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The growth of longitudinal social network analysis

A review of the key data sets and topics in research on child and adolescent development

RENÉ VEENSTRA, TERESA BERTOGNA, AND
LYDIA LANINGA-WIJNEN ■

INTRODUCTION

The PROSPER (PROmoting School-community-university Partnerships to Enhance Resilience) Peers project has been impressive in many ways: researchers on this project were among the very first to examine peer networks in adolescence, in an incredibly large sample, across a wide time span. The use of friendship networks allowed PROSPER researchers to expand on previous work by considering interdependencies in networks, to test hypotheses related to selection and influence in the context of substance use and mental health problems. The friendship nominations also enabled PROSPER researchers to use aggregated network constructs, such as individuals' status in a group, and to examine how these related to young people's development. The other chapters in this book show the depth and breadth of topics that could be addressed using this high-quality data set, such as how the intervention can change dynamics within peer networks (see Chapter 11) or how family relationships can influence dynamics in peer relations and behavior (see Chapter 8). PROSPER Peers has been very informative for both research and practice and undoubtedly will continue to be so in the future.

In order to fully understand the scientific contribution of PROSPER Peers, it is important to evaluate and compare it with other social network data sets. This chapter evaluates the growth of social network studies on children and adolescents and highlights the characteristics of these data sets as well as avenues for further research.

Currently, large numbers of researchers worldwide examine social networks of children and adolescents. In questionnaires, they list all classmates, students in the same grade, or schoolmates, asking: “Who are your best friends?”, “Who do you dislike?”, “Who bullies you?”, or “Who helps you?” Students may sometimes nominate as many peers as they wish; other times, the number of nominations is limited.

Social network researchers have investigated similarity in friendship networks. Similarity between friends was established as far back as classical antiquity (see McPherson et al., 2001). Resemblance is an important basis for the survival of friendships. Similarity in characteristics, attitudes, or behaviors means that friends understand each other more quickly, have common interests to talk about, know better where they stand with each other, and have more trust in each other (Laursen & Veenstra, 2021). As a result, such relationships are more stable and valuable. Moreover, looking more alike makes young people more confident and strengthens them in developing their identity (Hallinan, 1980). Similarity in behavior can result from two processes: selection (birds of a feather flock together) and influence (one rotten apple spoils the barrel).

These two processes can be distinguished using longitudinal social network analysis in the R package SIENA (Simulation Investigation for Empirical Network Analyses; Ripley et al., 2022; Snijders et al., 2010; Steglich et al., 2010). Since 2006, approximately 220 SIENA articles on children and adolescents have been published (see Figure 14.1). The introduction to stochastic actor-based models was published in 2010 (Snijders et al., 2010), a handbook chapter was published in 2012 (Veenstra & Steglich, 2012), and longitudinal social network analysis became mainstream after the publication of a special issue of the *Journal of Research on Adolescence* containing 15 empirical articles (Veenstra et al., 2013). Since that period, about 15 to 20 new SIENA articles have appeared per year.

MOST FREQUENTLY USED SOCIAL NETWORK DATA SETS

Figure 14.2 contains the 15 most frequently used social network data sets. The National Longitudinal Study of Adolescent Health (*Add Health*) is the most used adolescent network data set in the world. Friendships were measured twice, in 1995 and 1996. Add Health included 16 schools in the United States, where efforts were made to collect complete network data on all students attending seventh to 12th grades. Two schools were large (Jefferson High, a mostly white, Midwest school with 1,000 students, and Sunshine High, an ethnically diverse school in a Western metropolitan area with 2,100 students); the other 14 were much smaller (rural schools with fewer than 300 students). Longitudinal social network studies using Add Health focused on friendship processes related to the following behavioral outcomes: academic achievement (e.g., Duxbury & Haynie, 2020); alcohol use (e.g., Cheadle et al., 2013); body mass index (e.g., Simpkins et al., 2013); delinquency (e.g., Haynie et al., 2014); depression (e.g., Cheadle & Goosby, 2012);

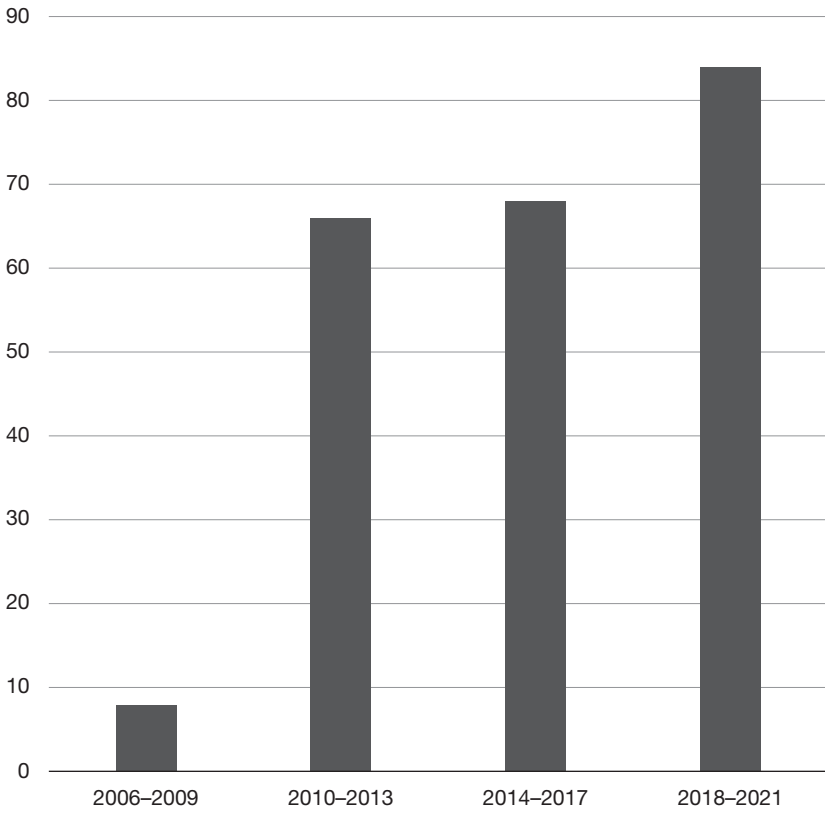


Figure 14.1 The number of longitudinal social network papers per 4-year period.

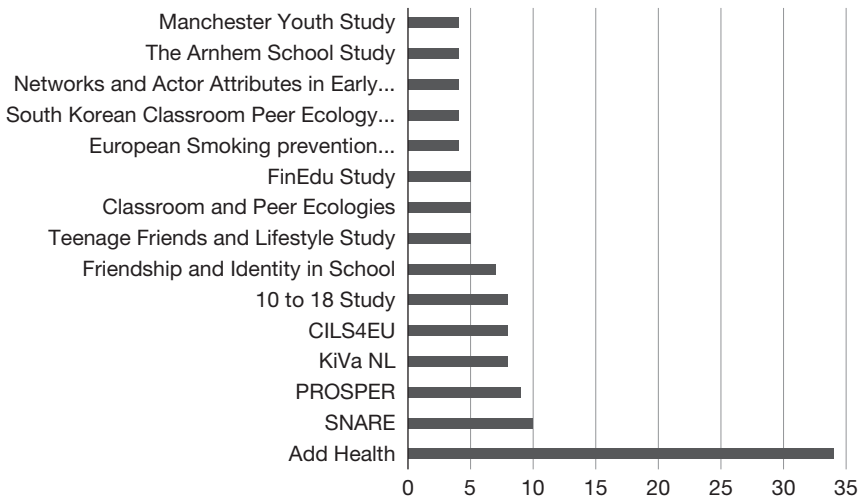


Figure 14.2 The number of longitudinal social network papers for the most used data sets.

marijuana use (de la Haye et al., 2013); physical activity (Simpkins et al., 2013); religious attitudes and behaviors (Adams et al., 2020; Cheadle & Schwadel, 2012); screen time use (Shoham et al., 2012); sexual debut (Trinh et al., 2019); smoking (e.g., Haas & Schaefer, 2014); sports participation (Shoham et al., 2012); violence (e.g., Haynie et al., 2014); and weight control (Simone et al., 2018).

SNARE (Social Network Analysis of Risk behavior in Early adolescence) is a Dutch adolescent peer network data set. *SNARE* contains two seventh-grade cohorts and one eighth-grade cohort, with about 1,800 students from two schools: one in the middle and one in the north of the Netherlands (Dijkstra et al., 2015). Data collection for the first cohorts started during 2011–2012 and for the second cohort during the following school year. Data collection occurred in October, December, and March for 2 to 4 years, resulting in at least six waves (and running up to 12 waves) of data for each cohort. Longitudinal social network studies using *SNARE* focused on friendship processes related to academic achievement (Gremmen et al., 2017, 2019; Laninga-Wijnen, Gremmen, et al., 2019); aggression (Laninga-Wijnen et al., 2017, 2020); externalizing behavior (Franken, Moffitt, et al., 2016; Franken, Prinstein, et al., 2016; Franken et al., 2017); helping (Van Rijsewijk et al., 2016, 2020); music genre preference (Franken et al., 2017); and prosocial behavior (Laninga-Wijnen et al., 2020). Additional data collection for *SNARE* took place in 2015–2016, referred to as *SNARE Genetics*. About 1,000 seventh to ninth graders in an additional secondary school answered almost the exact same social network questions as students in the other two *SNARE* schools, and half of them provided saliva to allow researchers to retrieve genetic information. Thus, in total, *SNARE* consists of networks from three schools and about 2,800 students (Laninga-Wijnen, Harakeh, et al., 2019).

PROSPER (PROmoting school-community-university Partnerships to Enhance Resilience) is the second U.S. adolescent peer network data set. *PROSPER* contains two sixth-grade cohorts, with more than 14,000 students from 28 (semi) rural communities in Iowa and Pennsylvania. Data collection for the first cohort started during 2002–2003 and for the second cohort 1 year later. Data collection occurred in the fall and spring in the sixth grade and then every spring through the 12th grade, resulting in eight waves of data for each cohort (see Chapter 1). Longitudinal social network studies using *PROSPER* focused on friendship selection and influence related to alcohol use (Hoeben et al., 2021; McMillan et al., 2018; Osgood et al., 2013, 2015; Ragan, 2014; Ragan et al., 2014); arrests (Jacobsen et al., 2022); delinquency (McMillan et al., 2018; Osgood et al., 2015); parental knowledge and parental discipline (Ragan et al., 2014); self-control (Ragan, Osgood, & Kreager, 2022); and smoking (McMillan et al., 2018; Osgood et al., 2015; Ragan, 2016).

KiVa (the Finnish word for “nice” and an acronym for “against bullying”) is a data set collected as part of the evaluation of the *KiVa* antibullying intervention in the Netherlands (Huitsing et al., 2020). *KiVa* NL contains cohorts of third, fourth, fifth, and sixth graders: about 10,000 students from 98 schools in total. Data collection started in 2012 with a preassessment in Grades 2–5 and was followed up in October and May for 2 years, resulting in five waves of data

for each cohort. Longitudinal social network studies using KiVa NL focused on the codevelopment of, on the one hand, bullying and victimization, and, on the other hand, antipathies (Kisfalusi et al., 2022); defending (Hooijsma et al., 2021; Huitsing et al., 2014); friendships (Hooijsma et al., 2020; Rambaran, Dijkstra, & Veenstra, 2020); and perceived popularity (Van der Ploeg et al., 2020). Two other network studies on victim-bully relationships examined the impact of single-grade and multigrade classrooms (Rambaran et al., 2019) and school and classroom stability (Rambaran, van Duijn, et al., 2020).

CILS4EU (Children of Immigrants Longitudinal Survey in four European Countries) is a data set collected in four countries: Germany, the Netherlands, Sweden, and the United Kingdom. The participants were eighth and ninth graders, with about 5,000 students per country. The first wave was collected in 2010–2011 and the second a year later. Six longitudinal social network studies using *CILS4EU* used only the German data and focused on academic achievement (Lorenz, Boda, & Salikutluk, 2021); academic self-concept (Jansen et al., 2022); antischool behavior (Lorenz, Boda, & Salikutluk, 2021); educational expectations (Kretschmer & Roth, 2021; Lorenz et al., 2020; Lorenz, Salikutluk, et al., 2021); school effort (Lorenz, Boda, & Salikutluk, 2021); and Muslim religiosity (Leszczensky & Kretschmer, 2022). Two *CILS4EU* studies used only the Swedish data and focused on antischool behavior (Geven et al., 2017) and STEM (science, technology, engineering, and mathematics) preference (Raabe et al., 2019).

The *10 to 18 Study* was a cohort-sequential study in a small Swedish town (with a population of about 26,000). The initial data collection took place during the 2001–2002 school year, with annual follow-ups. Five waves of data were collected among 2,000 respondents. At each wave, more than 90% of all young people in the community in Grades 4 through 12 responded (roughly ages 10–18). Longitudinal social network studies using the *10 to 18 Study* focused on alcohol use (Burk et al., 2012; DeLay et al., 2022); delinquency (Burk et al., 2008, 2007; Kerr et al., 2012; Tilton-Weaver et al., 2013); depression (Van Zalk et al., 2010); psychopathic traits (Kerr et al., 2012); school involvement (Burk et al., 2008); and social anxiety (Van Zalk & Kerr, 2011).

Friendship and Identity in School focused on the formation of interethnic friendships and ethnic identifications. Three waves of data were collected in May 2013 ($N = 1,668$ students), February 2014 ($N = 1,862$ students), and November 2014 ($N = 1,889$). A total of 1,249 students took part in all three waves. Researchers using this data set focused on friendship processes related to academic achievement (Kretschmer et al., 2018; Stark et al., 2017); ethnic self-identification (Jugert et al., 2018); ethnic-racial identity development (Jugert et al., 2020; Leszczensky & Pink, 2019); and Christian and Muslim religiosity (Leszczensky & Pink, 2017, 2020).

The other eight data sets (with at least four published social network studies) in Table 14.1 are discussed briefly, with a focus on the behavioral outcomes examined. Using data from the *Teenage Friends and Lifestyle Study*, researchers examined the following outcomes: alcohol use (Pearson et al., 2006; Steglich et al., 2010); marijuana use (Pearson et al., 2006); music genre preference (Lomi

Table 14.1 CHARACTERISTICS OF THE MOST USED SOCIAL NETWORK DATA SETS

Data set	Country	Setting	Sample size	Age at baseline	Time of collection	Waves (interval)
Manchester Youth Study	United States	G	480	11–12	1998–2000	3 (12 m)
The Arnhem School Study	The Netherlands	C	1,082	12–13	2008–2009	3 (3 m)
Networks and Actor Attributes in Early Adolescence	The Netherlands	C	3,171	12	2003–2004	4 (3 m)
South Korean Classroom Peer Ecology and Adolescent Development	South Korea	C	736	11–12	2014–2015	2 (5 m)
European Smoking prevention Framework Approach	Denmark, Finland, The Netherlands, Portugal, Spain, United Kingdom	G	7,704	13	1998–2001	4 (12 m)
FinEdu Study	Finland	G	1,419	16–17	2005–2006	2 (12 m)
Classroom and Peer Ecologies	United States	C	901	11–12	2011–2012	2 (6 m)
Teenage Friends and Lifestyle Study	Scotland	S	129	13	1995–1997	3 (12 m)
Friendship and Identity in School	Germany	G	1,249	13	2013–2014	3 (9 m)
10 to 18 Study	Sweden	T	2,000	13–14	2001–2005	5 (12 m)
CILS4EU	Germany, The Netherlands, Sweden, United Kingdom	C	5,000 per country	15	2011–2012	2 (12 m)
KiVa NL	The Netherlands	C; S	10,000	10	2012–2014	5 (6 m)
PROSPER	United States	S	14,000	11–12	2002–2009	8 (12 m)
SNARE	The Netherlands	C; G	2,843	13	2011–2016	6+ (4 m)
Add Health	United States	G	3,500	16	1995–1996	2 (12 m)

Note. m = months. Setting: C = class; G = grade; S = school; T = town.

& Stadtfeld, 2014; Steglich et al., 2006); pocket money (Block, 2018); and smoking (Pearson et al., 2006; Steglich et al., 2010). The *Classroom and Peer Ecologies* project focused on friendship processes related to academic adjustment (Laniga-Wijnen et al., 2018; Shin & Ryan, 2014a, 2014b); disruptive classroom behavior (Shin & Ryan, 2017); and teacher-reported prosocial and aggressive behavior (Shin et al., 2019). The *FinEdu Study* focused on alcohol use (Kiuru et al., 2010); depression (Kiuru et al., 2012); interest in academic subjects (Chow et al., 2018); school engagement (Wang et al., 2018); and smoking (DeLay et al., 2013; Kiuru et al., 2010). The *European Smoking prevention Framework Approach* (ESFA) study was used to investigate friendship dynamics related to smoking behavior in six European countries (Mercken et al., 2009), in Finland and Britain specifically (Mercken et al., 2010a, 2010b). Moreover, friendship processes related to alcohol use were examined among Finnish adolescents (Mercken et al., 2012). The only non-Western data set, stemming from the *South Korean Classroom Peer Ecology and Adolescent Development* project, was used to examine friendship selection and influence related to academic behavior (Shin, 2022b), bullying and victimization (Shin, 2022a), help-seeking tendencies (Shin, 2018), and physical aggression, prosocial behavior, perceived popularity, and social preference (Shin, 2017). Data from the project *Networks and Actor Attributes in Early Adolescence* were used to examine friendship selection and influence related to alcohol use (Knecht et al., 2011); behavioral problems at school (Geven et al., 2013); delinquency (Knecht et al., 2010); and teacher-reported study effort, such as being attentive in class and doing homework (Steglich & Knecht, 2014). The *Arnhem School Study* was used to examine intergroup attitudes (Zingora et al., 2020); music genre preference (Stark & Flache, 2012); negative outgroup attitudes (Stark, 2015); risk attitudes (Rambaran et al., 2013; Stark & Flache, 2012); and school attitudes (Stark & Flache, 2012). The *Manchester Youth Study* was used to examine antipathies (Rambaran et al., 2015); perceived popularity (Dijkstra et al., 2013); physical and relational victimization (Sentse et al., 2013); and weapon carrying (Dijkstra et al., 2012).

A COMPARISON OF SOCIAL NETWORK STUDIES

SAMPLE SIZE

With 14,000 respondents, PROSPER is the social network data set with the largest sample size. Another large data set, the Finnish KiVa study, with 9,000 respondents, has only been used once for longitudinal social network analysis (Sentse et al., 2014). Some studies had a large initial sample size, such as KiVa NL or CILS4EU. So far, the KiVa NL studies have been restricted to about 3,250 students in the control schools (see Rambaran, Dijkstra, et al., 2020), whereas the CILS4EU papers were restricted to about 2,500 adolescents in moderately stable classrooms in Germany or Sweden. Some Add Health researchers focused only on Jefferson and Sunshine High (for an exemplary study, see Haynie et al., 2014), whereas others also included the smaller high schools (see Cheadle et al., 2013).

The other social network studies presented in Table 14.1 had samples of between 736 and 7,704 students, with the exception of two old social network studies, the Manchester Youth Study and the Teenage Friends and Lifestyle Study, with 480 and 129 respondents respectively.

NUMBER OF WAVES

Most studies had two or three waves of data, whereas PROSPER, SNARE, KiVa NL, and the 10 to 18 Study had five or more waves. Most studies had one wave annually or two waves within one academic year, whereas both the Arnhem School Study and SNARE had three assessments within a year.

A relatively new approach is to examine social network information on a more frequent (e.g., daily) basis. A recent social network study combined a time-based online diary with an event-based smartphone survey. The aim of the time-based online diary (Van Zalk et al., 2020) was to collect repeated measures of friendships and self-reported extraversion. The aim of the smartphone survey, four waves in 15 weeks, was to obtain information on real-life interactions and examine interaction quality (a rating on a 7-point scale, from positive to negative) and sociable behavior (a rating on a 7-point scale, from sociable to reclusive). They found that freshmen who were more similar in extraversion enjoyed their interactions more, which increased the odds that they would befriend each other, suggesting that interaction quality may be the social glue that facilitates friendships between freshmen similar in extraversion (Van Zalk et al., 2020). Other researchers collected a daily pain logbook and a daily interaction diary among 17 participants in a 3-week hiking expedition in Greenland (Block et al., 2018). They found that friends influenced each other's mood, whereby there was stronger influence for negative than for positive mood (Block & Burnett Heyes, 2022). Another network study, with biweekly assessments, provided evidence that changes in delinquency were related to situational changes in unstructured socializing, alcohol use, and marijuana use (Weerman et al., 2018).

TIME WINDOW

Figure 14.3 shows the time window of the most used social network studies. The youngest students were third graders in KiVa NL. The oldest students were 12th graders in the 10 to 18 Study, PROSPER, and Add Health. The time window between 10 and 18 is dominant in longitudinal social network research. There was substantial heterogeneity in the length of time windows, with some studies following the same students for 8 years (PROSPER) and others following students for half a year (e.g., Classroom and Peer Ecologies).

Few longitudinal social network studies have considered early childhood. A Finnish study followed 1,000 children from Grades 1 to 4 and examined whether children selected friends based on their levels of reading fluency and comprehension as well as whether children were influenced by their friends' reading skills (Kiuru et al., 2017). Selection occurred based on reading fluency rather than reading comprehension, but peer influence occurred for both reading

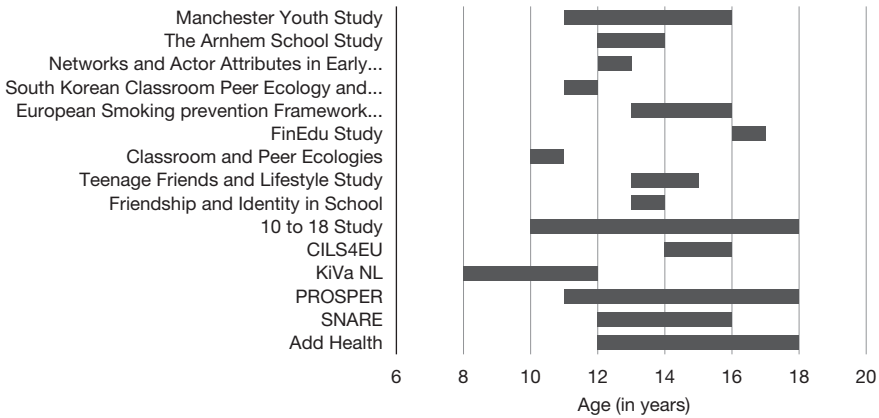


Figure 14.3 The time window of the most used social network data sets.

fluency and comprehension. This peer influence was stronger for children with high reading fluency and a high self-concept of reading ability. A U.S. study on 3- and 4-year-old children examined whether selection and influence processes among preschoolers were related to positive affect, negative affect, and effortful control (Neal et al., 2017). Both the temperament trait and social network data were based on observations. The results indicated that preschoolers selected each other on positive affect only, whereas peer influence occurred for positive affect and effortful control.

There are also several social network studies on (emerging) adults. An exemplary data set in young adulthood is the Swiss StudentLife Study (Vörös et al., 2021), which focused on topics such as the effects of social integration on the academic achievement of undergraduate students (Stadtfeld et al., 2019) and the short- and long-term effects of meeting opportunities on friendship networks (Boda et al., 2020). Another study examined peer selection and influence for marijuana use in an entire cohort of first-year college students (Barnett et al., 2022). The findings provided evidence that students were more likely to select others with similar marijuana use, and students with friends who frequently used marijuana increased their marijuana use. Another study demonstrated that freshmen chose friends who were as extraverted as they were and became more like their friends in their own extraversion (Van Zalk et al., 2020). Last, one study among young adults demonstrated the importance of considering differences in relationship strengths for influence and selection processes (Elmer et al., 2017). Respondents were asked to evaluate the quality of their relationship with every other participant on an 8-point scale. Strong ties were with peers who were perceived as high-ranking friends, close friends, or family members. Weak ties were acquaintances and low- or medium-ranking friends. Influence and selection processes regarding emotional well-being were stronger for strong ties. Young adults selected strong-tied friends based on emotional well-being and were influenced by their strong-tied rather than their weak-tied friends' emotional well-being.

NETWORK QUESTIONS

Most studies contained only data on friendships. Add Health asked respondents to nominate up to five male and up to five female best friends; FinEdu, ESFA, CILS4EU, the Teenage Friends and Lifestyle Study, PROSPER, and the Friendship and Identity in School Study used a maximum of 3, 5, again 5, 6, 7, and 10 nominations, respectively. Friendships in the 10 to 18 Study were measured by asking students to identify up to three friends, defined as people they talked with, hung out with, and did things with. These three friendship nominations were usually combined with the nominations for two other network questions, in which students were asked to name students they spent time with in school (up to 10 nominations) or out of school (up to 10 nominations). SNARE, KiVa NL, the South Korean Peer Ecology and Adolescent Development Study, the Arnhem School Study, and the Manchester Youth Study used unlimited friendship nominations. SNARE, KiVa NL, the South Korean Peer Ecology and Adolescent Development Study, the Classroom and Peer Ecologies project, and the Manchester Youth Study also contained unlimited antipathy nominations (who dislikes whom) as well as perceived status nominations (e.g., who perceives whom as popular, who likes whom). CILS4EU limited the number of popularity nominations to five.

KiVa NL and SNARE also contain other dyadic relationships. KiVa NL contains various dyadic questions on bullying, victimization, and defending. SNARE has information on positive relationships, such as helping (who helps whom) and trusting (who shares secrets with whom), negative relationships, such as bullying (who is victimized by whom) and gossiping (who spreads rumors about whom), and preferential attachment (who likes to hang out with whom, but is not associated yet). A SNARE paper on helping relationships showed that students can also be surrounded by peers who are not necessarily their friends, but who are willing to help them (Van Rijsewijk et al., 2016). Popular students supported other popular peers emotionally, instrumentally, or practically, but refrained from helping nonpopular peers. Other helping relationships were formed based on dissimilarities: higher-achieving students helped the lower academic achievers. Related to this, another study examined the codevelopment of academic partnerships (who studies with whom) and friendships (Palacios et al., 2019). This study demonstrated that adolescents in high-ability classrooms, but not in low-ability classrooms, chose high-achieving peers as academic partners and avoided peers engaged in school misconduct as academic partners. Furthermore, in both high- and low-ability classrooms, academic relationships led to friendship relationships and vice versa. Unlimited nominations for who studies (does their homework) with whom were also collected in CILS4EU (Jansen et al., 2022).

UNIQUE POSSIBILITIES IN SOCIAL NETWORK RESEARCH

The default in social network studies is to examine selection and influence processes. Peer selection is based on similarity in delinquency, alcohol use, and

smoking (Gallupe et al., 2019; Henneberger et al., 2021; Ivaniushina & Titkova, 2021), but is less likely for internalizing symptoms and aggression (Neal & Veenstra, 2021; Sijtsema & Lindenberg, 2018). Peer influence occurs more for internalizing problems, victimization, delinquency, alcohol use, and indirect aggression than for smoking or direct aggression (Gallupe et al., 2019; Henneberger et al., 2021; Ivaniushina & Titkova, 2021; Neal & Veenstra, 2021; Sijtsema & Lindenberg, 2018). The following sections discuss other possibilities that social network analysis offers.

Types of influence

Convergence versus contagion. Some types of influence may be convergence processes, such as mutual encouragement, deviancy training, and corumination, and others may be contagion processes, such as imitation and peer pressure (Laniga-Wijnen & Veenstra, 2023; Veenstra & Laniga-Wijnen, 2022). Convergence refers to a process in which friends' average behavior affects one's behavior both upward and downward (an *average similarity* effect in RSiena). Contagion refers to a process in which students with friends with relatively high levels of behaviors increase in these behaviors (an *average alter* effect in RSiena). An exemplary peer network study modeled two types of influence effects on depression to better understand the type of peer influence (Kiuru et al., 2012). The findings provided evidence for convergence rather than contagion because influence processes led to both increases and decreases in adolescent depression.

Initiation versus continuation. Social network analyses also enable researchers to distinguish the influence of friends on the initiation versus the cessation of a behavior. A network diffusion model allows comparison of the influence of friends on the onset versus the continuation of behaviors. Some researchers have applied this model to examine how peers contribute to the onset of substance use: adolescents were particularly influenced by their friends in the *onset* of substance use, which can be defined as the transition from no experience with drinking alcohol to having a first full drink (Light et al., 2013), or as having a first heavy drinking episode (Light et al., 2019), but also as starting to use marijuana (de la Haye et al., 2013) or starting to smoke (de la Haye et al., 2019). The network diffusion models point to social processes whereby exposure to friends who use substances provides information about socially attractive events like parties with popular peers as well as a social context in which peers model and approve of such behavior. In that way, exposure creates a normative context in which substances are easily available, which may influence adolescents' substance use expectations and hence facilitate the initiation of substance use. These exposure effects involve a unilateral transmission of a behavior from adolescents who engage in it to peers who do not. Another example of an exposure effect is that social networks affect whether young people reach the milestone of having sex (Trinh et al., 2019). The findings suggested that having friends who have already had sex increases the odds of adolescents' own sexual debut.

Cross-behavior influence. Research has demonstrated that cross-behavior influence also plays a role in behavioral change. For instance, friends' depressive symptoms and friends' impulsivity predicted an increase in adolescents' nonsuicidal self-injury behaviors (Giletta et al., 2013). Another study found that adolescents with relatively more aggressive friends were likely to decrease in prosocial behavior, whereas adolescents with relatively few aggressive friends were more likely to increase in prosocial behavior (Laninga-Wijnen et al., 2020).

Bundles of behaviors. Besides cross-behavior influence, adolescents may be influenced by their friends in *bundles* of behavior. Through "interpreted abstraction" processes, individuals may consider certain behaviors to belong together and to jointly form a lifestyle. For example, adolescents who engage in risky sexual behavior are also more likely to engage in substance use or direct aggression (Zweig et al., 2002), and engaging in this bundle of behaviors may be seen as a lifestyle. Thus, rather than adopting a specific behavior from friends, adolescents may adopt an entire bundle of behaviors or a lifestyle from others. An exemplary study identified three lifestyles: a mostly healthy, a discordant, and a mostly unhealthy lifestyle (Adams et al., 2022). The healthy group had high rates of nonsmokers, nondrinkers, individuals who had not had sex, and individuals who always wore a seatbelt. The unhealthy group showed high rates of substance use, did not use a condom when they last had sex, and had lower levels of physical activity. The patterns in the discordant group diverged between the schools. Overall, adolescents not only primarily selected each other as friends based on these lifestyles but also influenced their peers' lifestyles (Adams et al., 2022).

Being more susceptible or influential. Moderating effects of individual characteristics in the influence of friends have been tested in some social network studies. Boys were more susceptible to influence by delinquent friends (Burk et al., 2007), whereas girls were more susceptible to influence by depressed friends (Van Zalk et al., 2010). Impulsive youth were more susceptible to influence by alcohol-drinking friends (Rabaglietti et al., 2012), but not to influence by delinquent friends (Franken, Moffitt, et al., 2016). Adolescents with high levels of hostile attribution bias (Molano et al., 2013) or low self-esteem (Van Zalk, 2015) were more inclined to adopt their friends' antisocial and violent behavior. Youth with psychopathic traits as well as high-status youth were less susceptible to the influence of friends' delinquency (Kerr et al., 2012). Adolescents with high levels of social acceptance were less susceptible to influence on antischool behavior (Geven et al., 2013), whereas adolescents with low levels of social acceptance were more susceptible to influence on alcohol misuse (DeLay et al., 2022). Peers with high levels of social acceptance may be especially influential (Zingora et al., 2020). A novel network procedure allows researchers to assess who is more susceptible to influence and who is more influential (DeLay et al., 2022); the procedure uses an *individual susceptibility model* (to test whether peer influence differed as a function of an attribute of the recipient of influence), a *peer influence model* (to test whether peer influence differed as a function of an attribute of the agent of influence), and a *dyadic difference model* (to test whether peer influence or susceptibility to influence

differed as a function of the absolute difference in an attribute between the recipient and the agent of influence).

Types of complexity

The impact of social norms. It is likely that adolescents balance the costs and the benefits of certain behaviors before displaying them, and in particular benefits in terms of peer status and approval may be attractive to adolescents (LaFontana & Cillessen, 2010). Social norms are thought to define which behaviors may be approved of and seen as normative among peers (Chang, 2004). Therefore, adolescents may be more likely to select friends and be influenced by their friends on the basis of these normative behaviors. Accordingly, one prior study found that when adolescents perceived bullying norms to be positive, bullying behaviors were more likely to be used as a friendship selection criterion, and adolescents who scored high in bullying others had a greater tendency to select high-bullying peers as friends (Shin, 2022a). In addition, as adolescents perceived higher bullying norms, friendship influence on bullying and victimization was magnified. When they anticipate positive consequences of bullying, bullies seemed to be more likely to adopt the bullying behavior of their high-bullying friends and engage in bullying even more frequently. Furthermore, when adolescents perceived that their classmates condoned bullying, they seemed to be less likely to act on their empathy and intervene on behalf of or defend the victims because of their increased concerns about being potential future targets of bullies. Accordingly, when young people perceived bullying norms as positive, victimization experiences were more severe and friendship influence on victimization was stronger (Shin, 2022a). Whereas this prior study examined individuals' perceptions of peer norms, other research focused on peer norms *as context* for peer selection and influence processes. These studies examined whether friendship selection and influence processes varied across classrooms depending on descriptive norms (average behaviors in classroom) versus popularity norms (the within-classroom correlation between popularity and a behavior). It was found that the norms of popular peers (popularity norms) rather than the norms of all peers (descriptive norms) enhanced peer influence on risk attitudes (Rambaran et al., 2013), aggression (Laninga-Wijnen et al., 2017), and academic adjustment (Laninga-Wijnen et al., 2018). Popular peers may be more visible and central than other peers and more powerful in providing vicarious reinforcement or sanctioning deviation, and adolescents themselves may proactively try to fulfill their increasing desire for popularity or to avoid unpopularity (Laninga-Wijnen, 2020).

Complementarity and distinctiveness. The focus of social network studies has been to explain similarities among friends. Indeed, being similar is an important basis for friendship, but being different from each other and complementing each other can be beneficial within friendships as well (Urberg et al., 1998). For instance, young people who strongly strive for status were more likely to befriend

submissive rather than dominant peers, as this reduced conflict and enabled them to achieve their own goal for dominance (Dryer & Horowitz, 1997; Ojanen et al., 2013). Moreover, adolescents may attach value to developing a unique identity and therefore may aim to develop in somewhat different ways from their friends (Brewer, 1991). Some studies have demonstrated a decreasing return to multiple similarity (Block & Grund, 2014; Leszczensky & Pink, 2020). Their findings indicated that the effects of similarity on various dimensions were positive, but that the interaction of selection similarity effects was negative. These decreasing returns for similarity on many dimensions suggest that individuals seek social contact with others who are similar in some, but not in all, ways and allow heterogeneous groups to form. Another study (Block, 2018) demonstrated that having one joint forum for interaction increased the opportunities for friendship formation, but that every additional social situation was less important.

The impact of other actors. Some social network researchers have incorporated parental characteristics in their models (see also Chapter 8). The findings suggested that adolescents may select friends with similar levels of parental control (McCann et al., 2019) or parental knowledge and parental discipline (Ragan et al., 2014). Parental influence may also interact with peer influence: parental monitoring diminished adolescents' selection of delinquent friends (Tilton-Weaver et al., 2013), but only when adolescents did not feel overcontrolled. Parents who communicated disapproval had unintended effects on adolescents who were initially *not* delinquent: they became more susceptible to the influence of delinquent friends (Tilton-Weaver et al., 2013). Regarding alcohol use, it was found that those who reported consistent parental discipline, better parental knowledge, and fewer positive social expectations were more strongly influenced by their friends' level of alcohol use (Hoeben et al., 2021).

Friendship networks also connect adolescents to influence from a broader group of adults beyond their own families (Ragan et al., 2014). Parents' knowledge about the whereabouts of their children had a unique influence on the alcohol use of not only their own children, but also the friends of their children.

In an exemplary study, the influence of "actors at distance two" was examined (Cheadle et al., 2013). Influence on alcohol consumption also took place in networks of indirect relationships, so-called weak ties. Adolescents were affected by not only by their own friends but also the friends of their friends (Cheadle et al., 2013). In certain social settings, such as bars or parties, indirect contacts were likely to form norms and opportunities affecting alcohol use. Influence processes can thus occur in settings in which adolescents know each other only superficially (see Chapter 5).

Coevolving networks. The codevelopment of various relationships can be examined using multiplex social network analysis. Two studies examined the codevelopment of, on the one hand, victim-bully relationships and, on the other hand, victim-defender relationships (Huitsing et al., 2014) or friendships (Rambaran, Dijkstra, et al., 2020). Those longitudinal studies took as a starting point the similarity between victims (with victims being victimized by the same bully being positively associated through defending or friendship) and similarity

between bullies (with bullies targeting the same victim being positively associated through defending or friendship). The question posed in these studies was whether selection or influence led to similarity in network positions between victims and bullies. Victims selected other victims as defenders to seek support against the same bullies, but defenders of victims ran the risk that the bullies would retaliate and that they would become victimized themselves (Huitsing et al., 2014). Bullies selected other bullies as friends to collectively target the same victims (Rambaran, Dijkstra, et al., 2020). Being friends with a bully was also contagious: friends assisted bullies first, but later also bullied the victims themselves (Rambaran, Dijkstra, et al., 2020). Another study documented that friendships between bullies were more likely among same-sex than cross-sex bullies (Hooijsma et al., 2020).

Research on antipathies also found evidence for influence effects, suggesting that, over time, friends have a tendency to agree about whom to dislike (Berger & Dijkstra, 2013; Pál et al., 2016; Rambaran et al., 2015). Another study found that disliked children were likely to bully others over time, to be victimized by those who previously disliked them, and to be victimized by other schoolmates as well (Kisfalusi et al., 2022). Victims were likely to be more disliked by their bullies over time and to dislike their own bullies over time. Over and above these dyadic effects, victims did not become more disliked by children other than their own bullies, whereas bullies became more disliked by other children.

Another interesting area is the examination of the coevolution of friendships and romantic relationships (see Chapter 9): partner choices were less likely to grow out of previous direct or indirect friendships than to stem from having similar levels of prominence or status in the network.

CONCLUSION

The field of social network studies has expanded in recent decades. This chapter described the 15 data sets that have been the most central in research on social networks, including the PROSPER Peers data set. PROSPER is the social network data set with the largest sample size and follows adolescents for many years, which allows the examination of longer term development. Other network data sets are distinctive in other ways, for instance because they have unlimited nominations or network questions other than friendships or because they focus on age spans that generally have been overlooked.

The most used data sets predominantly stem from American and European—and mostly white—samples. Yet, prior work has detected cross-cultural variation in peer processes and development (e.g., Choukas-Bradley et al., 2015; see also Chapter 10); therefore, future researchers are encouraged to collect data among more diverse samples of adolescents. In addition, researchers have predominantly investigated networks of friendships, whereas considering the influence of other peers or types of networks is crucial to truly understand the size of peer influence during childhood and adolescence. The most frequently investigated time window

is between 10 and 18 years of age, a developmental period in which peers are increasingly essential (Laursen & Veenstra, 2021). Yet, the importance of peers in childhood and adulthood should not be overlooked and needs more exploration.

Most studies included in this review were based on data collected at least a decade ago, and the data set that has been used most frequently was collected prior to 2000. It is important to highlight this given the rapidly changing landscape of adolescent peer interactions. Several new data collections have taken place since the onset of COVID-19 (e.g., PRIMS—a project on the transition from PRIMARY to Secondary education—in the Netherlands, Zwier et al., 2023; CHALLENGE—a project on the characteristics and conditions of youth who remain victimized or continue bullying others despite targeted interventions—in Finland, Salmivalli, 2023), and these have the potential to render important insights into the role of peers in young people's adjustment during these times. The increase in social media connectivity has also transformed peer interactions and redefined network boundaries and influence (Nesi et al., 2018). The apps that students use enable them to fully track the whereabouts of peers they know at any time (e.g., Snapmap). This not only may enhance connectedness among adolescents, but also may cause young people to feel excluded; for instance, if they see that two of their peers are meeting while they have not been invited. Applying social network analyses to investigate such processes will provide a breakthrough in the literature.

Another characteristic of the “new generation” of adolescents (compared with the generation of 10 years ago) is that they seem to have become healthier. In the past decade, adolescents tend to smoke less, drink less alcohol (De Looze et al., 2015; Kraus et al., 2018), and postpone their age of sexual debut (Havaei et al., 2019). Social network studies may provide insights into the underlying explanatory mechanisms for these patterns and enable researchers to detect the “risks” of this new generation of adolescents (i.e., with regard to cosmetic surgery; De Vries et al., 2014; Saiphoo & Vahedi, 2019).

Ways to further improve SIENA models are needed (e.g., regarding its robustness; Edmonds & Meyer, 2013). As noted in Chapter 4, a large share of social network studies have yielded potentially imprecise results, with confidence intervals ranging from very small or negative to very large or positive (Gallupe et al., 2019). It was also found that findings based on conventional regression analyses, as long as appropriate controls are included, may not suffer from an inherent upward bias and should not be automatically discounted simply because they were not produced by SIENA (Ragan, Osgood, Ramirez, et al., 2022). Another study created an actor-based model to evaluate the estimation of selection and influence effects by SIENA, and they found that even though *influence estimates* were consistently robust to variation in SIENA specification, *selection estimates* were highly sensitive to misspecification in case of simple assumptions (Daza & Kreuger, 2021). It is, therefore, important that critical comparisons between SIENA and conventional regressions be performed on other big data sets as well, and it is highly useful to replicate social network studies using conventional regression studies and vice versa. Notably, SIENA remains exceptionally suitable for estimating alternative

and complex forms of influence that are difficult to estimate using conventional regression, such as the relative impact of asymmetrical versus reciprocal ties, cross-behavior processes, various susceptibility models, different types of influence, and the strength of influence in increases versus decreases in behavior. Thus, social network studies have the advantage of allowing examination of the different types of influence and complexity of social networks, as described in this chapter.

Another direction for future research is to explore the conditions under which friendship selection and influence may, or may not, occur. The role of genetics in social networks, for instance, is an underexplored area of research (see Chapter 12). Following differential susceptibility theory (Belsky & Pluess, 2009), genetic factors may both increase the risk for poor outcomes in adverse contexts and increase positive outcomes in beneficial contexts. Future work is encouraged to examine whether adolescents may be attracted to friends with similar phenotypes, or whether certain phenotypes could make adolescents particularly susceptible to friendship influence. Furthermore, in SIENA, the average similarity among adolescents and their friends is calculated, without considering whether the similarity may vary as a function of the strength of the friendship. However, it is plausible that adolescents are similar to some—potentially their closest—friends, but not to others (Elmer et al., 2017).

Not only individual or dyadic factors may increase susceptibility to peer processes, but also contextual factors, such as peer norms. An important question is how norms can best be conceptualized (Veenstra & Lodder, 2022). Several social network studies have analyzed norms as an individual's perception of what is prevalent or what is approved (e.g., Shin, 2022a). Although valuable, assessing norms in this way entails the risk of projection bias. Other work has assessed peer norms by aggregating outgoing peer nominations on behaviors or by correlating peer-nominated popularity with peer-nominated behavior within classrooms (e.g., Laninga-Wijnen et al., 2017). Nevertheless, it remains to be investigated whether these measures of norms are ideal and capture the consensus of young people on what behaviors are appropriate or expected in a particular setting.

This chapter has summarized the state of the art in social network studies. The PROSPER data set and other large-scale data sets have contributed greatly to the social network literature, and many interesting and innovative directions for future studies have been formulated. The ongoing refinement of social network methods, their application, and critical evaluation will undoubtedly give a boost to numerous innovative studies on topics that matter for the new generation of adolescents.

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