An assessment of social network data trustworthiness

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Thesis Proposal

# ABSTRACT

# ACKNOWLEDGEMENTS

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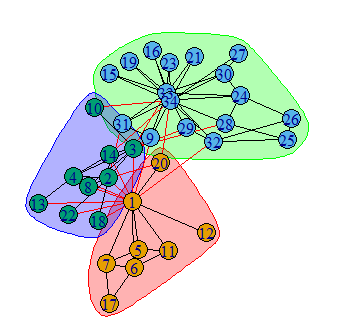
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# CHAPTER I: INTRODUCTION

“One of the most potent ideas in in the social sciences is the notion that individuals are embedded in thick webs of social relations and interactions” (Borgatti, Mehra, Brass, & Labianca, 2009).

In recent years there has been a growing interest in understanding human relationships within the social and behavioral sciences. Studying social networks is one method to help researchers understand these relationships. A social network is defined as a set of relationships between objects and how they can be mapped in a social structure (Kadushin, 2012). In social sciences, the term is most commonly referring to people, but the social networks to any set of related objects. Social network approaches have been used in a diverse set of scientific domains from understand neuronal connections (Bassett & Sporns, 2017) to understanding animal behavior (Brent, 2015).

Every network consists of a set of actors with defining characteristics (a node) and lines to represent the connection between them (known as a tie or edge). A node is an object with defining characteristics to be analyzed within a network of other nodes with similar, or differing, characteristics (Luke, 2015). Social network analysis quantitatively measures the connection of nodes through edges (Kadushin, 2012). Nodes may have several attributes such as, but not limited to, personality characteristics, gender, and age. The connection of these nodes through edges help understand how many connections a node may possess and where those connections come from. Social networks can be viewed from a more ecological standpoint to identify clusters of nodes and the commonalities between them such as family members, friends, and acquaintances (see Leskovec & Mcauley (2012) for an example of clustered networks). A visual display of nodes with attributes, edges, and clustering effects can be seen in *Figure 1*.



*Figure 1.* A social network from the *Zachary’s karate club network* (Gfeller, 2007). This network displays a university karate class’ connections and the clustering between them. The nodes (circles) have differing colors to represent attributes about the actor displayed. The edges (lines) show the connections between these nodes with certain attributes. Furthermore, the edges may be colored to characterize an attribute of the connection. Lastly, the surrounding colors identify how nodes are clustered into groups.

To study the organization of these nodes and edges that make up a social network, we use social network analysis. Social networks analysis (SNA) helps to define and measure the connections among people, organizations, and/or other individual units (T. W. Valente, 2010). More specifically, SNA is the process of understanding social structures quantitatively through network theory and graph theory (Butts, 2008). A wide array of statistics can be derived from social network analysis – often called network statistics. Network statistics allow researchers to quantitatively measure all levels of a social structure (Krause, Croft, & James, 2007). Social network theory, the overall encompassing theory surrounding SNA, can be applied to a wide variety of levels spanning from the simple connection of two people, up to a collection of people and how those people are integrated in a set of systems (Kadushin, 2012).

## **Background**

Historically, attempts to understand social networks have been around since the time of Socrates, whom theorized about the influences of social classes on people (Borgatti et al., 2009). However, the quantitative approach to understanding them is relatively new. It was not until the 1960’s that researchers began to theorize how the connections between people may impact the human experience. Travers & Milgram (1969) used social network methodology to determine everyone connected via six degrees of separation. Traverse & Milgram’s (1969) study represents the concept of the *small-world effect*, indicating that all individuals are in some way connected. These empirical studies have determined that the mean number of number of connections, despite the size of the network is relatively short (Newman, 2018).

Analyzing large scale social networks and performing the complex analyses associated with network theory in early scientific studies was nearly impossible. The scarcity of social network research in past decades is due to the overall complexity of social network data collection and analysis. However, the number of studies with network analysis methodologies have increased since the turn of the century. Advances in statistical programming have provided social science researchers an avenue to include strong social network components within their research studies (Luke, 2015). Several cutting-edge social network analysis methodologies require intensive processing power to be performed. Advanced Bayesian modeling techniques such as Exponential Random Graphing Models (ERGM) and *S*imulation Investigation for Empirical Network Analysis (SIENA) models (Ripley, Snijders, Boda, Vörös, & Preciado, 2019; Snijders, 2005) are examples of modeling techniques that require heavy processing power. These techniques are now feasible thanks to advances social computing that increase processing speeds and allow for large datasets (Parameswaran & Whinston, 2007); which social network data is notorious for producing.

Beyond analyses, social network data collection has also become more feasible over time. Social network sites such as Facebook and Twitter have provided a path for large quantities of social network data for analysis. Online social networks (OSN) are often collected via an application programing interface (API) provided by OSN providers. These OSN websites automatically collect a wealth of data from their users (Abdesslem, Parris, & Henderson, 2012). Modern utilization of SNA goes well beyond the of social networking websites. Research implementing social network methods include identifying characteristics of terrorist networks (Ressler, 2006), obesity (Cohen-Cole & Fletcher, 2008) and adolescent drug use (T. Valente, 2003).

## **Social Network Analysis in Psychological Research**

Psychological research often relies on self-report surveys to answer research questions. Therefore, social network survey methodologies have been created. Survey research with a social network component consists of questionnaires that ask about relationships among a specified target group (Serrat, 2017). Social network survey questionnaire data is otherwise known as egocentric data, in which the actor is responsible for identifying their own network (Mccarty, Bernard, Killworth, Shelley, & Johnsen, 1997). These questionnaires require careful thought. There are two common approaches to collecting social network data in survey research:

1. *Social Cognitive Mapping/Roster:* Originally developed by Cairns, Perrin, & Cairns (1985), this method shows survey responders a list of names of individuals within the network. Respondents are requested to selected all alters that they have a relationship with. Roster methods require the use of a stem question such as, “To whom do you report to at work?” or “Please select individuals you have a friendship with…”.
2. *Name Generator/Nomination method:* This method allows participants to name any one or several individuals within a network. The name that may be generated are arbitrary and limitless. A common prompt a participant may see is, “Please indicate five individuals that you would seek advice from within your office…”.

Both methodologies are notorious for creating enormous datasets - Datasets that are hard to sift through without a systematic and methodical approach. Both egocentric data collection methodologies have pros and cons. Roster methodology requires high participation to produce valid data (Wasserman & Faust, 1994). Additionally, a roster methodology may only be incorporated when all sets of potential alters in known (Butts, 2008). On the other hand, studies utilizing nomination methods have shown that subjects are likely to produce false negatives due to subjects forgetting or overall fatigue (Butts, 2008). Errors especially occur in instances where the ego (an individual node in the network) has many connections (Brewer, 2000).

These collection methods for social network analysis have been shown to have a useful place in community interventions. For example, Klovdahl (1985) created a social network intervention to identify and prevent HIV outbreaks within a homosexual population. DeLay and colleagues (2016) have used adolescent friendship networks to evaluate the Family Check-up model within adolescent populations. Kornienko, Dishion, & Ha (2018) used social network interventions to reduce antisocial and violent behaviors within adolescent population. Experimental research by Valente (2003) found differences in tobacco intervention programs that identified group leaders in network analysis. In summary measures and analysis of social network can inform and improve interventions directly.

## **Social Network Analysis in Adolescent Populations**

Adolescents are often a population of interest in social network research. Years of research have promoted the influence of peer networks towards cigarette smoking (Ennett et al., 1993; Ennet et al., 2008) and other

## **Implications of Social Network Analysis**

The dissemination of SNA information has real world implications that may influence communities. Therefore, researchers need to be held accountable that the data they collect are valid and trustworthy. When reviewing the social network literature, a check on data quality is never mentioned. Social science’s dependability on reporting of standardized validity, reliability measures and checks for data trustworthiness helps to ensure the credentials of the field. Social network analysis research, an expanding part of the social science field, does not follow these same rules. It is naïve to assume that the network data collected by researchers is valid and appropriate for analyses. Even more so, populations of interest may differ in the validity of network data collected. Therefore, because there is no standardized methodology to evaluating social network data, the legitimacy of the field is at risk.

Without assessing the trustworthiness of collected data, there is no understanding how valid our conclusions are. Cole et al. (2018) have proposed latent variable approaches to validating social network data. Sociometric reliability has also been a topic of discussion for some time now. Pepinsky (1949), mentions that there is that there is no guarantee of consistency regarding sociometric data. Contrarily, Harmon (1949) made the exact opposite argument, stating that reliability in sociometric data collection is not necessary because it serves as a description of the real world itself. Terry (2000) later indicated the validity of sociometric methods are of concern because the there is no consistency in question stems (i.e. “Who are your best friends” vs. “Name your friends”). In either instance, the participant is expected to recall their network, which is may be prone error.

Newman (2018) has expressed concern over the omission of reliability measurements in social network analysis. Social network measurement error is especially prevalent in social science research due to the subjective nature of the network by both the subject and the experimenter assessing the network (Bernard & Killworth, 1977; Killworth & Brenard 1976; Marsden, 1990). Furthermore, previous research shows that these subjective errors may have large impacts on results (CITE).

## **A Psychometric approach to Social Network Validation**

The aforementioned concepts are analogously related to classical test theory in the psychometric testing and measurement literature. Past research has noted this concern with validity as the observance of the true structure of the network as compared to the observed structure of the network (Wasserman & Faust, 1994).

These concerns are no different than the concerns in psychometric testing and measurement. Testing and measurement practices emphasize extreme precautions to ensure their measures are both reliable and valid. Quantitative measures for reliability and validity such as, internal consistency (Cronbach, 1951), interrater reliability, construct validity, and criterion validity among many others are essential components to the psychometric literature (DeVellis, 2016). It is common practice to report these quantitative statistics whenever possible. However, measures such as these do not exist in the social network literature.

**Current literature on Network Statistics and Measurement Error**

I Just finished a chapter about this in textbook called *Networks*  by Newman (2019), and will begin incorporating everything from that soon – Neil

## **Proposal**

I propose creating a standardized method for validating social network data. My proposal serves as a set of analogous measures to those used in psychometric testing and measurement. Several analogous measures will be tested such as reliability, trustworthiness, and validity levels.

References

Abdesslem, B., Parris, I., & Henderson, T. (2012). *Reliable Online Social Network Data Collection*. Retrieved from http://www.springerlink.com/

Bassett, D. S., & Sporns, O. (2017). Network neuroscience. *Nature Neuroscience*, *20*(3), 353–364. https://doi.org/10.1038/nn.4502

Borgatti, S. P., Mehra, A., Brass, D. J., & Labianca, G. (2009). *Network Analysis in the Social Sciences*. Retrieved from http://www.sciencemag.org/.

Brent, L. J. N. (2015). Friends of friends: are indirect connections in social networks important to animal behaviour? *Animal Behaviour*, *103*, 211–222. https://doi.org/10.1016/J.ANBEHAV.2015.01.020

Brewer, J. D. (2000). *Ethnography*. Retrieved from www.openup.co.uk

Butts, C. T. (2008). *Social network analysis: A methodological introduction*. https://doi.org/10.1111/j.1467-839X.2007.00241.x

Cairns, R. B., Perrin, J. E., & Cairns, B. D. (1985). Social Structure and Social Cognition in Early Adolescence: Affiliative Patterns. *The Journal of Early Adolescence*, *5*(3), 339–355. https://doi.org/10.1177/0272431685053007

Cohen-Cole, E., & Fletcher, J. M. (2008). Is obesity contagious? Social networks vs. environmental factors in the obesity epidemic. *Journal of Health Economics*, *27*(5), 1382–1387. https://doi.org/10.1016/J.JHEALECO.2008.04.005

Cole, V. T., Hussong, A. M., Faris, R. W., Rothenberg, W. A., Gottfredson, N. C., & Ennett, S. T. (2018). A Latent Variable Approach to Measuring Social Dynamics in Adolescence. *Journal of Research on Adolescence*. https://doi.org/10.1111/jora.12466

DeLay, D., Ha, T., Van Ryzin, M., Winter, C., & Dishion, T. J. (2016). Changing Friend Selection in Middle School: A Social Network Analysis of a Randomized Intervention Study Designed to Prevent Adolescent Problem Behavior. *Prevention Science : The Official Journal of the Society for Prevention Research*, *17*(3), 285–294. https://doi.org/10.1007/s11121-015-0605-4

DeVellis, R. (2016). *Scale development: Theory and applications*. Retrieved from https://books.google.com/books?hl=en&lr=&id=231ZDwAAQBAJ&oi=fnd&pg=PT15&dq=DeVellis,+R.+F.+(2016).+Scale+development:+Theory+and+applications+(Vol.+26).+Sage+publications.&ots=hE2TDoC7Sp&sig=hxDAh-Q8gE3qqUUKrKQThfn9mFg

Ennett, S. T., Bauman, K. E., Hussong, A., Faris, R., Foshee, V. A., Cai, L., & Durant, R. H. (1993). The Peer Context of Adolescent Substance Use: Findings from Social Network Analysis. *JOURNAL OF RESEARCH ON ADOLESCENCE Kobus*, *16*(2), 159–186.

Gfeller, D. (2007). *Simplifying complex networks: from a clustering to a coarse graining strategy*. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.362.5275&rep=rep1&type=pdf

Kadushin, C. (2012). *Understanding social networks: Theories, concepts, and findings*. Retrieved from https://books.google.com/books?hl=en&lr=&id=ALOhpMgkW\_cC&oi=fnd&pg=PP2&dq=Kadushin,+C.+(2012).+Understanding+social+networks:+Theories,+concepts,+and+findings.+Oup+Usa.&ots=7Q06cxqXqO&sig=rQbi342gYoMXdwr4qU7tolnjtd8

Klovdahl, A. S. (1985). Social networks and the spread of infectious diseases: The AIDS example. *Social Science & Medicine*, *21*(11), 1203–1216. https://doi.org/10.1016/0277-9536(85)90269-2

Kornienko, O., Dishion, T. J., & Ha, T. (2018). Peer Network Dynamics and the Amplification of Antisocial to Violent Behavior Among Young Adolescents in Public Middle Schools. *Journal of Emotional and Behavioral Disorders*, *26*(1), 21–30. https://doi.org/10.1177/1063426617742345

Krause, J., Croft, D. P., & James, R. (2007). Social network theory in the behavioural sciences: potential applications. *Behavioral Ecology and Sociobiology*, *62*(1), 15–27. https://doi.org/10.1007/s00265-007-0445-8

Leskovec, J., & Mcauley, J. J. (2012). *Learning to Discover Social Circles in Ego Networks* (pp. 539–547). pp. 539–547. Retrieved from https://papers.nips.cc/paper/4532-learning-to-discover-social-circles-in-ego-networks

Luke, D. (2015). *A User’s Guide to Network Analysis in R*. In *Use R!* https://doi.org/10.1007/978-3-319-23883-8

Mccarty, C., Bernard, H. R., Killworth, P. D., Shelley, G. A., & Johnsen, E. C. (1997). Eliciting representative samples of personal networks. In *N ELSEVIER Social Networks* (Vol. 19). Retrieved from https://pdfs.semanticscholar.org/21d2/38bb05cc8ed0b30ef00915618f4e790002bf.pdf

Newman, M. (2018). *Networks* (2nd ed.). https://doi.org/10.1093/oso/9780198805090.001.0001

Parameswaran, M., & Whinston, A. B. (2007). *Research Issues in Social Computing \** (Vol. 8). Retrieved from https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1418&context=jais

Pepinsky, P. N. (1949). The meaning of validity and reliability as applied to sociometric tests. *Educational and Psychological Measurement*, *9*(1), 39–49. https://doi.org/10.1177/001316444900900105

Ressler, S. (2006). Social network analysis as an approach to combat terrorism: Past, present, and future research. *Fas-Web.Sunderland.Ac.Uk*, *2*(2). Retrieved from https://fas-web.sunderland.ac.uk/~cs0her/CIS302 Lectures/content/PBL3/terrorism\_SNA.pdf

Ripley, R. M., Snijders, T. A. B., Boda, Z., Vörös, A., & Preciado, P. (2019). *Manual for RSiena*. Retrieved from http://www.stats.ox.ac.uk/~snijders/siena/RSiena\_Manual.pdf

Serrat, O. (2017). Social Network Analysis. In *Knowledge Solutions* (pp. 39–43). https://doi.org/10.1007/978-981-10-0983-9\_9

Snijders, T. A. B. (2005). *Models for Longitudinal Network Data*. Retrieved from https://www.stats.ox.ac.uk/~snijders/siena/cup\_ch11.pdf

Terry, R. (2000). Recent advances in measurement theory and the use of sociometric techniques. *New Directions for Child and Adolescent Development*, *2000*(88), 27–53. https://doi.org/10.1002/cd.23220008805

Travers, J., & Milgram, S. (1969). An Experimental Study of the Small World Problem. *Sociometry*, *32*(4), 425. https://doi.org/10.2307/2786545

Valente, T. (2003). *Social network influences on adolescent substance use: An introduction IDU Peer Recruitment Dynamics and Network Structure in Respondent Driven Sampling View project*. Retrieved from https://www.researchgate.net/publication/228688777

Valente, T. W. (2010). *Social Networks and Health: Models, Methods, and Applications - Thomas W. Valente - Google Books*. Retrieved from https://books.google.com/books?hl=en&lr=&id=xnMzd1-7iGgC&oi=fnd&pg=PR11&dq=Valente,+T.+W.+(2010).+Social+networks+and+health:+Models,+methods,+and+applications.+Oxford+University+Press.&ots=YrsR7jQ0\_E&sig=7VK2PHWqvd9qupqZPvR5b2msCrQ#v=onepage&q=Valente%2C

Wasserman, S., & Faust, K. (1994). *Social Network Analysis: Methods and Applications - Stanley Wasserman, Katherine Faust - Google Books*. Retrieved from https://books.google.com/books?id=wsMgAwAAQBAJ&printsec=frontcover&dq=Wasserman,+S.,+%26+Faust,+K.+(1994).+Social+network+analysis:+Methods+and+applications+(Vol.+8).+Cambridge+university+press.&hl=en&sa=X&ved=0ahUKEwi5lqWRrKDhAhWp7YMKHSU7DlUQ6AEIKjAA#v=o

Psychometric scales rely solely on self-report data and social network survey research utilize the same self-report methodology.

Despite these concerns, there are no standardized checks to test for data quality, accuracy, or trustworthiness.

Because social science relies heavily on self-report measures it is a necessary component of the literature. Measurements of reliability is among the most emphasized subjects in the social science domain. As with social network survey methodology, many psychological measures depend on self-report. These self-report questionnaires need to be assessed for their reliability through many statistical methods.

There is light research concerning this issue of social network data reliability and validity.

Other social science fields place a strong emphasis on ensuring construct measures are both reliable and valid.

Research on testing in employment processes has shown that anywhere from 15% to 40% of provide fake responses (Arthur, Glaze, Villado, & Taylor, 2010; Griffith, Chmielowski & Yoshita, 2007). Novel fake response detection methods such as unlikely response patterns detection (Holden et al., 2017) and social desirability scales (Crowne & Marlowe, 1960; Paulhaus 1999) have been utilized in order to retain scale validity and trustworthiness.

Social network research has no excuse to pursue similar practices to ensure the field is taken seriously.

Pat methodological approaches focused

Fields with an emphasis on testing and measurement incorporate a numerous number of methods to ensure validity and reliability exist within the measures they use. Social network data is a measure of relationships and bonds and there is no excuse to ensure the quality. This thesis project proclaims the assumption that social network data needs to be validated via standardized methods.

All the past research takes a focus on understanding data validity by use of the structural components of the network. However, the assumption that actors in a social network study can properly assess their own network is not nearly as researched. Often it is merely assumed that an actor assessing their own network through survey questions may accurately report. Ideally there needs to be systematic checks to determine the quality and trustworthiness of the data that has been collected. However, a standardized process to validate collected social network data remains unclear.

Using these methods to collect data requires a large assumption: *That respondents can properly assess their own networks*. This assumption is especially important depending on the population being assessed. For example, are adolescents able to properly assess their friendships with their peers? This overarching question is important and scarce in the literature.

The social ecological model is arguably the most heavily utilized model in public health and social science. The social ecological model emphasizes the integration of the social environment and an individual predicting determinant of health. We can approach the social ecological model’s integration of social systems and the individual via the social networks of these system.

The validation of network data comes with its challenges. When social network data is collected, it

There are a variety of methods for collecting friendships and bonds.

Despite these differing methods, the way social network data is processed is quite similar. Social network data may be represented in terms of an edge list or adjacency table. However, despite the standardized way of representing social network data, there is no standard process in existence to ensure the quality of social network data.

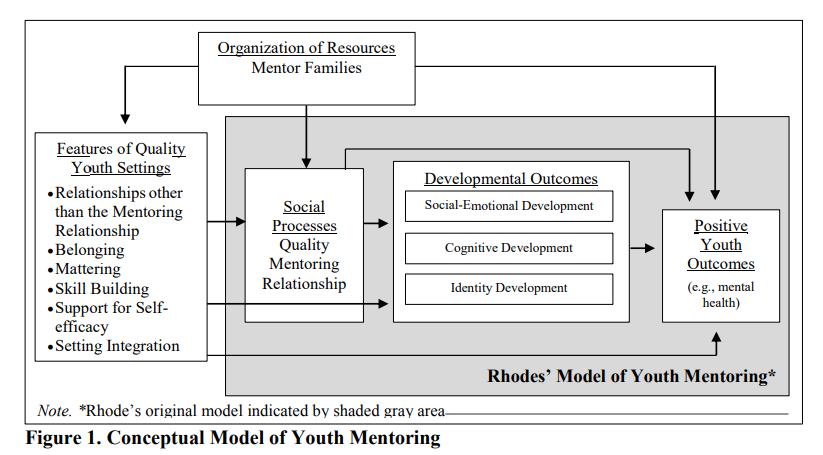
At the end of the project, a series of “checks” will be created to create an understanding of the validity of social network data. This is an essential step to determine the true effects of the network on health outcomes.

Due to the quantitative properties of SNA, a series of quantitative terms are used to represent relationships between people and systems. When these terms are used, we are establishing a mathematical representation of the network as a whole or the individual components of the network. Individual units in the network are referred to as nodes. In SNA, we study the connection and relationships between nodes (Marin & Wellman, 2008). The connecting points representing edges within a network are known as edges.

**Data Collection**

Data for this thesis project were collected via Campus Connections (CC), a youth mentorship service-learning program at Colorado State University (CSU). Campus Connections trains undergraduate students to mentor at-risk adolescents (i.e., those deemed at risk for not 2 E reaching their full potential due to significant individual and/or environmental risk) aged 11-18 within the local community. Youth and mentors pair up one time a week for four hours per week for 12 weeks. To date, more than 1,500 mentee-mentor pairs have participated in this program to date. Past work indicates that CC is practical, feasible, and in high demand.

Campus Connections utilizes evidence-based practice to promote positive youth outcomes. Along with CC’s desire for evidence-based practice, it utilizes and extension of Rhode’s model of youth mentoring as shown in Figure 1(Rhodes, 2002, 2005).



Results from past research indicate that Campus Connections adolescent outcomes rank similarly to other youth service programs. These effects on positive youth development tends to be relatively modest with some key outcomes not being substantially improved. A unique aspect of CC is the establishment of a *Mentor Family* component. Mentor families involve nesting three to four mentor-mentee pairs into a “family group” to experience the program in unison. These mentor families consist of multiple levels of support. Level one consists of the mentor-mentee dyad. Mentors and mentees establish a closely-knit bonding experience between the mentor and mentee. Level two is the establishment of the mentor family. The mentor family component of CC is based on a

Abdesslem, F. B., Parris, I., & Henderson, T. (2012). Reliable online social network data collection. In *Computational Social Networks* (pp. 183-210). Springer, London.

Aggarwal, C. C. (2011). An introduction to social network data analytics. In *Social network data analytics* (pp. 1-15). Springer, Boston, MA.

Arthur Jr, W., Glaze, R. M., Villado, A. J., & Taylor, J. E. (2010). The magnitude and extent of cheating and response distortion effects on unproctored internet‐based tests of cognitive ability and personality. *International Journal of Selection and Assessment*, *18*(1), 1-16.

Bassett DS, Sporns O. Network neuroscience. *Nat Neurosci*. 2017;20(3):353-364.

Butts, C. T. (2008). Social network analysis: A methodological introduction. *Asian Journal of Social Psychology*, *11*(1), 13-41.

Borgatti, S. P., Mehra, A., Brass, D. J., & Labianca, G. (2009). Network analysis in the social sciences. *science*, *323*(5916), 892-895.

Bronfenbrenner, U. (1977). Toward an experimental ecology of human development. *American psychologist*, *32*(7), 513.

Cairns, R. B., Perrin, J. E., & Cairns, B. D. (1985). Social structure and social cognition in early adolescence: Affiliative patterns. *The Journal of Early Adolescence*, *5*(3), 339-355.

Cohen-Cole, E., & Fletcher, J. M. (2008). Is obesity contagious? Social networks vs. environmental factors in the obesity epidemic. *Journal of health economics*, *27*(5), 1382-1387.

Cole, V. T., Hussong, A. M., Faris, R. W., Rothenberg, W. A., Gottfredson, N. C., & Ennett, S. T. (2018). A Latent Variable Approach to Measuring Social Dynamics in Adolescence. *Journal of Research on Adolescence*.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *psychometrika*, *16*(3), 297-334.

Crowne, D. P., & Marlowe, D. (1960). A new scale of social desirability independent of psychopathology. *Journal of consulting psychology*, *24*(4), 349.

Day, E., Copello, A., Seddon, J. L., Christie, M., Bamber, D., Powell, C., ... & Frew, E. (2018). A pilot feasibility randomised controlled trial of an adjunct brief social network intervention in opiate substitution treatment services. *BMC psychiatry*, *18*(1), 8.

DeLay, D., Ha, T., Van Ryzin, M., Winter, C., & Dishion, T. J. (2016). Changing friend selection in middle school: A social network analysis of a randomized intervention study designed to prevent adolescent problem behavior. *Prevention Science*, *17*(3), 285-294.

DeVellis, R. F. (2016). *Scale development: Theory and applications* (Vol. 26). Sage publications.

Gfeller, D. (2007). *Simplifying complex networks: from a clustering to a coarse graining strategy* (Doctoral dissertation, Verlag nicht ermittelbar).

Griffith, R. L., Chmielowski, T., & Yoshita, Y. (2007). Do applicants fake? An examination of the frequency of applicant faking behavior. *Personnel Review*, *36*(3), 341-355.

Haring, T. G., & Breen, C. G. (1992). A peer‐mediated social network intervention to enhance the social integration of persons with moderate and severe disabilities. *Journal of applied behavior analysis*, *25*(2), 319-333.

Harmon, L. R. (1949). A Note on Pepinsky's Analysis of “Validity” and “Reliability” of Sociometric Data. *Educational and Psychological Measurement*, *9*(4), 747-747.

Kadushin, C. (2012). *Understanding social networks: Theories, concepts, and findings*. Oup Usa.

Klovdahl, A. S. (1985). Social networks and the spread of infectious diseases: the AIDS example. *Social science & medicine*, *21*(11), 1203-1216.

Kornienko, O., Dishion, T. J., & Ha, T. (2018). Peer network dynamics and the amplification of antisocial to violent behavior among young adolescents in public middle schools. *Journal of Emotional and Behavioral Disorders*, *26*(1), 21-30.

Krause, J., Croft, D.P. & James, R. Behav Ecol Sociobiol (2007) 62: 15. <https://doi.org/10.1007/s00265-007-0445-8>

Leskovec, J., & Mcauley, J. J. (2012). Learning to discover social circles in ego networks. In *Advances in neural information processing systems* (pp. 539-547).

Luke, D. A. (2015). *A user's guide to network analysis in R*. London, England: Springer.

Marin, A., & Wellman, B. (2011). Social network analysis: An introduction. *The SAGE handbook of social network analysis*, *11*.

McCarty, C., Bernard, H. R., Killworth, P. D., Shelley, G. A., & Johnsen, E. C. (1997). Eliciting representative samples of personal networks. *Social networks*, *19*(4), 303-323.

Milgram, S. (1967). The small world problem. *Psychology today*, *2*(1), 60-67.

Paulhus, D. L. (1998). *Paulhus deception scales (PDS): the balanced inventory of desirable responding-7: user's manual*. North Tanawanda, NY: Multi-Health Systems.

Parameswaran, M., & Whinston, A. B. (2007). Research issues in social computing. *Journal of the Association for Information Systems*, *8*(6), 22.

Pepinsky, P. N. (1949). The meaning of" validity" and" reliability" as applied to sociometric tests. *Educational and psychological measurement*, *9*(1), 39-49.

Ressler, S. (2006). Social network analysis as an approach to combat terrorism: Past, present, and future research. *Homeland Security Affairs*, *2*(2).

Rhodes, J. E. (2002). Stand by me: The risks and rewards of youth mentoring today’s youth. Cambridge, MA: Harvard University Press.

Rhodes, J. E. (2005). A model of youth mentoring. In D.L. Dubois & M.J. Karcher (Eds.), Handbook of youth mentoring, (pp. 30-43). Thousand Oaks, CA: Sage.

Ruth M. Ripley, Tom A. B. Snijders, Zsofia Boda, Andras Voros, and Paulina Preciado (2018). Manual for Siena version 4.0. R package version 1.2-12. <https://www.cran.r-project.org/web/packages/RSiena/>.

Scott, J. (1988). Social network analysis. *Sociology*, *22*(1), 109-127.

Serrat, O. (2017). Social network analysis. In *Knowledge solutions* (pp. 39-43). Springer, Singapore.

Snijders, T. A. (2005). Models for longitudinal network data. *Models and methods in social network analysis*, *1*, 215-247.

Terry, R. (2000). Recent advances in measurement theory and the use of sociometric techniques. *New directions for child and adolescent development*, *2000*(88), 27-53.

Valente, T. W. (2003). Social network influences on adolescent substance use: An introduction. *Connections*, *25*(2), 11-16.

Valente, T. W. (2010). *Social networks and health: Models, methods, and applications*. Oxford University Press.

Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications* (Vol. 8). Cambridge university press.