



The coevolution of beliefs and networks



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ABSTRACT

Social psychologists have shown that people experience cognitive dissonance when two or more of their cognitions diverge, and that they actively manage the dissonance. With this in mind, we develop a model of social learning in networks to understand the coevolution of beliefs and networks. We focus on beliefs concerning an objective phenomenon. Initial beliefs are based on noisy, private and unbiased information. Because the information is noisy, initial beliefs differ, creating dissonance. In our model, behavior is motivated by a desire to minimize this dissonance. In many circumstances this behavior adversely affects the efficiency of social learning, such that in equilibrium the mean aggregate belief is biased and there is significant variation of beliefs across the population. The parameterizations of our model that result in the most inefficient learning produce a fractionalized network structure in which there are a number of distinct groups: within any group all beliefs are identical; beliefs differ from group to group, sometimes greatly; there is no intergroup interaction. Since dissonance minimizing behavior is apparently a deeply rooted feature of humans, we are led to ask: What policies could improve the situation? Our results suggest that policies that improve the availability of objective information and/or increase the size of networks enhance efficiency of social learning. On the other hand, anything that makes changing networks more attractive as a dissonance minimizing strategy has the opposite effect.

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1. Introduction

Two facts motivate this paper: beliefs regarding many objective issues vary significantly over individuals in the same society; within personal networks the beliefs on such issues tend to be similar, often identical.¹ These two facts suggest that beliefs are to a significant degree socially constructed as opposed to being based solely on objective information.² It

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¹ This phenomena is commonly referred to as *homophily*, which Lazarsfeld et al. (1954) define as the tendency of individuals and their associates to have similar beliefs, ethnicity, age, religion, party affiliation, education, occupation, etc. McPherson et al. (2001) provide an insightful review of this literature. For a more recent and exhaustive review on homophily, see Chapter 4 in Easley and Kleinberg (2010).

² The controversy over Barack Obama's place of birth illustrates both phenomena. A July 2010 CNN poll found that while forty two percent of respondents were certain that he was born in the US, more than a quarter had doubts about his birth country and more than a tenth were certain that he was born outside the US. Further, among Democrats surveyed only 15 percent thought it was possible Obama was born outside the US, compared to over 40 percent of the Republicans. Since friends of Democrats tend to be Democrats and those of Republicans to be Republicans, this data supports the second phenomena. Berelson et al. (1954) were the first to document homophily with respect to party affiliation in the US.

is also the case that the composition of personal networks is determined in part by beliefs. If the beliefs of people in one's current network are quite different from one's own beliefs, and if divergent beliefs create friction (or cognitive dissonance) in personal relationships, then one way of dealing with the friction (or decreasing the dissonance) is to develop a new network composed of people with beliefs similar to one's own. Consistent with these observations, our model is one in which beliefs and personal networks coevolve.

Kandel (1978) was the first to carefully document coevolution of this sort. Using longitudinal data on adolescent friendships from five New York State high schools during the 1971–1972 academic year, she assessed the roles of socialization and friend selection on specific behaviors and attitudes. Of roughly 1000 friendship pairs identified at the beginning of the school year, two-thirds remained at the end of the year. These friendship pairs tended to be those in which initial behaviors and attitudes were initially similar, and further they became more similar over the year. The friendship pairs that dissolved by the end of the year tended to be those in which initial behaviors and attitudes were dissimilar. As well, the initial behaviors and attitudes of people in newly formed friendship pairs tended to be similar and they became more similar over the course of the year.

It is our view that cognitive dissonance and efforts to manage it are the keys to understanding the social forces that drive the coevolution of beliefs and personal networks. Carsey and Layman (2006) provide a nice illustration of how this process works. In an American context, they ask whether one's party affiliation determines one's preferences on issues, or whether one's preferences determine one's party affiliation. Using the 1992, 1994, and 1996 National Election Surveys, they construct a panel of voters and track their party affiliation, their attitudes on issues, including the relative importance of different issues to the voter, and their awareness of party differences on issues. They discover that when there is no significant difference between the individual's attitude and the position of her current party on issues of major importance to the individual, the individual tends to adopt the position of her party on most issues. However, when there are significant differences on issues of major importance, the individual tends to change party affiliation by choosing to affiliate with the party whose positions on the important issues most closely reflect the individual's own attitudes.

This nicely illustrates dissonance minimizing behavior. The divergences of one's own attitudes on active issues from those of one's current party create uncomfortable cognitive dissonance. The individual can reduce that dissonance either by changing her own attitudes to conform with the positions of her current party, or by changing her party affiliation. Individuals choose the latter when there are significant differences with respect to the issues of major importance to the individual, and the former when there are no such differences.

Our objective is to develop a deeper understanding of the interplay between objective information and dissonance minimizing behaviors in the dynamic formation, or coevolution, of beliefs and personal networks.³ We develop a model of network structure and beliefs of individuals on an objective issue. Initial beliefs are determined by noisy, private information and initial networks are randomly determined. In each period, there is a conversation concerning beliefs in which utterances are chosen to minimize dissonance. Subsequently, people adjust their beliefs and networks in light of the utterances of their associates, and again the objective is dissonance minimization. This process is repeated until beliefs and networks converge. In the resulting equilibrium, there are clusters of people with identical beliefs and the network connections of all people in any cluster are exclusively with other people in the same cluster, so in equilibrium, beliefs are perfectly homophilous. Across clusters, beliefs may vary, sometimes greatly. A large number of interesting questions can be articulated in the model. We use simulation techniques to explore these questions because the model is intractable using standard techniques.

In our model, behavior is motivated by a desire to minimize cognitive dissonance. In this, we are following the lead of Festinger (1957). Elliot and Devine (1994) introduce their experimental paper confirming this approach in the following way: "As presented in his classic monograph, Festinger (1957), cognitive dissonance theory is fundamentally motivational in nature. Festinger posited that the perception of an inconsistency among an individual's cognitions generates a negative interpersonal state (dissonance), which motivates the individual to seek and implement a strategy to alleviate this aversive state." Further, the experiments reported in Elliot and Devine (1994) provide support for the sequential structure in our model. First they create dissonance in their subjects by giving them an opportunity to advance the policy discussion concerning a proposed tuition increase. Subjects can choose to write an essay outlining the pros or the cons of the proposal, but they are informed that what is really needed is an essay in support of the proposal because the reasons for opposing it have already been thoroughly surveyed. This creates dissonance because in prior screening subjects have revealed that they strongly oppose any increase in tuition. Hence, they can advance the policy discussion only by voluntarily choosing to write an essay in support of a position they strongly oppose. Subjects manage this dissonance by actually writing an essay in support of the proposal. This act, of course, creates more dissonance since they have now expressed an opinion they do not hold. Subsequently, when given a chance to revise their position on the tuition issue, they manage this dissonance by changing their position.

The foundational model for social learning in networks is a model of what has come to be known as *naïve learning* developed in DeGroot (1974).⁴ The naïve learning model employs an iterative process of belief updating, or social learning,

³ Akerlof and Dickens (1982) and Rabin (1994) incorporate cognitive dissonance into rational choice models and show how it can lead people to underestimate the likelihood of a bad outcome happening to them, and how it can lead people to consume too much of an immoral good, respectively. Neither of these papers investigate how cognitive dissonance influences social learning and/or networks of people, the focus of this paper.

⁴ See, for example, Golub and Jackson (2010), DeMarzo et al. (2003), Acemoglu et al. (2010), Acemoglu et al. (2010) and Bala and Goyal (1998).

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