et al., 2010), and of age (Crockett et al., 1984) on the formation of friendships. Especially the questions, which pupil's characteristics are rewarded with popularity have drawn attention. Popularity friendship research in school classes asks which pupils tend to attract much friendship avowals. Since friendship formations and popularity rankings in schools reflect also how social ties operate in the larger society, as Coleman (1961) argues, the study of pupils friendship networks can generate conclusions on the functioning of such processes on a more general level.

Against this backdrop we present one of the earliest studies – maybe the earliest study – in the field of social network analysis

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¹ Hollstein showed that Simmel revealed different kinds of structural configurations which are still used in current network analysis (Hollstein, 2001, 2008).

² An early network analysis regarding the homophily of friendships in school classes can be found in Monroe (1898).

³ There are probably also methodological reasons for the ubiquity of friendship networks in school classes as a topic of network analysis. School classes are easily accessible, have rather well-defined boundaries, and are not too big in size.

which was carried out prior to the theoretical foundations of network thought by [Simmel \(1908\)](#) or the empirical works which were mentioned above. In the year of 1880–1881 the German teacher Johannes Delitsch collected socio-relational data of a class with 53 pupils with the aid of a sociomatrix. The results were published in the year 1900 in the ‘*Zeitschrift für Kinderforschung*’ (‘Journal of Child Study’). Delitsch’s empirical work is a germ of early social network analysis and an unmarked curiosity of its history. First it provides an insight into the process of friendship formation in school classes during an interesting time where western states were establishing their public education sector ([Hofstetter and Schneuwly, 2006](#)). Furthermore, the empirical approach was methodologically elaborated and in form and content a distinguished work in its own right. With the aid of a mixed method approach he collected quantitative and qualitative data which has started to grow in popularity in the network-research community only recently (e.g. [Gamper et al., 2012](#); [Hollstein, 2010, 2011](#)). The analysis of this data promises insights into what characteristics defined friendship networks in school classes in Germany at the end of the 19th century and how the school class can be described in regard to transitivity, reciprocity, clique behavior, and stratification. The huge amount of knowledge accumulated in more than one hundred years of research on friendship ties in school classes makes a look back on this early forgotten work from today’s perspective a promising endeavor.

Since the original study by Delitsch was written in German, the access to his work is hindered for the present-day social network analysis community. Furthermore the special historical and scientific context of the original study has to be clarified, to further elucidate the work. Therefore, we take a closer look at the original data collection process and the presentation of the dataset. In the original article many of his hypotheses remain implicit, and he also lacks the modern statistical tools to test them thoroughly. Therefore we put forward new hypotheses in reformulating implicit assumptions by Delitsch, and align them to what we theoretically and empirically know today about friendship networks in school classes. In our statistical model we take a deeper look at structural characteristics of friendship ties for the pupils in this primary school class like reciprocity and different forms of triadic closure. Beyond this we analyze the relationship between the class ranking position, which depends on the marks of the pupil, and the pupil’s popularity. We test whether this effect is produced through a higher probability of directed friendship ties going up in the hierarchy in opposition to ties going down. Furthermore we modify our model by including special terms for exceptional pupils Delitsch described with qualitative methods. He argued that the four repeaters and a ‘sweets giver’, a guy who gives sweets to other pupils, have a higher popularity in the class. On the other hand pupils with a physical, psychological or social disability are less popular. Through this approach, we can discern, whether the mixed-method approach by Delitsch produces a benefit for the statistical model. At the end we draw a short conclusion.

2. Historical and academic context of the Delitsch study

Delitsch’s study is not only worthy to be recognized in respect to the history of social network analysis, but also because of the historical insights it gives. The German empire at the end of the 19th century is an interesting historical context for an analysis of friendship networks in school classes. In the 19th century the nation state was a decisive agency for establishing public schooling in Western civilization: ‘schooling gradually became an affair of State, each and every one considering that the nation’s future was at stake’ ([Hofstetter and Schneuwly, 2006](#): 1; see also [Tröhler et al.,](#)

[2011](#)). The objective targets differ thoroughly in content and topic among the national educational systems, however: In the US the establishment of a national democratic identity was prevalent to aid in integration of the unending stream of immigrants, whereas in Germany – which did not become a national state until 1871, comparatively late in the history of European state formation – public schooling was supposed to help develop *one* national consciousness in the many former kingdoms and principalities. The latter was defined more strongly by hierarchical structures than current societies – at least in the so-called ‘western’ world. According to national stereotypes, this was especially true for the German empire where militarism was very visible in public life. Though current historic research qualifies the image of a totalizing militant society in the German empire ([Clark, 2006](#): 596–611), from a sociological perspective it is nevertheless beyond question that the relation between individual and community was defined on different terms than it is today.

At this important period Delitsch carried out his mixed method study which was published in the German ‘*Zeitschrift für Kinderforschung*’ (‘Journal of Child Studies’).⁴ This journal was founded in 1896 by a group of pedagogues, medics and theologians in order to deal with psychological aspects of child education and therapy ([Trüper, 1896](#)). For this purpose the articles strongly referred to a ‘new’ tradition of research that spread from Northern America and Great Britain to continental Europe at the turn from the 19th to the 20th century ([Ufer, 1896](#): 117). The so called Child Study Movement deployed positivist notions of science and Darwinian theory in order to study children ([Depaepe, 1993](#)). This new paradigm provoked a great number of empirical research projects that affected the education of children ([Hulbert, 2003](#)). In order to gain knowledge about the ‘nature’ of the child, parents, teachers, and doctors started to observe their children systematically in everyday life ([Eßer, 2011](#); [Tervooren, 2008](#)). Although ‘Child Study’ as a movement came to an end around the beginning of World War I ([Depaepe, 1993](#): 54), the long lasting effects may not be underestimated (e.g. [Ryan, 2011](#)).

Delitsch and his network study, which was published in 1900, fitted well into the framework of the German Child Study journal. This may be understood thematically as well as biographically: Johannes Delitsch was born in 1858 into a bourgeois home in Leipzig/Saxony and started his career as an elementary teacher in the provincial town Plauen in 1882 ([Schmidt, 2008](#)). There he founded a special class for handicapped children and, later on, became the first principal of the school for mentally handicapped children. Besides that, he was socially committed to the foundation of a local youth services organization and worked as a house teacher. Other than his empirical study on pupils friendships Delitsch published articles on social welfare for mentally handicapped juveniles ([Delitsch, 1912](#)) and neglected children ([Delitsch, 1910a,b](#)) in the ‘*Zeitschrift für Kinderforschung*’. Johannes Delitsch died in 1920 at the age of 61 ([Fig. 1](#)).

Delitsch’s study on his school class is remarkable in several respects even within the context of the Child Study Movement. Whereas the importance of nurture for the development of children was broadly discussed, comparable empirical approaches to peer culture are hard to find. Delitsch had already conducted the fieldwork to his article in the years 1880/1881. Contrastable and influential studies of that time focused on the observation of the single child’s development (i.e. [Darwin, 1877](#); [Preyer, 1882](#)). While for many of his contemporaries the mind of the child was the object of interest ([Shuttleworth, 2010](#): 359), Delitsch was

⁴ For a closer description of the journal see also [Eßer \(2010\)](#).



Fig. 1. Johannes Delitsch (1858–1920).

interested in the relations in which morality and friendships are generated.

According to our knowledge Delitsch's whole network approach to peer culture, as we will describe in detail in Section 3, is at least remarkable, if not outstanding for 19th century Germany.⁵ This assumption is backed by the fact that it took Delitsch nearly 20 years to publish his results. He could neither refer to similar studies, nor was his work recognized and valued by his contemporaries. Until today, the article remains nearly uncited.⁶

However some of the more peripheral protagonists of Child Study and their successors started to empirically include friendship in their observation. They were especially interested in how mutual contact impacts on behavior and on mental as well as physical development (Elbing, 1963). This empirical work was methodologically based on a dyadic level and mainly interested in parameters like reciprocity versus asymmetry of ties and homophily. One early example is the study by Monroe (1898) (which is not cited by Delitsch). He was interested in friendship relationships of young children. He asked 1068 boys and 1268 girls, at the age from 7 to 16 years: 'What kind of a chum do you like the best?'. Monroe found that a large part of the pupils wanted friends that have

the same sex and those who were older or at least the same age. Other pedagogues and psychologists like Terman (1904), Almack (1922), Wellman (1926) or Reiningner (1924) used nearly the same approach. Even if those researchers focused on relations, the structures of whole networks were a desideratum at this time. Most of the results were statistics of correlations which were reported in tables. A whole network approach to (small) school classes including sociomatrices (Bott, 1928: 63) and visualizations of whole networks (Moreno, 1934: 141) became more prominent only 50 years after Delitsch's data collection during the first 'birth of social network analysis' and the emergence of 'sociometry' (Freeman, 2004; Dollase, 1973).

3. Aim, methodology and methods of Delitsch's study

Johannes Delitsch gathered data combining observation, interviewing pupils and parents, and analyzing school essays during one school year (1880–1881). Thereof he constructed a whole network-matrix of directed (reciprocated and non-reciprocated) friendship relations for a German boys' primary school class ('Volksschulklassen') in the 4th grade. The aim of his endeavor was twofold: On the one hand he wanted to use this information as a pedagogical instrument. Since he was new to the huge class of 53 schoolboys and had been a house teacher with only few pupils prior to that, he wanted to get a quick and accurate access to the social structure of the class to better understand the children.⁷ He focused on the friendship relationships among the pupils in order to find out more about students' disposition ('Gemütsleben'), true to the saying: 'Tell me whom you hang around with and I will tell you who you are' (Delitsch, 1900: 150f. [translation by authors]). In cases of class conflicts for example, which are negotiated by an internal class court ('Schulstübengericht'), he was able to find out whether pupils lied out of loyalty to protect their friends. Knowledge of the relational system of the class enabled him to identify functional relationships which led to a positive mental and scholarly development, and dysfunctional relationships which hindered such a development. On the other hand he had also an analytical and scientific interest in the network of friendship relations. He wanted to understand why and between whom friendship relations form. For this purpose Delitsch developed some half-explicit hypotheses which can explain the social structure of the pupils' network.

What makes Delitsch's study so interesting for a re-analysis with contemporary analytical techniques and a comparison with recent network studies on pupils' friendship relations are not only the relational considerations he undertakes but also his multi-sited and mixed-method approach which allows him to collect very 'rich' data about the friendship relationships of the pupils. Furthermore, the data he reports in his 1900 published article represents – to the best of our knowledge – the first ever primarily collected social network data. He developed an innovative way for the depiction of relational data in a matrix. Taking into account the comprehensiveness of his considerations and the richness of his empirical approach makes it even more surprising that Delitsch's work has hardly been picked up by succeeding scholars.

Delitsch applied an empirical approach that – according to its variety of inquiry methods – can be compared with the now-classical Marienthal study on the social impact of unemployment on a small community (Jahoda et al., 1933) and can be seen as seminal work for current considerations about qualitative and mixed-methods approaches in social network analysis (e.g. Gamper et al., 2012; Hollstein, 2010, 2011). His research methods, which Delitsch pretested in the year of 1879–1880 with the former

⁵ No similar studies have been published in the 'Zeitschrift für Kinderforschung' in the years from 1896 to 1914. In another influential German journal on child and youth studies (Zeitschrift für Jugendwohlfahrt, Jugendbildung und Jugendkunde) there is another single article on friendship – but it addresses the subject on a very abstract level with general statements and does not draw on any empirical data like Delitsch does (Laux, 1912).

⁶ A search for references to the article in "google scholar" lists only nine (mainly German) citations. Only one English citation occurs in "A handbook of child psychology" by Murchison (1933). Also, we did not find any citation in the cited references search of the Social Science Citation Index (1945–2012).

⁷ He uses the same approach for a second class of the same size and age, but does not report this data in his article.

4th graders, include observations, focus groups and interviews at different research sites. First, he carried out participant and non-participant observations before, during, and after school lessons as well as during arranged meetings on weekends. For example, he observed pupils repeatedly going their way to and from school jointly, having close contact on the playground or during breaks and excursions, or friendship avowals during the lessons. He stresses the point that, because pupils become more and more confident with him during the school year, he can even observe chatty conversations right in front of his desk which allows him to gain deeper insight into the pupils' friendship network. In order to come in closer contact with the pupils and to complete his observations, Delitsch secondly arranged extracurricular meetings on Sundays, on which he carried out focus groups with each 10 pupils of the class. During these discussions he stimulated the pupils to narrate personal experiences by talking about read-out stories or illustrated drawings. Delitsch accentuates his close contact to the pupils in mentioning that he even actively participates in the thief-game during leisure time. Because both, observational data and narrative data from the focus groups, were still not satisfactory for Delitsch, he thirdly conducted written semi-structured interviews with the pupils. He used composition tests at school in which he gives the pupils special topics to write about, e.g. the excursion to fair or their way to school. He cross-validates his observations with information he receives from the pupils' parents, in cases of relations he still is unsure about.

Not only his mixed methods approach to collect and gradually validate the information about the relationship data is worth mentioning, but also his ways of presenting the relational data. Delitsch reports that he carefully takes notes of his observations, but his notes do not shed much light on explaining how he documents and analyze his data. Basically he documents and differentiates ingoing and outgoing friendship relations based on his observations. For ingoing relations, Delitsch uses the expressions "angeboten" (1900: 154), which can be translated in "offered" or "wurde umworben" (1900: 163), probably best translated in "being courted by someone". For the outgoing relations he uses the terms "erstrebt" (1900: 154), what means "aspires" or "näherte sich" (1900: 163), which means "to approach someone". Besides these unidirectional sympathies "einseitige Sympathieen" (Delitsch, 1900: 153), he also observes reciprocated friendship relationships as strong and relatively stable ("relative feste Freundschaften"; 1900: 153).⁸

In the article of 1900, besides displaying short parts of the composition tests and interpretations of his observation, he integrates his observations in a twofold manner: He both delineates a matrix of the friendship relationships (see Fig. 2) and illustrates his results in the rank ordering (see Table 1). Both presentations of his results show specific characteristics. The adjacency matrix delineated by Delitsch implies unique properties (see Fig. 2). Delitsch displays both, ingoing friendship relations (= 'angebotene Freundschaften') within the rows using a vertical line ('|'), as well as outgoing friendship relations (= 'erstrebte Freundschaften') within the columns also using a vertical line ('|'). For reciprocated friendships (= 'geschlossene Freundschaften') he uses a plus/cross ('+') in

the matrix. This notation, which is truly innovative for the end of the 19th century, resembles a matrix depiction without clearly identifiable precursors and successors.

Delitsch suggests that friendships form along the hierarchy of school performance which was embodied in a school ranking system at that time. The so-called 'Lokation' or 'Klassenrangordnung' was widespread during the 19th century in Germany and replaced gradually by school grades as they are known today (Herdegen, 2009). Although the concept is much older, the basic implementation can be backtracked to the Jesuit colleges. The rank ordering system implied a visual representation of the school performance since pupils were allocated to the tables based on their achievements. Good pupils sat in the front and bad pupils in the back of the classroom. The term 'Klassenprimus' (first of the class) which stems from this system is still known in Germany (Gruenig and Rauschenberger, 1999). At the end of the school year the Lokation was publicly announced.⁹ Although the system was mainly based on school performance, for example the number of errors in Latin exams, it contained also a judgment about the honor and moral value of a pupil. Consequently, the system also occasionally led to conflicts with influential parents who felt their reputation was under attack when their son was placed at the end of the ranking (Herdegen, 2009). This can be regarded as evidence of two conflicting principles: While in 19th century German society birth and socio-economic class were the predominant factors in general, a main purpose of the public schooling system was to unite the young German nation across class boundaries (Schröer, 1999: 60).¹⁰ Thus Lokation provided a principle that was integrative – good achievements were initially independent from parentage – and at the same time not only highly meritocratic but also hierarchical. By displaying the personal success of a child in a very obvious manner Lokation transferred the structure of a militarily shaped society into the classrooms by making the 'rank order' very visible.

This system of Lokation was also practiced in the Delitsch's boys' school class. He refers to it as a 'principle of rank ordering based on mental achievements' (Delitsch, 1900: 156 [translation by authors]). Delitsch defines directed friendships ties as "Beifallsbekundung" (Delitsch, 1900: 153) (translation: "avowal of approval") and differentiates in the amount of ingoing ties (today often called indegree or popularity) and outgoing ties (today often called outdegree or activity): "Depending on his particular talents and the degree of their exertion he will gain much or little, from this or that friend. But not only the amount of received friendship, but also the desire for being involved in friendships will be subject to individual variations." [translation by the authors] Delitsch implicitly states that he expects an effect of the rank ordering on popularity of pupils which was regarded as healthy by Delitsch from a pedagogical perspective. That is why he also abolished the usual practice to give the class primus the task of supervising break time, which usually lead to a high unpopularity of the class primus (Delitsch, 1900: 157).¹¹ However his explanations how the rank order system is exactly interfering with the friendship ties remain vague. On the one hand there is the expectation, that pupils

⁸ The method of Delitsch differs from current studies, because Delitsch reports friendship relations on the basis of his observations, while current studies mostly use self-reports via questionnaires to elicit friendship relations, e.g. Knecht et al. (2010) ask for up to 12 nominations with the item "Who are your best friends in class?" (p. 504). Similarly, De Klepper et al. (2009) use the item "Please indicate which of the following definitions characterizes your relationship with the students mentioned below" with the response scale of the following four answering categories, "troubled, neutral, friendly and friendship" (p. 85) and formed a friendship matrix for the category 'friendship'. However, Delitsch reports unidirectional friendship relations (offered and aspires), wherefrom we can assume that pupils with higher number of offered friendship relationships are more popular.

⁹ There was also a competitive element concerning the school ranking which was called "certieren". In a kind of performance game pupil could (temporarily) change their position in the class ranking, depending on who won the match. However Delitsch makes no reference to "certieren".

¹⁰ In fact this interconnection between nation building and mass schooling may be generalized for all Western societies of the 'First Modernity' (e.g. Hofstetter and Schneuwly, 2006; Michel and Varsa, 2010).

¹¹ Remains of this constellation can still be found in German school classes nowadays when the best pupil is called in a pejorative manner Streber, a word which cannot be easily translated into English, but is probably best represented by "teacher's pet".

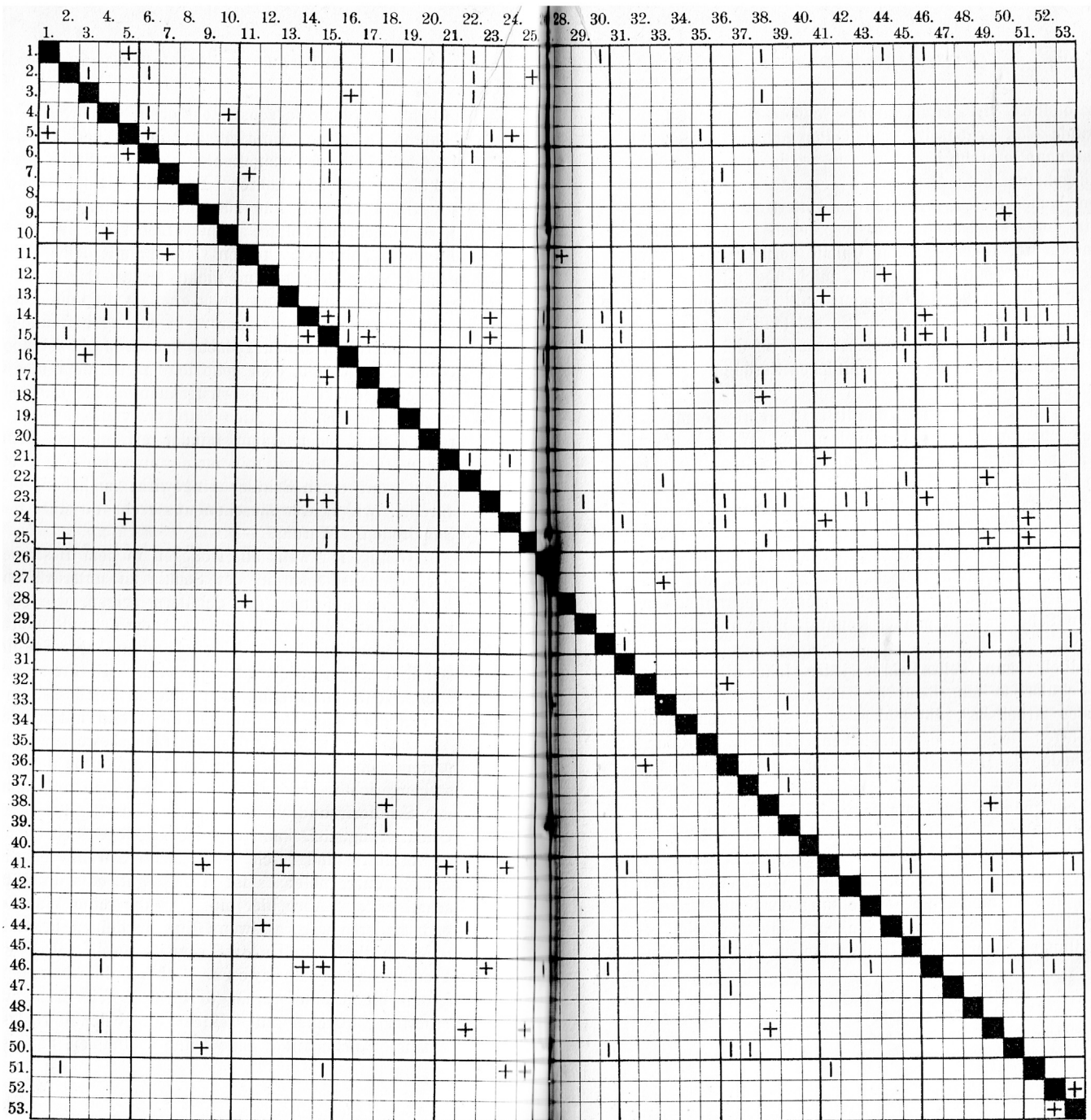


Fig. 2. Original matrix of friendship as it was delineated by Delitsch (1900: 160f).

placed high in the rank ordering are more successful in generating popularity. On the other hand, he suggests, that this effect is produced through a congruency of friendship tie directions with the rank order, which means that the probability that directed friendship ties go toward higher positions in the rank order is higher than the probability of friendship ties going downwards. To test this assertion he produced a three-dimensional cross-table with pupils in the rows ordered by Lokation and columns with ingoing, outgoing and reciprocated friendships going up or down in the rank ordering (see Table 1). We will later explain that both competing hypotheses are logically amalgamated. However it remains unclear which of the two hypotheses (up-rank or rank-popularity) Delitsch regards as the decisive one.

Delitsch names some pupils that can be seen as 'outliers' as they do not fit perfectly into their predicted position within the network structure. On the one hand there are 4 repeaters (named Pfeil, Vetter, Schnabel, R. Schubert), so-called street heroes which were strong, lively, and energetic 'especially outside of the classroom' (Delitsch, 1900: 147 [translation by authors]). This clique of four pupils does physically outmatch the other pupils and often leads at the games during leisure time. They, for example, play the policemen at a thief-game. These four pupils are, following Delitsch, overly popular, although their school performance as well as their position in the rank ordering is less distinguished. For another pupil (Lasch) the discrepancy between popularity and ranking position is even more pronounced. Delitsch labels him

Table 1

Replication of Delitsch's original table sorted by the rank ordering from Schlegel (highest) to Albin Hager (lowest) (Delitsch, 1900: 154).

Name	Reciprocated			Unreciprocated outdegree			Unreciprocated indegree			Sum all
	Upwards	Downwards	Sum	Upwards	Downwards	Sum	From up	From down	Sum	
Schlegel	0	1	1	0	2	2	0	7	7	10
Albert Hager	0	1	1	0	2	2	0	3	3	6
Böger	0	1	1	1	3	4	0	2	2	7
Meier	0	1	1	0	5	5	2	1	3	9
Meinhold	1	2	3	0	1	1	0	3	3	7
Herold	1	0	1	2	1	3	0	2	2	6
Rettig	0	1	1	0	1	1	0	2	2	4
Meyer	0	0	0	0	0	0	0	0	0	0
Schneider	0	2	2	0	0	0	1	1	2	4
Köchel	1	0	1	0	0	0	0	0	0	1
Wolf	1	1	2	1	2	3	0	6	6	11
Ernst	0	1	1	0	0	0	0	0	0	1
Trampler	0	1	1	0	0	0	0	0	0	1
Vetter	0	3	3	1	0	1	4	7	11	15
Pfeil	1	3	4	3	2	5	2	11	13	22
Pröse	1	0	1	2	1	3	1	2	3	7
Holz Müller	1	0	1	0	0	0	0	4	4	5
Eisenreich	0	1	1	2	3	5	0	0	0	6
Pröhl	0	0	0	0	0	0	1	1	2	2
Reinh. Zimmermann	0	0	0	0	0	0	0	0	0	0
Schaller	0	1	1	0	0	0	0	2	2	3
Stolze	0	1	1	7	2	9	0	2	2	12
Schnabel	2	1	3	1	0	1	2	6	8	12
Schmidt	1	2	3	1	0	1	0	2	2	6
Fritzsche	1	2	3	0	0	0	1	1	2	5
Röhling	0	0	0	2	1	3	0	0	0	3
Rudolf	0	1	1	0	0	0	0	0	0	1
Hofmann	1	0	1	0	0	0	0	0	0	1
Kießling	0	0	0	2	0	2	0	1	1	3
Räuber	0	0	0	2	2	4	0	3	3	7
Haas	0	0	0	4	1	5	0	1	1	6
Bernhardt	0	1	1	0	0	0	0	0	0	1
Rausch	1	0	1	1	0	1	0	1	1	3
Bernh. Schubert	0	0	0	0	0	0	0	0	0	0
Flach	0	0	0	1	0	1	0	0	0	1
Groß	1	0	1	5	3	8	2	1	3	12
Kneisel	0	0	0	1	1	2	1	1	2	4
Seifert	1	1	2	8	2	10	0	0	0	12
Thrum	0	0	0	3	0	3	2	0	2	5
Hergert	0	0	0	0	0	0	0	0	0	0
Lasch	4	0	4	0	1	1	3	3	6	11
O. Müller	0	0	0	2	1	3	0	1	1	4
R. Müller	0	0	0	3	1	4	0	0	0	4
Pröse	1	0	1	1	0	1	1	1	2	4
Rich. Zimmermann	0	0	0	6	0	6	2	1	3	9
R. Schubert	3	0	3	1	0	1	5	2	7	11
Wilhelm	0	0	0	2	0	2	1	0	1	3
Neidhardt	0	0	0	0	0	0	0	0	0	0
Fährmann	3	0	3	6	0	6	1	0	1	10
Pippig	1	0	1	3	0	3	3	0	3	7
Golla	2	0	2	1	0	1	3	0	3	6
Ebersbach	0	1	1	3	0	3	0	0	0	4
Albin Hager	1	0	1	3	0	3	0	0	0	4
Σ	30	30	60	81	38	119	38	81	119	298

the 'sweets giver', because he generously 'buys into' friendships with sweet and money from his grandmother, who sells sweets at fairs.

On the other hand, there are some pupils that are notably unpopular even though their position in the school rank order is average. There are two pupils with a psychological difficulty. One is, following Delitsch, exceptionally rude and selfish (Meyer) and the other is completely apathetic (Bernh. Schubert). Three pupils are physically handicapped (Pröhl, Hofmann, Neidhardt) and have either a chronic eye ophthalmitis, anemia or are lame. Two pupils come from a socio-economically aggrieved family and have been orphans (Fährmann, Stolze).

4. Friendship relations in school classes today and hypotheses

In the 19th century the theoretical background, the statistical instruments of social network analysis and the scientific statements on which such a work could be built were limited. For this reason, we build upon Delitsch's data and hypotheses, which we derived from his article, and complement them with the most relevant and latest theoretical and empirical approaches on school networks. Novel research on friendship ties in school classes shows that the roots of these networks are already laid out in preschool classes. The first basic step takes place when reciprocal ties emerge. Reciprocity

is a network formation process which makes no complex coordination activities necessary. Children just need to respond kindly to positive behavior in a dyad. A second step is the emergence of more popular individuals, which can be characterized by preferable intrinsic properties or which just have slightly more friendship ties in the beginning, which leads to a self-enforcing process. Following Schaefer et al. (2010) a third step of complexity is reached when processes of triadic closure emerge. Triadic closure means that triads tend to close, leading to nuclei of cliques. For directed ties we can distinguish two mechanisms leading to triadic closure, transitivity and cyclicity. Both have different social rooting, although the result of the emergence of closed triads and cliques is similar. Transitivity is given, when pupils tend to choose “friends of friends” as friends. If, for example, pupil “A” has a directed friendship relation to pupil “B” and pupil “B” to pupil “C”, this will most likely lead to a new tie from “A” to “C”.

Cyclicity is often described in terms of a small “generalized exchange”. A cyclic triple emerges if “A” chooses “B” as friend, “B” chooses “C” and “C” again chooses “A”. Such a situation can be described as a “generalized exchange” because the recipient of positive affect reciprocates the positive affect indirectly through a cycle. Whereas transitive closure has an affinity to hierarchical relations, cyclicity is more akin to equality and collaboration.

Processes of triadic closure are socially and mentally more demanding, because they necessitate that “A” and “C” recognize that they have both a friend in common without being already friends to each other. Nowadays transitivity in US school classes emerges already in pre-school, which is why triadic closure should already be visible in primary school classes (Schaefer et al., 2010), thus we do not expect fundamental differences to secondary school classes. Doreian et al. (1996) argue that triadic closure needs some time in a network formation process to emerge; which is the case for the German primary class that already existed 4 years, when Delitsch conducted his study.

Both tendencies (toward reciprocity and triadic closure) are corroborated in many cross-sectional and longitudinal studies of friendship networks in primary and secondary schools (Pearson et al., 2006; Snijders and Baerveldt, 2003; Runger and Wasserman, 1980; Urberg et al., 1995; Knecht, 2008; Light and Dishion, 2007; Dijkstra et al., 2010). Because of their universal relevance reciprocity and triadic closure are usually included by default into network models. Although the German teacher does not mention a tendency to reciprocity explicitly, he attaches some importance to this question. This is made obvious by his observational strategy, which distinguishes one-sided and reciprocated friendships. In principle he regards reciprocated friendship ties as healthier for children. Concerning triadic closure, he detects a tendency to clique formation, but he did not have the statistical means and theoretical knowledge, to address mechanisms of clique formation explicitly. In many of these studies triadic closure is conceptualized in terms of transitivity, although they often do not differentiate between transitivity and cyclicity. Since the Delitsch school class has, following his description, a hierarchized structure we expect to find triadic closure through transitivity and not cyclicity. Based on this theoretical background we state following hypothesis.

Hypothesis 1. (a) The 1880/1881 pupils network has a tendency to reciprocated friendship ties.

(b) Triadic closure is generated through transitivity and not through generalized exchange (cyclic triples).

With increasing age clique formation processes become more important (Crockett et al., 1984). Pupils want to distinguish themselves by membership to cliques and exercise their social competences. Nowadays heterogeneous and co-educational school class research on friendship networks, which is mainly conducted in western countries, has identified gender as the most basic

variable determining clique and tie formation in secondary school. Especially in the first years of secondary school sex segregation is strong (Goodreau et al., 2009; Lubbers and Snijders, 2007). Later on, cross-gender relations become more important (Shrum et al., 1988; Urberg et al., 1995; Feiring, 1999). In some cases of stringent sex segregation it can even be statistically more convenient to study the networks for boys and girls separately, as Lubbers and Snijders (2007) did in a longitudinal analysis of 57 Dutch school classes in secondary school, because there were nearly no cross-sex friendships to be found. A second basic attribute contributing to clique segregation and assortive mixing in school classes is ethnicity. It is especially well documented for American schools (Goodreau et al., 2009) and seems to be weaker for Dutch schools (Snijders and Baerveldt, 2003; Knecht et al., 2010). De Klepper et al. (2009) and van Duijn et al. (2003) find some evidence that friendship selection processes are especially determined by visible attributes, which could explain the strong influence of gender, ethnicity, and age on clique formation. Besides such visible and “immutable” attributes that have an effect on homophilic friendship and clique formation has also been found for more changeable and/or less visible attributes. Nowadays western schools pupils choose similar friends depending on taste in music (Steglich et al., 2006), marijuana use, alcohol consumption, and smoking (Kandel, 1978; Steglich et al., 2006; Knecht et al., 2010), pro-social behavior/delinquency (Knecht, 2008), psychological traits (Selfhout et al., 2010) or sportiness (Cohen, 1977; Coleman, 1961). What could have had an homophily-effect on Delitsch’s class similar to ethnicity at that time was religious denomination. However, Plauen, the city in which Delitsch taught, was nearly completely protestant back then. As far as the teacher’s observations reveal, further influences on clique formation in contemporary schools such as taste of music or smoking behavior seem to be not relevant and not strong enough to lead to clear clique segregation.

Research about the influence of ‘school achievement’ or ‘educational aspiration’ on friendship selection shows less congruent effects than what can be found for gender and ethnicity (Kandel, 1978; Lubbers and Snijders, 2007; Knecht, 2008). While Kandel (1978) finds a significant homophily effect for educational aspiration on friendship selection and also a reciprocal influence of friendship ties on educational aspiration, Cohen (1977) finds a homophily selection effect for the ‘value of learning as much as possible’ only for girls.

More recent studies find similar gender specific differences in the effects taking the whole network structure in a longitudinal framework into account. Lubbers and Snijders (2007), in a meta-analysis of Dutch schools, find a homophily effect concerning performance in a standardized school performance test only for girls. The most differentiated quantitative analysis has been done by Knecht (2008). She collected friendship networks for 126 Dutch secondary education school-classes in four waves during a one-year-time period. She included a composite variable called ‘school attitudes’ that measures if pupils appreciate doing homework, getting good grades, being intelligent, and so on. Both selection and influence effects are tested, which means, that on the one hand, her model analyses whether there is an effect of school attitude on choosing friends, and on the other hand, whether friends influence each other concerning school attitudes. For the selection processes she differentiates a homophily effect and a popularity effect. Homophily would mean that pupils with similar school attitudes tend to become friends. The popularity effect measures whether pupils with positive school attitudes are more popular (or unpopular, respectively). In the meta-analysis of all networks there is no significant selection or influence process. Knecht reports however for her Dutch schools that at the level of singular cases in some classes pupils with positive school attitudes are significantly more

popular, while in other classes the contrary is true (Knecht, 2008: 59).

Ethnographic observations in school classes show that social stratification in status hierarchies is commonplace in preadolescent friendship networks (Adler and Adler, 1995). Some older sociometric studies measure the conditions that make pupils more popular and prerequisite why pupils do not reciprocate friendship avowals. While there seems to be some evidence that pupils with good school achievements and behavior seem to be more popular (Hardy, 1937; Bonney, 1946) and that a similar school performance increases probability of friendship (Wellman, 1926), other factors such as psychological traits, physical attractiveness, and socio-economic status exhibit a stronger influence on popularity.

In “the adolescent society” from 1961, the now classic study of the value system and popularity stratifications in 9 high schools James Coleman finds for the American society of the late 50s a remarkable unimportance of school achievement and aspiration on the popularity of pupils (Coleman 1961). According to Coleman, too much school achievement and the aspiration of being a “brilliant scholar” can even be harmful for a pupil’s popularity and in some cases lead to social isolation. What is highly rewarded with popularity is sportiness (or being a cheerleader for girls), having a car and being popular with the opposite sex. Coleman sees especially the cross-sex relations as devaluating school performance since educational aspiration is not rewarded with “dates”. He attaches some criticisms to this situation in the US school system, because the adolescent culture drives pupils into aspirations which are unwanted. As we will see, Delitsch’s boys school class can in some respect be understood as the counterexample from a different historic point in time and cultural background, which probably would have been welcomed by Coleman.

While Coleman explains the missing effect of school performance on popularity especially with the cultural preconditions of the US society and the “adolescent culture” concerning cross-sex relations, a good explanation for the varying effect of school performance on popularity in a friendship formation process was later given by Hallinan and Smith (1989), which is more located at the institutional level. They argue that the importance of school achievement for friendship formation is dependent on the class climate and the importance and pressure that are attached to school performance by the teacher. They also find empirical evidence for this causal mechanism in a study of 48 school classes at ten American Schools: ‘the less a teacher emphasizes success on standardized tests and good grades, the more heterogeneous are the students’ cliques with respect to reading achievement. This interesting finding suggests an important mechanism through which teachers influence student social development. By stressing success on achievement tests and good grades, a teacher seems to influence students to create social networks comprised of peers who are at an academic level similar to their own’ (Hallinan and Smith, 1989: 910).¹²

In the light of these results we can revert to the German boys’ school class and recapitulate which hypothesis Delitsch formulates in respect to the influence of school performance on friendship formation. Delitsch suggests that school performance plays an important role for the formation of friendships. Since the rank ordering system, as it is described above, attributes such a high importance to the school performance, represented by the spatial ordering, we follow Delitsch’s hypothesis that the position of a pupil in the “Lokation” hierarchy determines his popularity.

We operationalize popularity based on Delitsch’s differentiation and in concord with modern network studies by the number of

ingoing ties. We call this the popularity-ranking hypothesis. We adjoin an additional argument, why the hypothesis concerning the effect of the Lokation on popularity seems plausible. Modern network research has shown that visible attributes (which is the case for the “Lokation”) usually have a stronger impact on tie formation than less visible attributes (van Duijn et al., 2003).

However, as we have presented, Delitsch has also an alternative explanation, how the rank is interfering with the friendship formation process. He produces a table, which suggests, that the probability of ties going upwards the ranking is higher, than vice versa. We call this the up-rank hypothesis. There is also some plausibility for this assertion: the ordinal metric of the system inevitably produces inequality, since no two pupils can be in the same position, in contrast to the interval scaled grades, which are common today, where two or more pupil can have the same mark. Fiske (1992) discerns different models of judging and behaving in social relations, one of which is called the ‘authority ranking’ principle, where relationships are ‘based on a model of asymmetry among people who are linearly ordered among some social dimension’ (Fiske, 1992: 691), which fits well into the ‘Lokation’ practice. If the class is structured by the relational model of this ‘authority ranking’ (Fiske, 1992), this should affect the whole network structure and lead to an up-rank effect. However both hypothesis (the up-rank and the rank-popularity hypothesis) are interrelated: If ties are usually sent upwards the rank order (the “Lokation”), then pupils being in high positions have a higher number of pupils under them in the ranking, which could send friendship ties to them. Although there may be some propensity in the network of reciprocating ties, altogether the number of ingoing ties should be higher for pupils placed high in the rank ordering. In contrast, for pupils which are placed low in the ranking, there are only few other pupils in lower positions, which can send ties upwards to them. Thus their indegree-popularity can be expected to be low. The opposite effect can be expected for the outdegree: low outdegree for pupils high in the ranking and high outdegree for pupils low in the ranking. However the rank-up hypothesis leaves some room for variation. To assert which of the hypothesis gives the better explanation, we test both hypothesis separately and then jointly in one model.

As other effects that usually have an impact on clique formation like race and gender can be excluded, we conclude that the position in the rank ordering is the main determining factor of the friendship network structure for the 1880/1881 boys school class. This assumption is further supported, if we also take into account the results of the “adolescent society”-study by Coleman (1961), which suggests, that the absence of cross-sex relations should increase the importance of school performance. We do not only test whether the rank position has an effect on popularity (rank-popularity) or if there is an propensity of friendships going upwards in the rank ordering (up-rank), but we also include a homophily effect concerning the rank order in our model.

Hypothesis 2. (a) The higher the position of a pupil in the class ranking, the higher is his popularity (rank-popularity hypothesis)

(b) The probability of ties going upwards the rank ordering is higher than vice versa (up-rank hypothesis)

Having outlined the basic parameters describing the network structure, the exceptional cases described by Delitsch ought to be taken into account, because they may not follow this model. As already described above there are four repeaters (Pfeil, Vetter, Schnabel, R. Schubert) and a ‘sweets giver’ in the school class that are more popular than it would be expected respective their position in the rank order. Another group of outliers consists of psychologically or physically handicapped (Meyer, Bernh. Schubert, Pröhl, Hofmann, Neidhard) or socio-economically deprived (Fährmann, Stolze) pupils. Increased popularity for physically attractive children is found especially in early sociometric studies

¹² Interestingly enough they also find that more pressure on school performance leads to less clique segregation.

of school friendships (Young and Cooper, 1944). High unpopularity and social isolation of physically handicapped pupils is corroborated for overweight school children with network analysis of the large add-health data set of American school classes (Strauss and Pollack, 2003). Following these arguments and Delitsch's ethnographic description we formulate the third hypothesis.

Hypothesis 3. The four repeaters and the 'sweets giver' have a disproportionately high popularity. The opposite is true for the physically, psychologically or socially hampered pupils.

5. Application of contemporary research methods and analysis

We used the values in the data of the matrix of Delitsch (see Fig. 2) to construct a network with pajek (Batagelj and Mrvar, 1998). The only modification necessary to read the matrix is a rotation by 90° and mirroring it, since in Delitsch's notation the senders of ties were recorded in the columns and the receivers in the rows. After this operation the matrix resembles a visualization of a matrix that can be generated automatically by pajek.¹³ The resulting network consists of 179 ties with 30 mutual dyads. To test Hypotheses 1–3 we applied an ERGM to this network. ERGMs (also called p-star) are based on a probabilistic approach that treats networks as realizations of random variables (with an exponential family distribution). ERGMs can be used to model the global network structure based on local rules of tie selection. Local parameters like homophily and transitivity can be combined to a multivariate model that is fitted to the empirical network structure with a Markov Chain Monte Carlo (MCMC) procedure. The MCMC are used to estimate parameters which can generate a sample of networks for which the observed network is central. On this basis, the significance of the single parameters can be estimated. We used the well-established ERGM module in the "Statnet" package for R (Handcock et al., 2008) to build an exponential random graph model of the Delitsch-network and test the hypotheses. The models we choose are oriented toward the standard model proposed for positive affect ties by Robins and Lusher (2013), which includes standard effects, like the edges effect giving the overall propensity of edges and the reciprocity effect, accounting for the number of mutual ties.

We likewise include the "social circuit" parameter GWESP, which models geometrically the number of edgewise shared partners, whereby high numbers are weighted down. Such an alternating triangle parameter avoids convergence problems leading to degenerate models with "clumped" triangles (Hunter, 2007). The ERGM module in statnet assumes transitive closure for the GWESP parameter in directed networks. Cyclicity is modeled with the "ctrple" term which is included only as a simple Markov coefficient. By including both terms, we can assess whether triadic closure is based on transitivity or on a tendency toward cyclic triples. The twopath coefficient is included as control term and measures the extent to which actors who send ties also receive them. We do not model the degree distribution directly with a geometrically weighted term, since the effects of class rank ordering produces

Table 2

Basic structural parameters of friendship network of 1880–1881.

Actors	53
Average degree	6.755
Connectedness	0.819
Connectedness (directed)	0.719
Proportion of mutual ties	0.335
Average path length	3.382
Average clustering coefficient	0.285
Indegree-centralization	0.267
Outdegree-centralization	0.169
Modularity	0.293

an in- and outdegree distribution which nicely fits to the observed network. To test Hypotheses 2a and 2b we need to slightly modify the model. Hypothesis 2a can be tested with a standard term, modeling a covariation of the rank ordering with the indegree. The rank ordering is coded with values from 1 to 53, whereby low values stand for low positions in the "Lokation" and high values for high positions. We coded the rank ordering that way (Delitsch uses the opposite numbering), to make the main effects on the degree more readable. This means, that a positive value for the "Lokation" on the indegree means, that pupils placed high in the Lokation tend to have a higher indegree. The test of Hypothesis 2b needs the programming of a special user-defined term, which counts the number of ties going up in the hierarchy and thus gives, like for the other effects a coefficient with the conditional log-odds for such ties and asserts the significance of such an effect. We use the `ergm.userterm` package to build this term (Hunter et al., 2013). Although Delitsch did not visualize his original school class friendship network we can easily do this based on the data that is provided in his matrix. In Fig. 3 friendship ties are represented by directed arcs and pupils by circles. Large circles represent a high position in the school class ranking ('Lokation'). The Kamada–Kawai algorithm is used to produce a visualization of the network.

The visualization already indicates that there is no strong clique segregation within the network. The structure of the network can be examined in more detail by computing the basic structural parameters described in Table 2.

The network contains 53 pupils with an average of 6.755 network ties. The connectedness value of 0.819 (0.719 directed) shows that a large proportion of the network is connected. The average path length from one pupil to another is 3.382; the clustering coefficient is nevertheless high with a mean value of 0.285. The clustering coefficient shows that Delitsch's school class displays a clear tendency to triadic closure, although a test for the exact structural arrangement needs a probabilistic rather than a descriptive approach, which will be provided in the ERGMs. The indegree-centralization in the Delitsch school class is higher than the outdegree-centralization, which means that the inequality of popularity (receiving ties) is higher than the inequality of friendship activity (sending ties). The modularity indicating a division into dense subsets has a value which is generally regarded as low. This corresponds to the impression of the visualization, which does not exhibit clearly identifiable cliques.

Having outlined some basic structural properties, we model the Delitsch school class in detail to assert whether the structural mechanisms of friendship selection implicitly postulated by Delitsch can be substantiated with recent probabilistic methods. Our central question here is whether the 'Lokation' leads to popularity stratification in the school class. We constructed multivariate ERGMs for the network based on our Hypotheses 1–3. The results of the ERGMs are presented in Table 3 which includes the coefficients, the standard errors, and the significance. We test three different models:

Models 1–3 include all the same structural effects. The edges coefficient can be interpreted as intercept; it is usually negative

¹³ This operation led to a network with 118 unreciprocated ties. Since Delitsch stated explicitly in the text that there are 119 unreciprocated ties, and the sum for the columns of unreciprocated ties (Delitsch, 1900: 154; here Table 1) is 119 we reproduced Table 1 with R and checked for differences. Because the sums of the rows suggest that in Delitsch's matrix one unreciprocated tie is missing from Seifert to Thrum, we added this tie to the network. There is a second minimal error in the table by Delitsch: Following the Sociomatrix, Ernst (12th position in the rank ordering) has one reciprocal tie with Präse (44th position), which means that the reciprocal tie from Ernst goes downwards and not upwards, as denoted wrongly by Delitsch. A third small error in Delitsch's original table is given for the sum of the unreciprocated outdegree of the same Präse (the one which is lower in the rank-ordering, there are two Präse). It should be 1 and not 3.

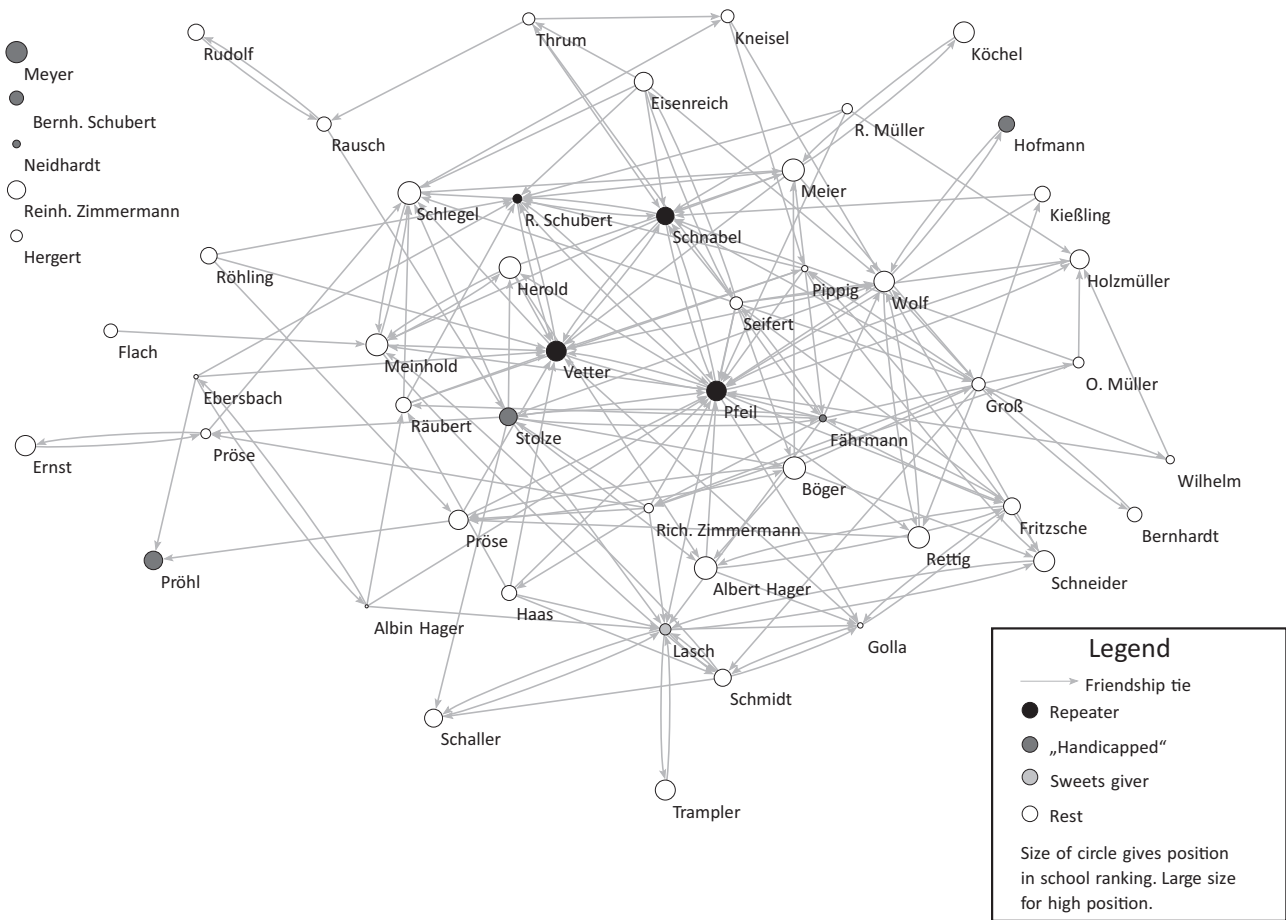


Fig. 3. Visualization of friendship network (Spring-embedder Kamada–Kawai).

Table 3
Results for multivariate ERGM.

	Model 1 (rank-popularity)			Model 2 (up-rank)			Model 3 (rank-popularity + up-rank)		
	Coefficient	Std. error	p-Value	Coefficient	Std. error	p-Value	Coefficient	Std. error	p-Value
<i>Intercept</i>									
Edges	−3.7590	0.3077	0.0000*	−4.1749	0.3983	0.0000*	−4.1283	0.4506	0.0000*
Up-rank									
Up-rank	–	–	–	0.7436	0.2324	0.0014*	0.6280	0.4052	0.1213
<i>Main effects on indegree</i>									
Class ranking (rank-popularity)	0.0157	0.0053	0.0029*	–	–	–	0.0035	0.0086	0.6845
Repeaters and sweets giver	1.1325	0.1963	0.0000*	1.1302	0.1913	0.0000*	1.1405	0.1971	0.0000*
‘Handicapped’	−0.4177	0.2996	0.1634	−0.4231	0.3005	0.1593	−0.4192	0.3000	0.1625
<i>Main effects on outdegree</i>									
Class ranking	−0.0092	0.0051	0.0705	0.0060	0.0058	0.3041	0.0033	0.0099	0.7401
<i>Homophily effects</i>									
Class ranking (absolute difference)	−0.0060	0.0062	0.3371	−0.0031	0.0062	0.6137	−0.0037	0.0067	0.5792
<i>Structural effects</i>									
Gwesp (transitivity)	0.7339	0.1413	0.0000*	0.7388	0.1321	0.0000*	0.7326	0.1418	0.0000*
Gwesp (alpha)	0.8818	0.1470	0.0000*	0.8866	0.1467	0.0000*	0.8846	0.1465	0.0000*
Reciprocity	2.5103	0.3618	0.0000*	2.5501	0.3611	0.0000*	2.5465	0.3570	0.0000*
Cyclic triple	−0.8000	0.2827	0.0047*	−0.8026	0.2804	0.0042*	−0.7953	0.2833	0.0050*
Twopath	−0.0149	0.0318	0.6387	−0.0164	0.0298	0.5819	−0.0161	0.0313	0.6064
Null deviance	3821	2756 df		3821	2756 df		3821	2756 df	
Residual deviance	1119	2745 df		1116	2745 df		1116	2744 df	
Deviance	2702	11 df		2705	11 df		2705	12 df	
AIC	1141			1138			1140		
BIC	1206			1203			1211		
MCMC sample size	1,000,000			1,000,000			1,000,000		

* Significance codes: p-value < 0.05.

because ties are less probable than absent ties provided that all other coefficients are zero. [Hypothesis 1](#) predicts that there is a tendency toward reciprocity and transitive closure together with an avoidance of cyclic triples. We included four structural effects in the first model, the mutuality-effect accounting for reciprocal ties and the geometrically weighted edgewise shared partner (GWESP) (as parametrized) accounting for transitive closure in triads, the cyclic triple and the two-path effect.¹⁴ We consider the idiosyncratic conditions, described in [Hypothesis 3](#), which Delitsch ethnographically observed for some cases, the repeaters and the ‘sweets giver’, for which Delitsch predicted a higher popularity than expected by their position in the class ranking, and as negative outliers the ‘handicapped’ pupils which are socially, physically or psychologically hampered. The models differ however in the way how [Hypothesis 2](#) is included. In all three models we include the main effect of the rank order position on outdegree and a homophily effect concerning the rank order. However the rank order stratification for the friendship ties is modeled differently: in Model 1 we test the rank-popularity hypothesis by including the rank ordering as main effect on the indegree. In Model 2 we exclude this term and include instead the up-rank effect. In Model 3 we take into account both terms, to assert which of both effects gives a better description of the interrelation of the rank-hierarchy with the friendship ties. We also computed a fourth model, which is the same as Model 3, but did not include the special terms for the outlier cases. However we do not report this model here, since the MCMC and Goodness-of-Fit statistics showed, that the 3 models presented here perform best.¹⁵

As [Table 3](#) shows, the structural parameters behave for both models as expected. We find a significant positive effect for reciprocity, which means that friendship ties tend to be reciprocated. Moreover, we find a significant positive effect for transitive closure (GWESP), which means that friends of friends tend to be friends. In contrast the cyclic triple term has a significant negative coefficient which shows in combination with the GWESP parameter, that triadic closure is not generated to “generalized exchange” but through transitivity, which is more compatible with a hierarchical structure, thus [Hypotheses 1a and 1b](#) can be confirmed.

In Model 1 the class ranking position has a significant positive effect on popularity. Pupils who are placed in a higher position in the rank ordering are more popular in the network. There is no homophily effect and a nearly significant weak negative effect of the “Lokation” on outdegree, which means, that pupils in high positions have a lower outdegree. Thus Model 1 is confirming [Hypothesis 2a](#). This is however also the case for Model 2 and the [Hypothesis 2b](#). If we replace the ranking-popularity effect, by the up-rank effect, we find the up-rank effect to be significant. However the value of the Akaike Information Criterion shows, that Model 2 altogether shows a slightly better fit. If we include both effects, they lose their significance. However the conditional log-odds for the up-rank effect scales down only slightly from 0.7436 to 0.6280, whereby the ranking-ordering effect on indegree diminishes by a higher magnitude from 0.0157 to 0.0035. Thus the additional log-odds for an ingoing tie to the actor which is highest in the hierarchy are with

$0.0035 \times 53 = 0.19$ still lower than the additional log-odd for any tie going upwards in the hierarchy. The up-rank effect is nearly significant at a 10% level, in contrast to the rank-popularity effect, which is far from significance, in the combined Model 3. The homophily effect, and the outdegree effect for the rank order are not significant.

All outlier effects behave as predicted by Delitsch. He mentions the four physically matures: repeaters, who are leading break activities and the ‘sweets giver’ who is ‘buying’ his popularity. Both hypotheses can be confirmed empirically. The outsiders are the ‘handicapped’ or ‘defect’ pupils. Here we find a negative effect on popularity, which is however not significant at the 5% level. Altogether [Hypothesis 3](#), regarding the outliers, can be verified. The comparison of both models shows, that the “Goodness of Fit” of the model is better if we include the outliers, as we can see in the Akaike Information Criterion, which is lower for Model 4, which is not reported here. This supports Delitsch’s methodological approach of generating detailed ethnographic accounts.

The rank ordering structure of the school class leads not to coequal cliques, but to a friendship system of stratified popularity with transitive closure going “upwards” in the rank ordering. This stratified transitive popularity hierarchy is clearly induced by the rank ordering. However the exact mechanism remains still opaque. Besides the social effect of producing a reputation stratification (or what [Fiske \(1992\)](#) calls an “authority ranking”), the “Lokation” is also physically represented in the table ordering. Thus it can also partly reflect an opportunity structure which makes it easier for pupils seated behind or besides others to attract their attention which might affect friendship formation. Furthermore, there can be some unobserved third variables like “social background”, or psychological traits like “extraversion” both of which can have an effect on “Lokation” and popularity. Unfortunately that kind of information was not mentioned by Delitsch and therefore it cannot be included in our analysis.

6. Conclusion

Delitsch’s study is an unlikely but lucky case: His way of collecting and presenting data makes a 19th century social network accessible for the methods of 21st century social network analysis. Although the work belonged, as we have shown, to a specific research field prevalent at that time, it is still a riddle why the work remained totally uncited. Certainly Delitsch was a practitioner not affiliated to a university, like many scientists from the journal in which he published (*Zeitschrift für Kinderforschung*). Furthermore he additionally abandoned the subject of friendship networks after this article. Since the early network approaches by [Almack \(1922\)](#), [Wellman \(1926\)](#), [Bott \(1928\)](#) and [Hubbard \(1929\)](#) were written in English, the German language may have played a role. The main explanation for this lack of impact is, that the work anticipated approaches, methods and ways of thinking, which were not embedded in a scientific community and successfully institutionalized at that time, in contrast to Moreno’s afterborne “Sociometry”-approach, for which in 1937 a respective journal and later on several research centers were founded. This makes Delitsch’s article even more impressive, because it illustrates, that “network-thinking” seems to be a universal approach, which in principle can be deduced by profound reflection about social conditions.

Testing Delitsch’s hypotheses and reanalyzing his results in these terms provides a unique insight into the social world of a school class in the society of the German Empire. In this line our purpose of this study was to understand in more detail the basic structuring principles of the friendship network from 1880/1881. We found that structural principles comparable to more modern school classes like reciprocity and transitive triadic closure do exist

¹⁴ As already indicated we follow [Hunter and Handcock \(2005\)](#) and [Snijders et al. \(2006\)](#) who suggest that modeling structural effects with non-linear parameters leads to less degeneracy and better Goodness-of-Fit of ERGM. Empirically the gwesp term has been successfully used to model the Add-Health school data with ERGM by [Goodreau et al. \(2009\)](#).

¹⁵ We found no signs of degeneracy for all of the three models by looking at the MCMC diagnostics. Goodness-of-fit was asserted by the comparison of the distributions for in- and outdegree, minimum geodesic distance and edge-wise shared partners of the empirical network and the simulated networks, where we found a nice fit. Results can be retrieved from the authors.

on a significant level. We also found some significant effects on popularity for special outliers in our network, like the repeaters and the sweets giver.

Due to the detailed ethnographic account by Delitsch we can explain such special cases. Notwithstanding, the main principle structuring the school class friendship network is the “Lokation”, the school class rank ordering visually represented in the sitting order of its pupils. We could clarify, in which way the “Lokation” is interfering with the friendship network structure. Besides a tendency to reciprocation and transitivity, there is an additional probability for directed friendship ties going up in the hierarchy, which leads to a popularity stratification along the rank order. From a modernization point of view the rank ordering system is ambivalent: On the one hand it contains elements of modernity in respect to its meritocratic foundation, on the other hand the enforced production of a clearly visible ranking has a harsh tone of a vertically stratified traditional society. Consequently the system faded away and school grades gained dominance; there was never a serious discussion to revive it. Nowadays such a system representing an ‘authority ranking’ relational model would probably not be accepted in western societies as it is not compatible with ‘modern’ values, based more on ‘equality matching’. However Coleman would argue, that in such a system as the Delitsch school class, the main function of the educational system, namely the production of education and knowledge, would be supported by the adolescent culture. More precisely, the cultural and institutional preconditions of this school class are structured, in such a way, that there is congruence between what is rewarded by the pupils’ behavior, and what is wanted by the educational system. However, there is a price to pay: Delitsch’s assumption, that the dependency of the friendship popularity on “Lokation” is healthy for the pupils, seems to be disproved. The Aberdeen children cohort study (Almquist, 2011) showed that the long term life satisfaction of pupils is better for less centralized school class networks, with more reciprocity. Unfortunately, although there are so many studies on school friendship networks with a high level of statistical sophistication, the reflection of the historical, cultural and institutional preconditions of such networks lag behind since Coleman’s work. The forgotten visionary work of Delitsch reminds us about such inconsiderate preconditions and if it is what scientometrists call a ‘sleeping beauty’ (van Raan, 2004), it has slept for a long time.

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