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Food sharing networks in lowland Nicaragua: An application of the social relations model to count data

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ABSTRACT

Previous research on food sharing in small-scale societies provides support for multiple evolutionary hypotheses, but evolutionary anthropologists have devoted relatively little attention to the broader relational context of inter-household transfers of food. The present research observes transfers of meat over a yearlong period among 25 households of indigenous Mayangna and Miskito horticulturalists in Nicaragua. To analyze these data, we extend the multilevel formulation of the social relations model to count data, namely the number of portions of meat exchanged between households. Along with other covariates, we examine the effect of an "association index," which reflects the amount of time that households interact with one another. The association index exhibits a positive effect on sharing, and our overall results indicate that food sharing networks largely correspond to kin-based networks of social interaction, suggesting that food sharing is embedded in broader social relationships between households. We discuss possible extensions of our methodological approach, as appropriate for research on food sharing and social network analysis more broadly.

1. Introduction

Compared to other animals, humans have a unique propensity for sharing food, which anthropologists have related to other traits that distinguish humans from other apes (Isaac, 1978; Gurven et al., 2012; Wood and Marlowe, 2013). Food sharing has therefore attracted considerable attention from evolutionary anthropologists (Gurven, 2004; Jaeggi and Gurven, 2013). There are multiple hypotheses to explain transfers of food between households, and a common approach is to develop multivariate statistical models that simultaneously test the evidence for these alternative hypotheses (Ziker and Schnegg, 2005; Allen-Arave et al., 2008; Nolin, 2010). Generally, however, these analyses explore only the role of covariates for which there is an unambiguous evolutionary hypothesis. Yet, evolutionary anthropologists are increasingly acknowledging the multifaceted complexities of familial and inter-household relationships and the need for studies that encompass variables other than kinship, differences in production, and reciprocal food exchange (e.g., Gurven and Hill, 2010).

In the current study, we observe transfers of meat over a yearlong period among 25 households in a community of indigenous Mayangna and Miskito horticulturalists in Nicaragua. The data are dyadic and have a "round-robin design" whereby each household interacts with every other household in the community and where we observe the number of transfers given in each direction within each household dyad. We analyze these data using the social relations model (SRM) developed by Kenny and colleagues to separate individual effects from relationship effects in relational or dyadic data (Kenny, 1994). The SRM decomposes the variance in a dyadic outcome into separate giving-, receiving- and relationship-variance components, and allows for correlation in giving and receiving behaviors as well as for correlation of responses within a dyad. The SRM variance and covariance/correlation parameters are typically estimated by formulating the model as either a structural equation model or a multilevel model. Applied to our data, the SRM estimates the relative importance of households in their role as givers, households in their role as receivers, and unique relationship effects themselves as sources of variation in the number of portions of meat exchanged between households. In addition, the SRM estimates "generalized reciprocity", the degree to which households in general reciprocate transfers, and "dyadic reciprocity", the degree to which transfers are, on average, reciprocated within a dyad. Accessible introductions to the SRM and other models for dyadic data analysis are provided by Kashy and Donnellan (2012), Kenny and Kashy (2010), and Kenny et al. (2006). van Duijn and Huisman (2011) provide an accessible review and comparison of

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the SRM to other statistical models for network data, including the Quadratic Assignment Procedure (QAP) and the p_1 and p_2 models. The SRM has been widely applied in social and behavioral research, especially in psychology (Back and Kenny, 2010). While evolutionary anthropologists have recently begun to implement multilevel modeling approaches for the analysis of network data (Allen-Arave et al., 2008; Hooper, 2011; Macfarlan et al., 2012; see also Gomes et al., 2009), we are not aware of any prior applications of the SRM to anthropological data from small-scale societies.

In this paper, we make two contributions, one substantive, the other methodological. First, we analyze inter-household meat sharing among indigenous Nicaraguan horticulturalists as a function of multiple predictor variables, including an "association index," which provides a measure of the amount of time that households are spending together and perhaps engaging in mutually beneficial activities. As a related objective, we assess how the generalized and dyadic reciprocity correlations and the observed variance in the data structure are explained by the covariates. Second, we extend the multilevel modeling formulation of the SRM to accommodate the count data nature of our response variable, and we describe how to fit this model using Bayesian methods as implemented in the free WinBUGS software (Lunn et al., 2000). Standard applications of the SRM are confined to the analysis of continuous responses, and so this extension represents a valuable approach for researchers with dyadic count data, whether on food sharing or other outcomes.

The remainder of the paper is structured as follows. Section 2 discuses theories and predictors of food sharing. Section 3 presents the multilevel modeling formulation of the SRM for count data. Sections 4 and 5 introduce the data and describe the analysis. Sections 6 and 7 present and discuss the results. Section 8 concludes.

2. Theories and predictors of food sharing

2.1. Evolutionary models and predictions

Among humans, but also other animals, food sharing and cooperation more broadly may reflect *kin selection* (the evolutionary strategy of favoring the reproductive success of one's relatives, even at the expense of one's own survival and reproduction). This evolutionary model extends conventional understandings of natural selection to consider the effects of an individual's behavior on the evolutionary fitness (cumulative reproductive success) of their kin (Hamilton, 1964). In other words, even though relinquishing food is costly, the evolutionary benefits of sharing with relatives at the allelic level can be recouped via the reproductive success of genetically similar recipients. Hamilton's Rule (Hamilton, 1964) indicates that kin selection can occur when $b \times r > c$, where b is the fitness benefit to the receiver, c is the cost to the giver, and r is Wright's coefficient of genetic relatedness (Wright, 1922), or the likelihood of sharing alleles by common descent. Assuming that benefits and costs are held constant, Hamilton's Rule predicts greater altruism and cooperation among close genetic kin, such as the parents, offspring, and full siblings of the giver, than among more distantly related kin or unrelated individuals.

Natural selection can also favor transfers of food between unrelated individuals, particularly if partners enter reciprocal relationships in which they alternately exchange food (Trivers, 1971). Considering the unpredictability with which human foragers successfully acquire fish and game, reciprocal sharing of meat can reduce the day-to-day variability of available meat for such partners (Winterhalder, 1986). A positive correlation between the bidirectional flows within a dyad, generally known as "contingency," provides empirical support for the evolutionary model of *reciprocal altruism* (Gurven, 2004). Owing to the costs of unreciprocated transfers, humans may possess evolved psychological mechanisms that facilitate the detection of cheaters and "free-riders" (Cosmides et al., 2010).

Especially for foods that cannot be stored for long periods of time, such as meat in tropical settings, resources exhibit diminishing marginal valuation (Winterhalder, 1996). Whereas the first portion of a harvest may provide essential nutrients, the value of additional consumption declines as needs are met and physiological constraints prevent individuals from obtaining further nutritional benefits. Such differences in the marginal valuation of portions can promote kin selection and reciprocal altruism, as sated individuals donate remaining portions to kin or reliable partners. Possessors of food might also relinquish portions to "scroungers" if the cost of defending the resource exceeds the expected marginal value of retaining it. This evolutionary model, known as *tolerated scrounging*, predicts transfers according to differences in need with little expectation of subsequent benefits for the original possessor. Notably, the opportunity to sell portions of meat may attenuate the diminishing value of large resources and reduce the prevalence of tolerated scrounging (Gurven, 2004).

Another evolutionary model, *costly signaling theory*, suggests that possessors of food share widely in order to convey information about their traits, including their generosity or their ability to obtain (and waste) resources (Bliege Bird and Smith, 2005). This information benefits observers, who can subsequently choose the best available mates and allies, which in turn benefits the original signalers. Although the evolutionary logic of costly signaling theory is generally accepted, empirical tests remain challenging because of the need to satisfy multiple conditions of the theory while ruling out alternative hypotheses (Smith and Bliege Bird, 2000).

2.2. Association indices as a predictor of food sharing

Evolutionary anthropologists recognize that food can be "traded" for other fitness-enhancing currencies, such as childcare, political support, reproductive opportunities, help with agricultural labor, or other needed goods and services (Winterhalder, 1996; Gurven, 2004; Patton, 2005; Nolin, 2012). Within cooperative groups, including households as well as broader groupings, the trading of foods for other currencies may promote specialization that promotes group-level efficiency by allocating tasks to the most productive individuals (Gurven, 2004). Such considerations rarely receive formal attention, however, primarily owing to the challenge of determining the relative costs and benefits of each currency (Winterhalder, 1996).

In addition to scenarios where trades between households are implicit, individuals in small-scale societies cooperate in multiple, beneficial ways. For example, women may forage together, exchanging their insights about the locations of food and boosting overall productivity while also providing emergency assistance and defending each other from external threats (Marlowe, 2010). Within the community, people share tools, build houses together, teach each other skills, jointly care for livestock, and treat others' illnesses. In some cases, such favors entail specific expectations of repayment (i.e., trade), but among close associates, these interactions largely reflect a broader commitment to ongoing relationships in which there is no clear record of debts and credits.

The analysis in this paper hinges on the idea that these multifaceted inter-household relationships provide the social context in which food sharing occurs. Furthermore, we assert that the strength of such relationships is reflected by the amount of time that households spend in each other's company. Time spent together, as measured by an *association index* (Cairns and Schwager, 1987), is not necessarily a causal variable itself. Instead, because cooperation between individuals and households frequently requires direct interaction, the association index serves as a proxy for the multifaceted interdependencies that characterize those relationships.