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Reciprocity, transitivity, and the mysterious three-cycle

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ABSTRACT

Reciprocity and transitivity are the two most important structural mechanisms underlying friendship network evolution. While on their own they are understood in great detail, the relation between them is rarely studied systematically. Are friendships outside of social groups more or less likely to be reciprocated than friendships embedded in a group? Using a theoretical framework that focusses on the situations in which friends interact and the social structures that stabilise one-sided friendships, I propose that the tendency towards reciprocation of friendships within transitive groups is usually lower than outside of transitive groups. In a meta-analysis of two datasets including 29 friendship networks using stochastic actor-oriented models (SAOMs), the interaction between reciprocity and transitivity is analysed. Supporting the theoretical reasoning, the interaction is consistently negative. Second, the tendency against forming three-cycles in friendship networks, which was consistently found in previous studies, is shown to be spurious and a result of neglecting to control for the tendency against reciprocation in transitive groups. The tendency against three-cycles is commonly seen as an indicator that unreciprocated friendships indicate local hierarchy differences between individuals; this proposition has to be re-evaluated in light of the findings of this study. Future studies that analyse the evolution of friendship networks should consider modelling reciprocation in transitive triplets and potentially omit modelling three-cycles.

1. Introduction

Interpersonal friendships are an important part of many people's lives and have been researched by social scientists for more than a century (Heidler et al., 2014). What constitutes a friendship in academic research? Although friendship is not a well defined concept (Fischer, 1982; van de Bunt et al., 1999), the majority of friendship definitions have two aspects in common. First, friends tend to voluntarily spend time together in social situations. This is put forward for example by Fischer (1982), who finds in an inductive study that "[friendship] ties tended primarily to be relations of sociability, ones in which people visited, went out together, discussed shared pastimes, participated in some organization together, and so on." (p. 306). Carley and Krackhardt (1996) refer to friendship as an interaction-based relationship. In "Friendship as a social process", Lazarsfeld and Merton (1954) propose that friendship develops and is maintained through voluntary and rewarding contact with another individual. Evidently, having a forum for interaction is a condition for friendship.

Second, and this might seem fairly obvious, the interactions are rewarding, i.e., people like spending time with their friends; and more generally, people like their friends. Thus, friendship has two dimensions – interaction and evaluating these interactions positively. Naturally, these two are highly interdependent. For people to evaluate interaction positively, it has to take place; and people seek to interact with others they like. While this distinction might seem trivial and obvious, it is very relevant. Most theories that explain the evolution of friendships and the emergence of particular patterns focus on either one of these processes – what makes people likely to interact? and what makes people likely to evaluate interactions and people positively? This article, which treats the interrelation between two prominent friendship evolution mechanisms, will focus on both of these two distinct dimensions.

A substantial part of the evolution of friendships over time is driven by endogenous network mechanisms. An actual or potential friendship between two individuals is embedded within a friendship network that guides the creation of new and the maintenance of existing friendship ties. This means that the current state of a friendship network depends on its previous state, and certain changes of friendship configurations between two or more individuals are more likely than others.

Paramount among the endogenous mechanisms, as suggested by a long tradition of network research, are the mutuality of friendships and that friends tend to form groups (Rivera et al., 2010). Indeed, statistical modelling of friendship dynamics shows that the two most important endogenous, or relational, network

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mechanisms are reciprocity and clustering (Snijders et al., 2010; Veenstra et al., 2013). Degree dynamics, which play an important role in other types of social networks, such as sexual contacts (Liljeros et al., 2001) or citation networks reflecting the "Matthew effect" (Merton, 1968), are less important in friendship networks, as the continuing investment of time and resources in friendships inhibits actors from acquiring a very high degree (Rivera et al., 2010). Hence, this article focuses on reciprocity and clustering in friendship networks.

1.1. Reciprocity

In the context of friendship, reciprocity means responding to other peoples friendly gestures in kind (Schaefer et al., 2010). In network terms, reciprocation describes the increased likelihood of individuals to send ties to those from whom they receive a tie. This dyadic relational mechanism is intuitively plausible and, for strong friendship ties, often understood as implicit in the definition of friendship (Newcomb, 1956). Some research defines friendship ties *a priori* as mutual (e.g. Krackhardt, 1992) and, therefore, models friendships as undirected. In statistical analysis of friendship digraphs, reciprocation is often the most powerful predictor of the existence of a tie.

A common explanation underlying reciprocation in friendships is based on Social Exchange Theory (Emerson, 1976; Rusbult and Buunk, 1993). It suggests that people invest in those they perceive as friends and expect rewards from these investments. Both costs and returns can take the form of time committed, emotional support, advice, presents, and so on. In case individuals find the balance between costs and returns unsatisfying or they have a better alternative, the friendship may be broken. From this perspective, friendship needs mutuality in investment to be evaluated positively and one can see why friendships tend to be reciprocated. However, based on Social Exchange Theory, it is not strictly necessary that friendships are reciprocated. Rather the balance of given and received friendly behaviour needs to be satisfying for an individual. This is of course more likely if both parties involved in a friendship perceive the other as a friend. However, a one-sided friendship can also be stable if the sole nominator does not feel an imbalance between giving and taking in the relationship.

Other intuitions behind reciprocity propose that similarity breeds connection (called homophily, Lazarsfeld and Merton, 1954). As similarity is a characteristic of a pair of individuals, it breeds connection in both directions. Similarity can include any type of measurable and latent attributes and attitudes. Further, Homans (1950) states that time spent together makes people more likely to become friends. Time spent together is symmetric between two individuals, therefore leads to reciprocated friendships.

1.2. Clustering

The other persistent relational network mechanism underlying friendship dynamics is clustering. Clustering describes the tendency of people to form ties within social groups, where one's friends are connected to each other, too. This means that indirect connections between individuals – i.e., two unconnected actors that are tied to the same third party, or that are connected by a two-path – tend to become direct connections over time. In directed friendship networks, closure is generally represented by a transitive triplet (see Snijders et al., 2010). A transitive triplet between the three actors *i*, *j* and *h*, is defined as a tie being present from *i* to *j*, from *j* to *h*, and a tie being present from *i* to *h* (Fig. 1a). There are many theoretical rationales that explain clustering/transitive closure in friendship networks.

One of the first approaches was given by Simmel (1950). He suggested that joint membership in a group leads to clustering in social networks. Further, if two people have a common acquaintance, they are more likely to meet and get to know each other (e.g. Granovetter, 1973). In other words, time constraints in individuals' social contacts lead to clustering in a network. Both of these very similar explanations propose that having a common friend makes it more likely that people meet and spend time together and thus become friends. These explanations therefore operate on an increased likelihood to interact between people with common friends.

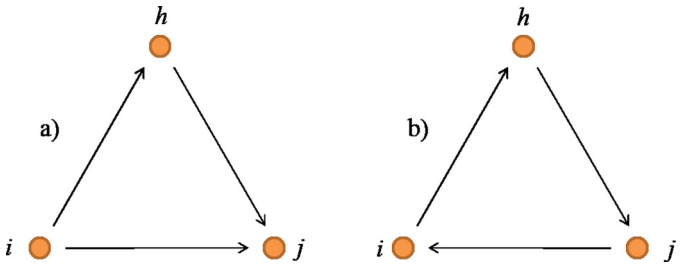

Fig. 1. (a) Transitive triplet and (b) three-cycle.

Complementary to this, Balance Theory (Heider, 1946; Newcomb, 1961) proposes that people tend to evaluate the friends of their friends more positively. It suggests that people seek balanced relationships in their lives and a triad is only balanced if the number of positive ties is odd. Therefore, open triads tend to either close, or loose a positive tie. In other words, if my friend likes somebody I do not like, I will feel psychological discomfort and either change my opinion about the friend-of-friend in a positive way or break my relation to the friend.

Further mechanisms that lead to clustering are that an indirect connection can ease access to information about the potential interaction partner, reducing the potentially involved risk of engaging in interaction (Granovetter, 1985) and homophily of a group of people leading to network closure (Goodreau et al., 2009, e.g.).

1.3. The mysterious three-cycle

Since the increasing popularity of stochastic actor-oriented models (SAOMs), another triadic configuration that guides network evolution has received growing attention, and is by now among the frequently used relational mechanisms modelled in analyses of friendship networks using SAOMs: the three-cycle. In a triad of actors *i*, *j*, and *h*, it describes the configuration where a tie from *i* to *j*, a tie from *j* to *h*, and a tie from *h* to *i* is present (Fig. 1b). This configuration is similar to the transitive triplet, except that the direction of the tie from *i* to *h* is reversed. With surprising consistency, it has been found in many analyses of friendship networks that the effect that models whether actors choose to be in such a cyclic configuration is negative and both, highly significant and of substantial size (in recent studies for example Cheadle et al., 2013; Ellwardt et al., 2012; Giletta et al., 2012; Preciado et al., 2012; Snijders et al., 2010; Steglich et al., 2012; van Workum et al., 2013; Veenstra et al., 2013).

The canonical explanation for the negative three-cycle effect in friendship networks refers to a theoretical model proposed by Davis and Leinhardt (1970), and its further elaboration (Davis, 1970). This model states that the directionality of an unreciprocated tie indicates a hierarchy difference, where the recipient of a tie occupies a higher position than the sender. Presence of a cyclic network configuration indicates a cyclic hierarchy, which is very unlikely as hierarchy is generally transitive. Following this model, the tendency against three-cycles in friendship networks is commonly interpreted as an indication of the presence of local hierarchies in friendship networks. This implies that the observed preference