

# Interdependent Sampling and Social Influence

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Most explanations of social influence focus on why individuals might want to agree with the opinions or attitudes of others. The authors propose a different explanation that assumes the attitudes of others influence only the activities and objects individuals are exposed to. For example, individuals are likely to be exposed to activities that their friends enjoy. The authors demonstrate that such influence over sampling behavior is sufficient to produce a social influence effect when individuals form attitudes by learning from experience. Even if the experiences of 2 individuals, when they sample an object or event, are independent random variables, their attitudes will become positively correlated if their sampling processes are interdependent. Interdependent sampling of activities thus provides a different explanation of social influence with distinct empirical and theoretical implications.

*Keywords:* social influence, conformity, attitude formation, learning, sampling

Why do the attitudes or opinions of individuals depend on the attitudes or opinions of socially proximate others? Researchers have explained such social influence effects by assuming that individuals are motivated to agree with others because they want to get along with them, because they identify with them, or because they believe their opinions are accurate (Cialdini & Goldstein, 2004; Deutsch & Gerard, 1955; Festinger, Schachter, & Back, 1950; Hogg & Turner, 1987; Turner, 1991; Wood, 2000).

These theories focus on why an individual would change his or her attitude when becoming aware of the attitudes of others. The assumption that the attitudes of others have such a direct effect is perhaps the most natural explanation of social influence effects. A focus on direct effects, however, neglects the many indirect ways in which the attitudes of others will influence an individual (Forgas & Williams, 2001). The attitudes of others do not only provide information and signal appropriate norms. Unless an individual ignores the desires of others, the attitudes of socially proximate others will also influence his or her behavior. In particular, the attitudes of others often influence the activities and objects an individual gets exposed to. If a person's friends all enjoy a restaurant, that person may join them there even if he or she does not believe the food is any good.

In this article, we show that such influence over behavior can provide a simple alternative explanation of social influence. Even if

the attitude of Individual B influences only whether and when A gets exposed to an activity, A's attitude toward the activity will become correlated with B's attitude. Surprisingly, this occurs even if the extents to which A and B will enjoy the activity, if they engage in it, are independent random variables. To illustrate this, we develop a simple stochastic model of attitude formation by two individuals. The model assumes that an individual's attitude to a restaurant or a tenants' organization (cf. Festinger et al., 1950) depends only on his or her own experiences with the restaurant or the organization. The experiences of the two individuals, if they choose to go to the restaurant or attend a meeting of the organization, are assumed to be independent random variables. For example, the individuals may have different tastes. On the basis of his or her attitude, each individual has to decide, in every period, whether to sample the restaurant or organization again. We assume that the sampling processes of the two individuals are interdependent: The decision to go to the restaurant again or to the next meeting depends on the attitudes of both individuals. Even though the two individuals have independent experiences, when they do sample, we show that their attitudes will become positively correlated.

The model of interdependent sampling provides a vivid illustration of how an individual's attitude may be influenced by the attitudes of others even when the attitudes of others influence only the activities and objects the individual gets exposed to. In the model, the attitude of Individual B has only an indirect influence on the attitude of A, which operates through changes in the probability that A will sample an activity or object. The model thus offers a different theoretical perspective on why, how, and when social influence occurs. In line with recent work on sampling in impression formation (Denrell, 2005; Fiedler, 1996, 2000; Fiedler & Juslin, 2006), this perspective emphasizes how influences on sampling behavior, rather than influences on cognitive or perceptual processes, can explain social influence effects.

Such an alternative perspective does not necessarily challenge the significance of existing explanations, for which much experimental support exists (L. Anderson & Holt, 1997; Asch, 1955; J. L. Davis & Rusbult, 2001; Deutsch & Gerard, 1955; Pool, Wood, & Leck, 1998; Schachter, 1951; Wood, 2000; Wood, Pool, Leck, & Purvis, 1996). Rather, it suggests a complementary explanation of

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We are grateful for discussion with and comments from Bill Barnett, Jon Bendor, Carter Butts, Jerry Davis, Peter DeMarzo, Henrich Greve, Mike Hannan, Chip Heath, Henning Hillman, Stefan Jonsson, Jim March, Dale Miller, Mark Mizruchi, Jeffrey Pfeffer, Jeffrey Zwiebel, and participants in seminars at University of Chicago; Northwestern University; Stanford University; the Academy of Management Annual Meeting, Honolulu, August 2005; the American Sociological Association Annual Meeting, Philadelphia, August 2005; and the Annual Meeting of the Society for Mathematical Psychology, Vancouver, British Columbia, Canada, July 2006. All errors are our own.

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social influence effects that is likely to be important in many realistic social settings where the activities individuals are exposed to are influenced by the attitudes of socially proximate others. Because the model relies on a different mechanism, it also predicts a different pattern of influence, with distinct empirical implications. In particular, the model suggests that social influence is asymmetric: Individual A is more influenced by B if the attitude of A is negative than if the attitude of A is positive. We show how this prediction can be used to distinguish our model from other models on the basis of panel data on attitudes, and we illustrate that the asymmetric pattern predicted by our model is present in Newcomb's (1961) longitudinal data on students' attitudes toward each other.

The model also provides a simple explanation for findings in field studies that individuals are most likely to be influenced by attractive and powerful others. In the model, this prediction follows from the more basic assumption that individuals are more likely to join the activities suggested by attractive and powerful others (Cialdini & Trost, 1998). Because the model relies on a mechanism that is distinct from existing theories, it also suggests that social influence can occur even in situations in which existing theories are not applicable. If B influences the activities A will sample, it is not necessary that A identifies with B, that A wants to comply with B, or that A regards the opinions of B as informative for social influence to occur.

To develop our argument, we first review existing explanations for social influence and introduce the idea of interdependent sampling. We then outline the formal model of interdependent sampling, illustrate how it generates a social influence effect, explain the underlying mechanism, and compare it to existing theories. In the following section, we discuss and test the asymmetry in social influence predicted by the model. Next, we outline how the model can account for existing findings on the effect of moderating variables, such as power and attraction, on social influence. Finally, we discuss the assumptions of the model and how sensitive the results are to those assumptions.

### Existing Explanations of Social Influence

Social influence is usually conceptualized as a causal relation between the attitudes of others and the attitudes of a given individual (March, 1955; Martin & Hewstone, 2003). Individual B influences A if an exogenous change in the attitude of B changes the attitude of A. Whereas some scholars have used the term *social influence* to also cover phenomena such as obedience and compliance with the requests of others (e.g. Cialdini & Goldstein, 2004), here we focus on how an individual's attitude is influenced by the attitudes of others.

Numerous studies in the social sciences have examined such social influence empirically. Cross-sectional field studies have shown that socially proximate individuals tend to have similar attitudes and opinions. The attitudes of students are similar to other students they live with (Bourgeois & Bowen, 2001; Bowen & Bourgeois, 2001; Crandall, 1988), the political opinions of individuals are similar to those of socially proximate others (Campbell, 1980; Huckfeldt & Sprague, 1991, 1995), and the perceptions and attitudes of individuals in formal organizations are similar to those they interact with (Friedkin, 1984; Ibarra & Andrews, 1993; Lazer, 2001; Meyer, 1994; Pfeffer, 1980; Pollock, Whitbread, & Con-

tractor, 2000; Rice & Aydin, 1991). Of course, similar attitudes can also be due to a shared environment or selection of similar others. Nevertheless, social influence effects emerge even after controlling, statistically, for shared environments and selection (Duncan, Haller, & Portes, 1968; Jussim & Osgood, 1989; Price & Vandenberg, 1980).

Longitudinal studies have also shown that the behaviors and opinions of individuals are likely to change in the direction of the modal opinions or behaviors of those in their peer groups (Cohn, Yee, & Brown, 1961; Ennett & Bauman, 1994; Jussim & Osgood, 1989; Kandel, 1978). Natural experiments provide more direct evidence for social influence. Sacerdote (2001) found that academic achievement was influenced by having a roommate (randomly assigned) with an academic orientation, and the decision to join a fraternity or sorority was influenced by having a roommate who later did join a fraternity or sorority. Festinger et al. (1950), using college students who were essentially randomly assigned to buildings, found greater similarities in attitudes within buildings. There is of course also a large experimental literature demonstrating the possibility of social influence (for reviews, see Allen, 1965, and Hogg & Abrams, 1988).

Explanations of social influence have focused on motives for why individuals would agree with others. Three motives have received the most emphasis (Chaiken, Giner-Sorolla, & Chen, 1996; Cialdini & Goldstein, 2004; Cialdini & Trost, 1998; Wood, 2000). First, individuals may be motivated to develop an accurate perception of reality. If others have access to more, different, or more accurate information, it may thus be sensible to adopt or be influenced by their opinions (L. Anderson & Holt, 1997; Banerjee, 1993; Bikhchandani, Hirshleifer, & Welch, 1992; Deutsch & Gerard, 1955). Second, individuals may be motivated to ensure satisfactory relationships with and get along with others. If expressing deviant opinions may lead to social sanctions or exclusion, individuals may thus feel compelled to express opinions in line with the majority (Asch, 1955; Festinger, 1957; Festinger et al., 1950; Katz & Lazarsfeld, 1955; Kelman, 1958; Kuran, 1998; Schachter, 1951). Third, individuals may be motivated to ensure a favorable evaluation of the self. To do so, individuals may shift their attitudes to align them with that of valued reference groups (Hogg & Abrams, 1988; Hogg & Turner, 1987; Pool et al., 1998; Turner, 1991; Wood, 2000; Wood et al., 1996).

Much of this theoretical work has focused on explaining why an individual, A, might change his or her attitude when becoming aware of the attitude held by another individual, B. The focus on such direct interpersonal influence stems, in part, from the experimental design used in many social influence studies. In a typical experiment, researchers manipulate whether and what participants are told about the attitudes or beliefs of others and examine whether and how participants subsequently change their own attitudes or beliefs (e.g. Asch, 1955; Deutsch & Gerard, 1955; Wood et al., 1996). To explain the outcomes of such studies, researchers naturally focus on the motives for why an individual would take into account the attitudes of others when formulating his or her own attitude.

Research in this tradition has uncovered many important insights into when and why social influence effects occur. Nevertheless, the theoretical focus and experimental design of studies of this kind tend to underplay indirect ways in which the attitudes of others influence the attitudes of an individual (Forgas & Williams,

2001). An interesting but little explored type of such indirect social influence is how the attitudes of others can influence the activities and objects an individual is exposed to.

### Indirect Influence Through Interdependent Sampling

Consider an individual forming an attitude about an object, such as a restaurant. The individual may be aware of the attitudes of others. In addition, the individual may have personal experiences with the object—that is, he or she may have attended the restaurant. Both of these sources of information will influence the attitude of the individual (Eagley & Chaiken, 1993; Fishbein & Ajzen, 1975). Existing research on social influence has mainly focused on how information about the attitudes of others has a direct influence on the attitude of the individual. But the attitudes of others can also have an indirect effect, by influencing the activities, objects, and events the individual is exposed to and thus the experiences that the individual has access to.

The idea that the attitudes of others can influence the behavior of an individual, and thus the set of activities and objects an individual experiences, is not new but is central to social psychology. Much behavior occurs in social interactions with others. In such social interactions, the behaviors, attitudes, and personalities of others are often important determinants of the world an individual experiences (Snyder & Ickes, 1985, p. 925). For example, an individual with several friends who enjoy classical music will experience an environment that is quite different from an individual whose friends enjoy disco music (Snyder, 1981). Learning about the world, information collection, and hypothesis testing are also often social activities and occur in social interactions with others (Higgins, 2000; Stasser & Titus, 1985, 1987). Individuals involved in ongoing social interactions do not sample information, activities, and objects independently of each other. Rather, the sampling decisions of such individuals are often interdependent.

There are several reasons for such interdependent sampling. Perhaps most important, people engage in ongoing social relationships in part to affiliate with others and to spend time together (Baumeister & Leary, 1995; Buss, 1986; Cialdini & Goldstein, 2004). People go to movies and sports events, attend political meetings, and discuss personal and political events together with others. Unless one individual dictates decisions about activities, this implies that decisions have to be made jointly. To get along with others, individuals have to attend to the attitudes of others and adapt their behavior accordingly (Chen, Shechter, & Chaiken, 1996; Snyder, 1992). Thus, family members or friends often have to reach consensus about the choice of activities, movies, restaurants, and other consumption decisions. As illustrated in research on consumption decisions within families, the preferences of all members often influence the final decision (Arora & Allenby, 1999; H. L. Davis, 1976; Wind, 1976). For example, one couple described the decision process they use to select the TV shows they watch as follows: “We both pick three shows a week. If they’re on at the same time, we flip a coin. Beyond those three favorites, we just take turns.” (“Compromise, and Pass the Remote,” 2005, December 15, p. 1E).

Social relationships often also involve reciprocity (Cialdini & Goldstein, 2004; Gouldner, 1960): Individuals may engage in activities that they are not especially interested in, if their friends or partners are interested, with the expectation that their friends or

partners will return the favor. For example, individuals may occasionally go to restaurants they are not especially interested in, if their friends really want to go there. Similarly, in their study of attitudes toward a tenants’ organization at a housing project at the Massachusetts Institute of Technology, Festinger et al. (1950) noted that one student went to the meetings of the organization “only because he was a close friend of the chairman” (p. 66). In social relationships characterized by such reciprocity, individuals will engage in activities they might have avoided if left to themselves.

Even if individuals do not engage in activities together, the attitude of others can still influence the information individuals have access to. Individuals often hear about events and activities that socially proximate others enjoy. For example, partners in a couple will often get to know the occupations and hobbies of their partners and are likely to get into contact with the friends of their partners (Kalmijn, 2003; Milardo, 1982). Similarly, members of an academic department get exposed to the research that other individuals in their departments enjoy and executives get exposed to the practices and strategies that other firms in their industries find useful. Discussions with friends and colleagues also provide individuals with additional information about activities or objects, which may influence their attitudes (e.g., Burnstein & Vinokur, 1975, 1977). The novel information that emerges in such discussions tends to conform to initial preferences (Dennis, 1996; Stasser & Titus, 1985, 1987), and individuals’ sampling of information is therefore contingent on others’ attitudes toward the issues being discussed.

Finally, in several social settings the attitudes of one individual may have an important influence on the sampling decisions of several others. Individuals with high formal or informal status in groups or organizations, such as managers or gang leaders, can often dictate or strongly influence the events, information, and activities that other members will attend to (Whyte, 1943). As a result, the sampling processes of individuals with low status will depend on the attitudes of individuals with high status.

Although interdependencies in sampling only influence whether and when Individual A will get exposed to an activity or an object, this can have systematic consequences for the development of A’s attitude. Left to his or her own, A might not sample activities or objects A has a negative attitude toward. As a result, A’s attitude will remain negative (Denrell, 2005, 2007; Fazio, Eiser, & Shook, 2004). If A’s friends or family have a positive attitude, A may be exposed to the activity or object again and might change his or her attitude. This might not have happened if A’s friends or family also had a negative attitude.

### A Model of Experiential Learning With Interdependent Sampling

To illustrate the implications of interdependent sampling, we develop a model in which two individuals form attitudes about an event on the basis of experiences with the event (Eagley & Chaiken, 1993; Fazio et al., 2004; Fishbein & Ajzen, 1975). We assume that only direct personal experiences influence attitudes (Fazio et al., 2004; Fazio & Zanna, 1981). Thus, information about the attitudes or experiences of others does not influence an individual’s attitude in our model. We also assume that the experiences of the individuals are independent random variables. This implies that their attitudes do not converge simply because their experi-

ences are similar. We make these assumptions to illustrate that interdependent sampling is sufficient to generate a social influence effect.

Figure 1 illustrates the structure of the basic model. The individuals decide independently, in each period, whether they want to sample the event or activity in the next period. We assume that the attitudes of the individuals influence this decision. Specifically, we assume that an individual with a positive attitude toward the attitude object is more likely to want to sample it again (Denrell, 2005; Fazio et al., 2004). We also assume, however, that the final sampling decision takes into account the desires of both individuals. If the individuals sample the event or activity again, their new experiences may change their attitudes (Fishbein & Ajzen, 1975), and thus their future desire to sample the event or activity.

*Assumptions of the Basic Model*

To develop a formal model of interdependent sampling, we need to specify the assumptions made about (a) experiences, (b) attitude formation, (c) how individual desires to take another sample are influenced by the current attitude, and (d) how the decision about sampling in the next period is determined.

*Experiences.* Whenever an individual samples the event, his or her experience can be positive or negative. Because the attractions of attending the event are likely to vary from occasion to occasion, the experience of Individual A in period  $t$ , denoted  $x_{A,t}$ , is modeled as a random variable. Specifically we assume that  $x_{A,t}, x_{A,t+1}, \dots$  are independent normally distributed random variables with a mean of 0 and a variance of 1. A positive value of  $x_{A,t}$  corresponds to an experience that was enjoyable to A, and a negative value of  $x_{A,t}$  corresponds to an experience that was not enjoyable to A. Because individuals may have different tastes, their experiences are not necessarily identical, even if they attend the same event in period  $t$ . One individual may enjoy himself or herself while the other does not. Thus, the correlation between the experiences of the two individuals in period  $t$ ,  $x_{A,t}$  and  $x_{B,t}$ , may be less than 1. Initially, we assume that the correlation between the experiences of the two individuals is zero, so that their experiences are independent random variables. As we show below, the basic result also holds if the correlation is positive or even negative. It also holds for distributions other than the normal distribution.

*Attitude formation.* We assume that an individual's attitude is based on his or her personal experiences with the attitude object.

On the basis of evaluations of past experiences, individuals learn to associate positive or negative consequences with the attitude object (Eiser, Fazio, Stafford, & Prescott, 2003; Fazio, 1990; Fishbein & Ajzen, 1975; Van Overwalle & Siebler, 2005). Whether an individual's attitude is positive or negative thus depends on whether his or her experiences with the attitude object have been mainly positive or negative (Fazio et al., 2004; Fishbein & Ajzen, 1975).

We model this process of attitude formation by assuming that individuals adjust their current attitudes on the basis of evaluations of new experiences (Fishbein & Ajzen, 1975; Van Overwalle & Siebler, 2005). Specifically, following models of information integration (N. H. Anderson, 1981; Busemeyer & Myung, 1992; Hogarth & Einhorn, 1992; Kashima & Kerekes, 1994), we assume that the revised attitude of Individual A is a weighted average of A's current attitude and A's new experience, if any. If the attitude of Individual A in period  $t$  is denoted  $\hat{x}_{A,t}$ , and the new experience is denoted  $x_{A,t+1}$ , the new attitude,  $\hat{x}_{A,t+1}$ , is equal to  $(1 - b)\hat{x}_{A,t} + bx_{A,t+1}$ , if A samples in period  $t + 1$ . If A does not sample in period  $t + 1$ , his or her attitude remains equal to  $\hat{x}_{A,t}$ . Here  $b$  is a positive fraction regulating the weight of the most recent experience. The attitude in the first period is assumed to be  $b\hat{x}_{A,1}$ .

This model implies that A's attitude is an exponentially weighted average of all of his or her experiences. Although such a weighted average model may seem to be an unrealistic model of the psychological processes underlying attitude formation (e.g., Fiske, 1982), it can in fact be derived from more realistic connectionist network models (Busemeyer & Myung, 1992; Kashima & Kerekes, 1994; Van Overwalle & Siebler, 2005). The weighted average model can thus provide a compact representation of the result of more complex processes underlying attitude formation. Because the model tries to describe only how attitudes change and not the psychological mechanisms underlying attitude change, it is compatible with both deliberate and implicit processes of attitude formation (Van Overwalle & Siebler, 2005).

As illustrated in Denrell (2005), the weighted average model provides a reasonable approximation to the dynamics of belief updating in several experimental studies. The weighted average model is also consistent with a recency effect, in which late experiences are given more weight than early experiences. A recency effect has been found in numerous experiments on information integration and belief formation (Denrell, 2005; Hogarth & Einhorn, 1992; Kashima &

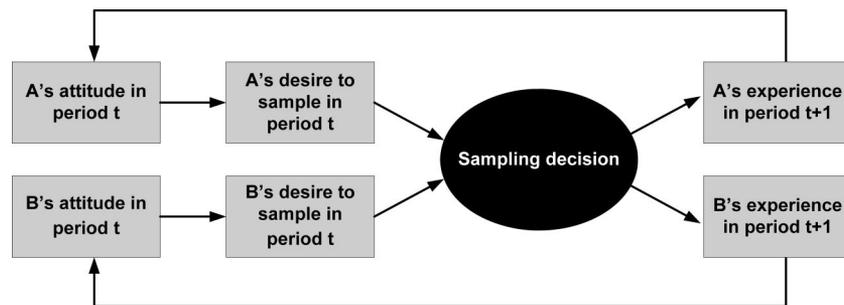


Figure 1. The structure of the model. In each period, individuals update their attitudes on the basis of their new experiences, if any. The desire to sample depends on the current attitude. The decision whether to sample in the next period is based on the desires of both individuals.

Kerekes, 1994). A limitation of the weighted average model is the assumption that the weight of the most recent experience ( $b$ ) is constant and independent of the current attitude and the valence of the new experience, which does not always hold (Hogarth & Einhorn, 1992; Skowronski & Carlston, 1989; Stangor & McMillan, 1992; Van Overwalle & Labiouse, 2004). As shown in Appendix C, the basic results also hold for models of attitude formation in which the weight of the most recent experience changes over time. Simulations show that the basic results also hold if the weight of the most recent experience ( $b$ ) varies with the valence of the experience (e.g., the value of  $b$  may be larger for negative experiences; Skowronski & Carlston, 1989).

*Individual desires to sample.* In every period, each individual has to decide whether he or she wants to sample the event. Sampling here refers to attending the event, or more generally choosing the attitude object, and thus experiencing its consequences. We assume that the attitude of the individual influences the sampling decision. The underlying idea is that individuals are likely to approach objects, individuals, and events associated with rewarding consequences and avoid objects and events associated with aversive consequences (Eiser et al., 2003; Erev & Barron, 2005; Fazio et al., 2004; Peeters, 1971; Peeters & Czapinski, 1990; Sugrue, Corrado, & Newsome, 2005; Thorndike, 1911). In situations in which an individual forms an attitude about how rewarding an activity is to him or her, this implies that individuals with positive attitudes should be more willing to sample than individuals with negative attitudes are.

To reflect this, we assume that the probability that Individual A wants to sample is an increasing function of the attitude of A. A simple model of such a choice process is the exponential version of the Luce choice model (Luce, 1959). In this model, the probability that Individual A wants to attend the event in period  $t + 1$  is

$$P(\hat{x}_{A,t}) = \frac{1}{1 + e^{-S\hat{x}_{A,t}}} \quad (1)$$

Here,  $S$  is a parameter regulating how sensitive the choice probability is to the value of the estimate. If  $S$  is large, the probability of sampling will be highly sensitive to the value of the attitude: An individual is very likely to attend if the attitude is positive but very likely not to attend if the attitude is negative. It is also assumed that each individual attends the event in the first period:  $P(\hat{x}_{A,1}) = 1$ .<sup>1</sup>

This exponential version of the Luce choice model is commonly used for modeling choices in reinforcement learning (e.g., Erev & Barron, 2005; Sutton & Barto, 1998). It also fits well to data on repeated choices between uncertain alternatives (Busemeyer & Stout, 2002; Daw, O’Doherty, Dayan, Seymour, & Dolan, 2006; Yechiam & Busemeyer, 2005). Because of this, we use the exponential choice model to illustrate the consequences of interdependent sampling. However, the basic result holds for many other choice models. As we demonstrate in Appendix B, it is sufficient to assume that  $P(\hat{x}_{A,t})$  is an increasing function of  $\hat{x}_{A,t}$ . Moreover, as illustrated in Appendix C, the basic result also holds if the probability of sampling changes with experience, which would happen if individuals were more willing to sample the event initially, when they have less precise information about it.

These three assumptions define a model in which individuals learn independently from independent experiences. Such a model does not generate a social influence effect. Rather, the attitudes of

the two individuals will remain independent. To generate a social influence effect, however, we need to add a fourth assumption:

*Joint decision about sampling in period  $t$ .* Whether A and B decide to sample in period  $t$  depends on the desires of both A and B in period  $t$ . Specifically, even if A does not desire to sample in period  $t$ , he or she may nevertheless do so if B wants to sample in period  $t$ . To illustrate the implications of such an assumption of interdependent sampling, we initially assume that they both sample whenever one of them wants to. As we demonstrate later, the basic results also hold for many other assumptions about interdependent sampling.

This assumption of interdependent sampling implies that the probability that Individual A will sample will be an increasing function of B’s attitude. Specifically, the probability that A (and thus also B) will sample in period  $t + 1$ ,  $Q(\hat{x}_{A,t}, \hat{x}_{B,t})$ , can be written as

$$Q(\hat{x}_{A,t}, \hat{x}_{B,t}) = \underbrace{P(\hat{x}_{B,t})}_{\text{B wants to sample}} + \underbrace{[1 - P(\hat{x}_{B,t})]P(\hat{x}_{A,t})}_{\text{B does not want to sample but A wants to}} \quad (2)$$

The probability that A will sample is a weighted average of  $P(\hat{x}_{A,t})$  and 1, where the weight on 1 is  $P(\hat{x}_{B,t})$ , the probability that B wants to sample. Inserting the expressions for  $P(\hat{x}_{A,t})$  and  $P(\hat{x}_{B,t})$  we get

$$Q(\hat{x}_{A,t}, \hat{x}_{B,t}) = \frac{1}{1 + e^{-S\hat{x}_{A,t}}} + \left( \frac{e^{-S\hat{x}_{B,t}}}{1 + e^{-S\hat{x}_{B,t}}} \right) \frac{1}{1 + e^{-S\hat{x}_{A,t}}} \quad (3)$$

Figure 2 shows a plot of this function. As illustrated, the probability that Individual A will sample is an increasing function of the attitude of A ( $\partial Q[\hat{x}_{A,t}, \hat{x}_{B,t}]/\partial \hat{x}_{A,t} > 0$ ) but also of the attitude of B ( $\partial Q[\hat{x}_{A,t}, \hat{x}_{B,t}]/\partial \hat{x}_{B,t} > 0$ ). The probability that Individual A will sample is also less sensitive to the attitude of B whenever the attitude of A is high ( $\partial^2 Q[\hat{x}_{A,t}, \hat{x}_{B,t}]/[\partial \hat{x}_{A,t} \partial \hat{x}_{B,t}] < 0$ ). The intuition is that whenever the attitude of A is high, A is likely to want to sample anyway and whether B wants to sample will not change the outcome much. In contrast, if the attitude of A is negative, the probability that A will sample depends crucially on the attitude of B.

*Interdependent Sampling Is Sufficient to Generate a Social Influence Effect*

Figure 3 shows the development over time of the (Pearson) correlation between the attitudes of Individuals A and B (the correlation between  $\hat{X}_{A,t}$  and  $\hat{X}_{B,t}$ ) when their experiences are independent random variables (the correlation between  $X_{A,t}$  and  $X_{B,t}$  is zero). The correlation between the attitudes of Individuals A and B starts from zero but reaches .34 after 50 periods (on the basis of 100,000 simulations, where  $S = 4$  and  $b = 0.5$ ). The two individuals thus develop similar attitudes: A is more likely to have a positive attitude if B has a positive attitude than if B has a negative attitude. In this example, the conditional probability that Individual A has a positive attitude, given that Individual B has a positive attitude,  $P(\hat{x}_{A,50} > 0 | \hat{x}_{B,50} > 0)$ , is .47 (on the basis of 10,000 simulations). The conditional probability that Individual A

<sup>1</sup> Assuming that the initial probability of sampling is lower than 1 does not change the basic result.

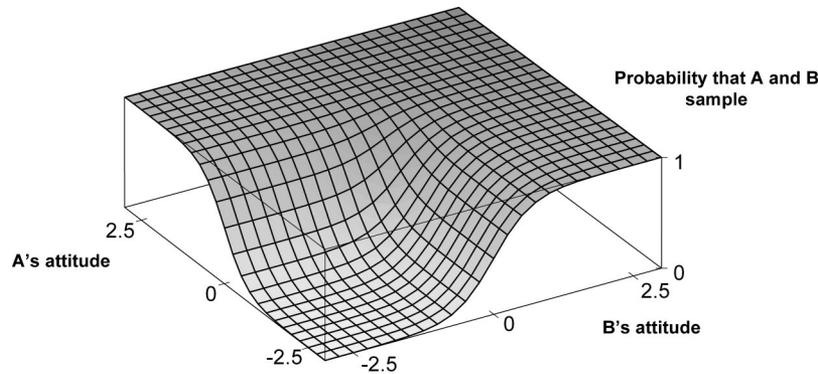


Figure 2. Probability that both A and B will sample, as a function of the attitudes of A and B, based on Equation 3, where  $S = 3$ .

has a positive attitude, given that Individual B has a negative attitude,  $P(\hat{x}_{A,50} > 0 | \hat{x}_{B,50} < 0)$ , is only .22. Thus, A is more than twice as likely to have a positive attitude if B also has a positive attitude.

The attitudes of A and B are also correlated over time. For example, the correlation between  $\hat{x}_{B,45}$  and  $\hat{x}_{A,50}$  is .27 (on the basis of 100,000 simulations). The influence of  $\hat{x}_{B,45}$  remains if we control for the attitude of A in Period 45. To illustrate this, we estimate the following regression  $\hat{x}_{A,50} = \alpha + \beta_A \hat{x}_{A,45} + \beta_B \hat{x}_{B,45} + \epsilon$ , by ordinary least squares (OLS), using simulated data from 5,000 pairs of individuals following the basic model (where  $S = 4$  and  $b = 0.5$ ). The result is  $\hat{x}_{A,50} = -0.153 + 0.350\hat{x}_{A,45} + 0.164\hat{x}_{B,45}$ , where all coefficients are significant at a  $p$  value below .001. As this regression shows, both the attitude of A and the attitude of B in Period 45 influence the attitude of A in Period 50. To demonstrate that B's attitude has a causal influence on the attitude of A, we perform the following experiment: In Period 45, we change the value of  $\hat{x}_{B,45}$  to +1 or -1. Simulations show that the probability that  $\hat{x}_{A,50}$  is positive is .39 if  $\hat{x}_{B,45}$  is set to +1, whereas it is only .23 if  $\hat{x}_{B,45}$  is set to -1.<sup>2</sup>

These illustrations are based on simulations, but it is possible to solve the model analytically. As  $t \rightarrow \infty$ , the joint distribution of  $\hat{x}_{A,t}$  and  $\hat{x}_{B,t}$  converges to a stationary joint distribution, which is derived in Appendix A. Figure 4 shows a graph of this asymptotic joint density, for the case in which  $S = 4$  and  $b = 0.5$ . As illustrated, the attitudes of A and B tend to cluster together close to the diagonal, which implies that they are positively correlated. In this case, the correlation is .42 (obtained by numerical integration of the asymptotic density). Although it is less clear from this figure, both attitudes tend to be negative: The average attitude is -0.36. The reason is that negative attitudes are more stable because sampling is less likely if the attitudes of A and B are both negative (Denrell, 2005, 2007).

So far, we have assumed that both individuals sample whenever at least one individual wants to. The basic result also holds for other assumptions. Suppose, for example, that both sample if both want to. But if only one of them wants to, they both sample with probability  $k$ . For any positive value of  $k$ , the correlation is positive. Alternatively, suppose that the probability that they sample is a weighted average of the individual probabilities:  $wP(\hat{x}_{A,t}) + (1 - w)P(\hat{x}_{B,t})$ . This rule also leads to a positive correlation. For example, if  $w = 0.5$ , the correlation is

.23 after 50 periods (when  $S = 4$  and  $b = 0.5$ ). A positive correlation also emerges even if it is not assumed that both individuals always sample together. Suppose, for example, that A always samples when he or she wants to. However, A only samples with probability  $r$  whenever he or she does not want to but B wants to sample. Whenever  $r > 0$ , the correlation will be positive. For example, if  $r = 0.5$ , the correlation is .30 after 50 periods (when  $S = 4$  and  $b = 0.5$ ). Finally, a positive correlation would also emerge if the two individuals took turns deciding whether to sample.

#### Why Social Influence Emerges Through Interdependent Sampling

Social influence emerges, in the model of interdependent sampling, because the attitudes of others may lead an individual to sample events and objects this individual has a negative attitude toward. As emphasized by Denrell and March (2001), Denrell (2005, 2007), Fazio et al. (2004), and March (1996), negative attitudes are unlikely to be corrected in learning from outcome feedback. If individuals believe that the outcome from choosing an activity will be negative, they are less likely to choose it and thus less likely to correct any false negative beliefs. By contrast, because individuals are likely to choose activities they believe will result in positive experiences, false positive beliefs are more likely to be corrected. Overall, this implies that false negative beliefs are more stable than false positive beliefs (Denrell, 2005, 2007; Eiser et al., 2003). This was illustrated in a recent experiment on attitude formation (Fazio et al., 2004). Participants in that experiment engaged in a survival game, in which they had to learn to distinguish between beans with positive and negative "energy value." Participants could learn about the energy value of beans with different shapes only by choosing to "eat" them. Because they avoided beans believed to have negative energy values, participants were more likely to underestimate than overestimate the value of beans at the end of the game.

Because the negativity bias is the result of the tendency to sample activities with positive expected outcomes, increasing the

<sup>2</sup> This finding is based on 100,000 simulations.

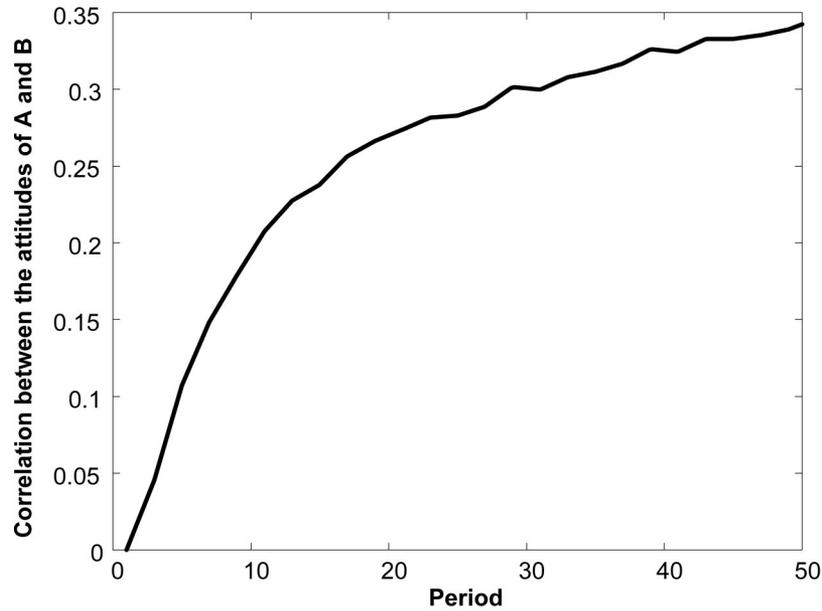


Figure 3. The development over time of the (Pearson) correlation between the attitudes of individuals A and B, based on 100,000 simulations of the basic model, where  $S = 4$  and  $b = 0.5$ .

probability of sampling activities with negative expected outcomes will increase the probability of a positive evaluation (Denrell, 2005, 2007; Denrell & March, 2001). For example, in the experiment on attitude formation by Fazio et al. (2004), manipulations that increased the probability that participants would approach beans increased the probability of positive attitudes. This suggests that mechanisms that increase the probability of sampling, particularly when estimates are negative, will increase the probability of positive evaluations.

Social interdependency in sampling is such a mechanism. If sampling decisions are interdependent, A may sometimes be forced to sample even if his or her own evaluation is negative. In addition, social interdependencies in sampling imply that the

probability of sampling by Individual A will be contingent on whether B's attitude is positive or negative. Individual A is more likely to take another sample when B's attitude is positive. As a result, a negative attitude by A is more likely to be revised and thus more likely to become positive, if B's attitude is positive. In contrast, a negative attitude by A is less likely to be revised and thus less likely to become positive, if B's attitude is negative.

To explain this in more detail, we consider the case with an asymmetric influence in sampling. The sampling process of A depends on B's attitude, whereas the sampling process of B is independent of A's attitude. Thus, A samples whenever B decides to sample but B ignores A in deciding whether to sample.

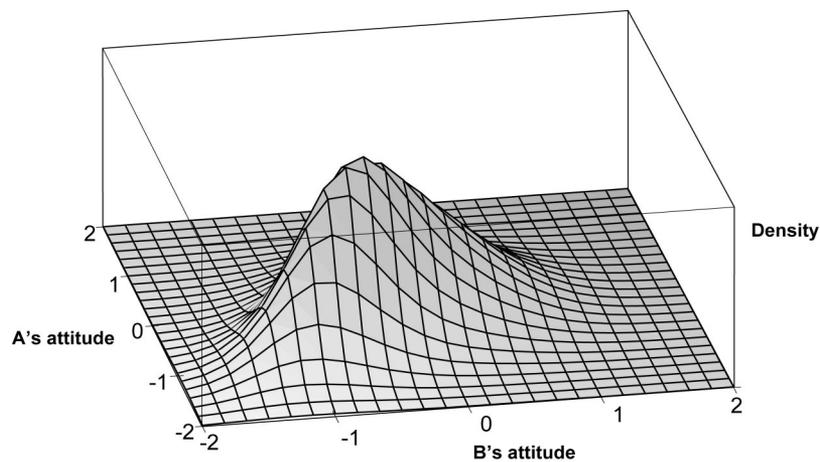


Figure 4. The asymptotic joint density of the attitudes of individuals A and B, based on numerical integration of Equation A5 in Appendix A. This example assumes that  $S = 4$  and  $b = 0.5$ .

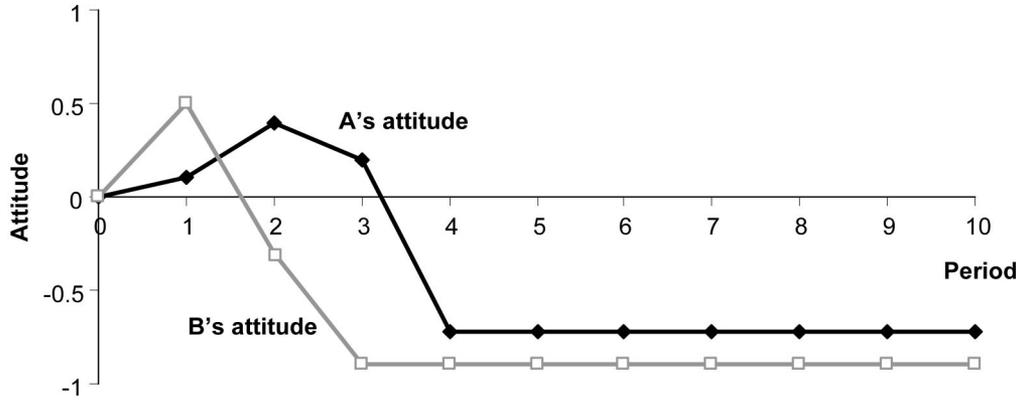


Figure 5. One example of the development of the attitudes of A and B.

Figure 5 illustrates one possible development over time of the attitudes of A and B. In Figure 5, B’s attitude quickly becomes negative. As a result, B is unlikely to sample and update his or her attitude. Because B’s attitude is negative, A will sample only if his or her attitude is sufficiently positive. As illustrated in Figure 5, A’s attitude also becomes negative in the fourth period. Because both A and B have negative attitudes, A is unlikely to take another sample. This implies that his or her attitude will not be updated but will remain negative. In summary, if B’s attitude is negative, A’s attitude will remain negative. Moreover, the more negative B’s attitude is, the higher the probability that A’s attitude will remain negative.

Figure 6 shows a different development over time of the attitudes of A and B. As above, we assume that A’s attitude becomes negative in the fourth period. In contrast to the trajectory depicted in the previous figure, B’s attitude remains positive. The positive attitude of B implies that A will still continue to sample. This implies that A’s negative attitude will likely be revised upward (because of regression to the mean). In summary, if B’s attitude is positive, A is more likely to change from a negative attitude to a more positive attitude. Moreover, the more positive B’s attitude is, the higher the probability that A’s attitude will change and become more positive.

So far, we have examined only the case in which the attitude of A was negative. What about the case in which A’s attitude is positive? One might imagine that in this case the result would be the opposite. If B has a positive attitude, A is more likely to sample and thus to change his or her attitude. A positive attitude by B would thus seem to reduce the probability that A’s attitude will remain positive. Although correct, this does not mean that the two different tendencies cancel out in the aggregate. The reason is that A’s sampling process is less influenced by B’s attitude whenever the attitude of A is positive ( $\frac{\partial^2 Q[\hat{x}_{A,t}, \hat{x}_{B,t}]}{\partial \hat{x}_{A,t} \partial \hat{x}_{B,t}} < 0$ , see Equation 3). As a result, the dominating tendency, and the reason for the above results, is the process explained above.

Whereas the above illustrations relied on a number of specific assumptions, it can be demonstrated formally that the basic result holds for a more general class of assumptions (see Appendix B for details): Experiences do not have to be normally distributed, the weight of the most recent observation does not have to be constant, the choice rule does not have to be the exponential choice rule but

can be any increasing function of the attitude. Finally, both individuals do not have to sample when one of them wants to. Rather, if  $Q(\hat{x}_{A,t}, \hat{x}_{B,t})$  is the probability that A and B will sample in period  $t + 1$ , it is sufficient to assume that

$$\frac{Q(\hat{x}_{A,t}, \hat{x}_{B,t}^*)}{Q(\hat{x}_{A,t}, \hat{x}_{B,t})} > \frac{Q(\hat{x}_{A,t}^*, \hat{x}_{B,t}^*)}{Q(\hat{x}_{A,t}^*, \hat{x}_{B,t})}, \tag{4}$$

whenever  $\hat{x}_{A,t}^* > \hat{x}_{A,t}$  and  $\hat{x}_{B,t}^* > \hat{x}_{B,t}$ .<sup>3</sup> This requirement is a generalization of the condition, discussed above, that the probability that both will sample is more sensitive to the attitude of B when the attitude of A is low than when it is high.<sup>4</sup> As demonstrated in Appendix B, this condition is satisfied for a wide range of assumptions about sampling and the final decision. It holds whenever both sample if one of them wants to, that is, when  $Q(\hat{x}_{A,t}, \hat{x}_{B,t}) = P(\hat{x}_{A,t}) + P(\hat{x}_{B,t}) - P(\hat{x}_{A,t})P(\hat{x}_{B,t})$  and  $P(\cdot)$  is strictly increasing. It holds if they both sample with probability 1 if both of them want to but only sample with probability  $k \in (0, 1]$  if only one of them wants to. It is also satisfied if the probability that both will sample is some weighted average of the individual probabilities:  $Q(\hat{x}_{A,t}, \hat{x}_{B,t}) = wP(\hat{x}_{A,t}) + (1 - w)P(\hat{x}_{B,t})$ , where  $P(\cdot)$  is strictly increasing.<sup>5</sup>

For all processes satisfying the assumptions of Appendix B, the correlation between the attitudes of Individuals A and B will be positive (as  $t \rightarrow \infty$ ), as formalized in Theorem 1 below.

*Theorem 1:* Let  $Y_A$  and  $Y_B$  denote the attitudes of A and B as  $t \rightarrow \infty$ . Then, under Assumptions 1–4 in Appendix B, we have  $\text{Corr}(Y_A, Y_B) > 0$ .

<sup>3</sup> If  $Q(\cdot)$  is twice continuously differentiable, this condition is equivalent to  $\frac{\partial^2}{\partial \hat{x}_{A,t} \partial \hat{x}_{B,t}} \ln[Q(\hat{x}_{A,t}, \hat{x}_{B,t})] < 0$ . This inequality holds whenever  $\frac{\partial^2}{\partial \hat{x}_{A,t} \partial \hat{x}_{B,t}} Q(\hat{x}_{A,t}, \hat{x}_{B,t}) < 0$ , as was the case in the basic model.

<sup>4</sup> That is, the above condition holds whenever  $\frac{\partial^2}{\partial \hat{x}_{A,t} \partial \hat{x}_{B,t}} Q(\hat{x}_{A,t}, \hat{x}_{B,t}) < 0$ , but also for other functions.

<sup>5</sup> It also holds if  $u = w\hat{x}_{A,t} + (1 - w)\hat{x}_{B,t}$  and  $Q(\hat{x}_{A,t}, \hat{x}_{B,t}) = R(u)$ , where  $R(\cdot)$  is the logistic function ( $1/[1 + \text{Exp}(-Su)]$ ), or  $R(\cdot)$  is the cumulative normal distribution function, that is, when the probability of sampling is an increasing function of a weighted average of the attitudes.

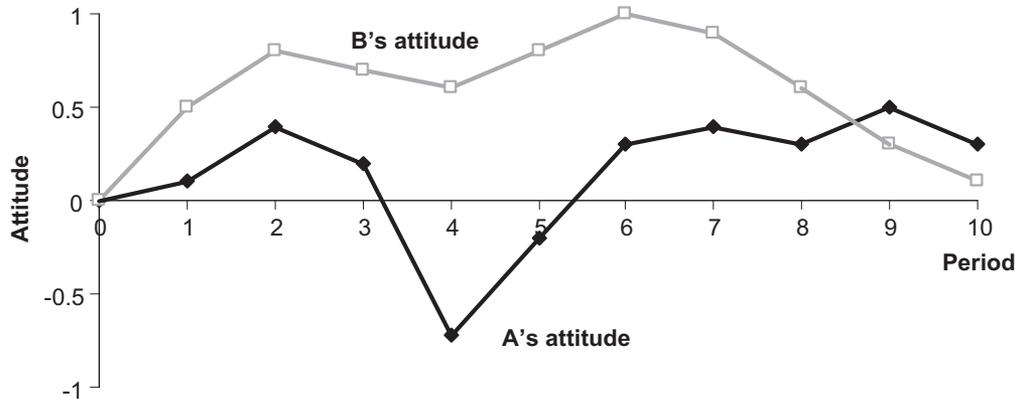


Figure 6. Another example of the development of the attitudes of A and B.

*How the Model Differs From Existing Theories*

*Direct versus indirect effects.* The model of interdependent sampling suggests a novel and alternative explanation for social influence effects. In contrast to most existing explanations of social influence, the model does not assume that a social influence effect occurs because an Individual A is motivated to agree with the attitude of another Individual B. Rather, in the model, A never changes his or her own attitude unless his or her own experiences change. The attitude of B thus cannot have a direct effect on the attitude of A. The model postulates only that the attitude of B has an impact on A's decision to sample an activity or object. Formulated differently, the model assumes only that A is motivated to engage in the activities that B enjoys. As shown, this assumption is sufficient to generate a social influence effect.<sup>6</sup>

To illustrate the distinction between this indirect source of social influence and direct sources of social influence, consider the classical study by Festinger et al. (1950) on attitudes toward a tenants' organization at a Massachusetts Institute of Technology dormitory called Westgate. The study found that individuals living in the same court were more likely to have the same attitude toward the organization, even though assignments to courts were effectively random. To explain this, they developed a theory of how individuals could be directly influenced by the attitudes of others, through processes of normative and informational influence (Festinger, 1950, 1954; Festinger et al., 1950; Schachter, 1951). It is plausible, however, that the attitudes of others also had an indirect effect, by influencing whether an individual attended additional meetings of the organization. Many of those who attended the first meeting got a very unfavorable first impression of the organization (Festinger et al., 1950, p. 63 and p. 67) because they found the meeting too formal. As a result, they avoided subsequent meetings (Festinger et al., 1950, p. 63). Subsequent meetings were more informal, however (Festinger et al., 1950, p. 63). If tenants with negative first impressions were persuaded by tenants with positive first impressions to attend again, as they sometimes were (Festinger et al., 1950, p. 66), tenants with negative first impressions might have changed their attitudes.

Although existing theories of direct influence and the model of interdependent sampling both predict a social influence effect, it is nevertheless possible in principle to distinguish between them because the model of interdependent sampling makes different

predictions about when a social influence effect occurs. According to this model, the probability that A samples the attitude object mediates the impact of the attitude of B on the attitude of A. Thus, if we control for the probability of sampling, the social influence effect generated by interdependent sampling should vanish.

To illustrate this, suppose that a researcher has access to longitudinal data on the attitudes of individuals and on whether these individuals sample an object in each period. Suppose moreover that these data are generated by the basic model of interdependent sampling (with  $S = 4$  and  $b = 0.5$ ). To check if there is a social influence effect, the researcher can estimate the following regression:  $\hat{x}_{A,50} = \alpha + \beta_A \hat{x}_{A,49} + \beta_B \hat{x}_{B,49} + \epsilon$ . The result is consistent with a social influence effect: The coefficients of both  $\hat{x}_{A,49}$  and  $\hat{x}_{B,49}$  are positive and significant (Model 1 in Table 1).

Consider, next, what happens if the same regression is estimated using only the observations in which A did sample in Period 50 (Model 2). Now only the coefficient for  $\hat{x}_{A,49}$  is significant. The same is true if only the observations in which A did not sample in Period 50 are used (Model 3). The reason is that the value of  $\hat{x}_{B,49}$  impacts only whether A samples.

To illustrate how  $\hat{x}_{B,49}$  does impact  $\hat{x}_{A,50}$  in a model using all the data, let  $I_{t+1}$  be an indicator variable that is equal to 1 if A samples in period  $t + 1$  and zero otherwise. Because

$$\hat{x}_{A,t+1} = I_{t+1}[b\hat{x}_{A,t+1} + (1 - b)\hat{x}_{A,t}] + (1 - I_{t+1})\hat{x}_{A,t} \quad (5)$$

which can be written as

$$\hat{x}_{A,t+1} = \hat{x}_{A,t} - bI_{t+1}\hat{x}_{A,t} + bI_{t+1}\hat{x}_{A,t+1}, \quad (6)$$

it follows that a correctly specified model, using all the data, is the following linear regression:  $\hat{x}_{A,50} = \alpha + \beta_1 \hat{x}_{A,49} + \beta_2 I_{50} \hat{x}_{A,49} + \epsilon$ . If  $E(X_{A,t+1}) = 0$ , then Equation 6 implies that the expected values of the coefficients in this regression are  $\alpha = 0$ ,  $\beta_1 = 1$ , and  $\beta_2 = -b$ . If  $\hat{x}_{B,49}$  were included in this correctly specified regression model, its coefficient would be zero and insignificant if there were no direct effect, as illustrated in Model 4 in Table 1. However, if there were in fact a direct effect of  $\hat{x}_{B,49}$  on  $\hat{x}_{A,50}$ , the coefficient for  $\hat{x}_{B,49}$  would be signif-

<sup>6</sup> We also do not assume that individuals adjust their attitudes to render them consistent with their behaviors (Bem, 1972; Festinger, 1957). Attitudes are only weighted averages of evaluations of past experiences.

Table 1  
Ordinary Least Square Regressions With  $\hat{x}_{A,50}$  as the Dependent Variable

Variable	Model 1 (all data)		Model 2 ( $I_{50} = 1$ )		Model 3 ( $I_{50} = 0$ )		Model 4 (all data)	
	Coeff.	<i>p</i> value	Coeff.	<i>p</i> value	Coeff.	<i>p</i> value	Coeff.	<i>p</i> value
Intercept	-0.063	.000	-0.013	.193	0.000	.432	-0.009	.135
$\hat{x}_{A,49}$	0.727	.000	0.499	.000	1.000	.000	0.986	.000
$\hat{x}_{B,49}$	0.093	.000	0.013	.426	0.000	.804	0.005	.571
$\hat{x}_{A,49}I_{50}$							-0.488	.000
$R^2$	.604		.260		1.00		.657	
<i>N</i>	5,000		2,581		2,419		5,000	

Note. This table is based on data generated by simulation of the basic model (5,000 pairs, where  $S = 4$  and  $b = 0.5$ ).

icant. These simple regressions thus provide a way of testing whether an observed social influence effect is due to interdependent sampling, if data on attitudes and whether individuals sampled are available. Although such detailed data are rarely available, we show in the next section that the different models can also be distinguished using only longitudinal data on attitudes.

*Comparison with existing formal models of social influence.* There are numerous mathematical analyses and computer simulations of models of social influence (e.g., Abelson & Bernstein, 1963; Coleman, 1964; Dodds & Watts, 2005; French, 1956; Friedkin, 1998; Harary, 1959). Perhaps most well known in psychology is the simulation of social impact theory (Nowak, Szamrej, & Latané, 1990). Our model differs in a fundamental way from most of these models. Whereas our model tries to explain why the attitudes of others can influence an individual’s attitude, most models assume that such social influence exists and examine the aggregate consequences of this assumption. For example, the dynamic model of social impact (Nowak et al., 1990) takes the existence of social influence as given and illustrates how such social influence, when operating within a population of individuals, can give rise to clusters of individuals with similar attitudes.

### Interdependent Sampling Implies Asymmetric Social Influence

The model of interdependent sampling is not only consistent with existing findings of social influence. Because it relies on a different underlying mechanism, the model also predicts a different pattern of social influence. Specifically, it suggests an asymmetry in social influence: Individual A should be more influenced by the attitude of Individual B when A has a negative attitude than when A has a positive attitude.

The key mechanism in the model is that an individual with a negative attitude might nevertheless take another sample, if others have a positive attitude. This might not happen if the attitudes of others were negative. When Individual A has a negative attitude, the probability of sampling is thus very sensitive to B’s attitude. In contrast, if A has a positive attitude, A might sample himself or herself anyway or might influence both of them to sample. In this case, the attitude of B will not matter much.

To illustrate this asymmetry, consider the basic model. Suppose that A’s attitude is quite negative,  $\hat{x}_{A,t} = -1.5$ , but that B’s attitude is positive,  $\hat{x}_{B,t} = 1$ . Because B’s attitude is positive, A’s

attitude will most likely become more positive. In this case, the expected value of A’s attitude in the next period,  $E(\hat{x}_{A,t+1} | \hat{x}_{A,t} = -1.5, \hat{x}_{B,t} = 1)$ , is  $-0.79$  (when  $S = 3$  and  $b = 0.5$ , based on Equation D2 in Appendix D). If B’s attitude is negative, however, A’s attitude will not change much. Specifically,  $E(\hat{x}_{A,t+1} | \hat{x}_{A,t} = -1.5, \hat{x}_{B,t} = -1)$  is only  $-1.46$ . Thus, when  $\hat{x}_{A,t}$  is negative, the value of  $\hat{x}_{B,t}$  has a large effect on the expected value of  $\hat{x}_{A,t+1}$ . Now suppose that A’s attitude is quite positive:  $\hat{x}_{A,t} = 1.5$ . In this case,  $E(\hat{x}_{A,t+1} | \hat{x}_{A,t} = 1.5, \hat{x}_{B,t} = -1)$  is  $0.75$ , whereas  $E(\hat{x}_{A,t+1} | \hat{x}_{A,t} = 1.5, \hat{x}_{B,t} = 1)$  is  $0.76$ . Thus, when  $\hat{x}_{A,t}$  is positive, the value of  $\hat{x}_{B,t}$  has only a small impact on  $\hat{x}_{A,t+1}$ . As Appendix D shows, this holds more generally. Specifically, suppose that  $\hat{x}_{A,t}^* > \hat{x}_{A,t}$  and  $|E(X) - \hat{x}_{A,t}| = |\hat{x}_{A,t}^* - E(X)|$ , that is,  $\hat{x}_{A,t}^*$  and  $\hat{x}_{A,t}$  are equally far away from  $E(X)$ . In this case, a change in the value of  $\hat{x}_{B,t}$  has a larger influence on the expected value of A’s attitude in period  $t + 1$  if A’s attitude in period  $t$  is low ( $\hat{x}_{A,t}$ ) rather than high ( $\hat{x}_{A,t}^*$ ). Formally, whenever  $\hat{x}_{A,t}^* > \hat{x}_{A,t}$  and  $\hat{x}_{B,t}^* > \hat{x}_{B,t}$ , then

$$|E(\hat{x}_{A,t+1} | \hat{x}_{A,t}, \hat{x}_{B,t}^*) - E(\hat{x}_{A,t+1} | \hat{x}_{A,t}, \hat{x}_{B,t})| > |E(\hat{x}_{A,t+1} | \hat{x}_{A,t}^*, \hat{x}_{B,t}^*) - E(\hat{x}_{A,t+1} | \hat{x}_{A,t}^*, \hat{x}_{B,t})|. \quad (7)$$

This asymmetry implies that if we estimate the effect of  $\hat{x}_{B,t}$  on  $\hat{x}_{A,t+1}$  separately for high and low values of  $\hat{x}_{A,t}$ , the absolute magnitude of the effect of  $\hat{x}_{B,t}$  will be larger for low values of  $\hat{x}_{A,t}$ . To illustrate this, we estimated, by OLS, the following linear regression:

$$\hat{x}_{A,50} = \alpha + \beta_A \hat{x}_{A,49} + \beta_1 \hat{x}_{B,49} I_{\hat{x}_{A,49} < 0} + \beta_2 \hat{x}_{B,49} I_{\hat{x}_{A,49} > 0} + \epsilon. \quad (8)$$

Here  $I_{\hat{x}_{A,49} < 0}$  is an indicator variable equal to 1 if  $\hat{x}_{A,49} < 0$  and zero otherwise, and  $I_{\hat{x}_{A,49} > 0}$  is defined similarly. Applied to data from a simulation of the basic model (using data on 5,000 pairs, in which  $S = 4$  and  $b = 0.5$ ) the result is

$$\hat{x}_{A,50} = -0.057 + 0.692 \hat{x}_{A,49} + 0.143 \hat{x}_{B,49} I_{\hat{x}_{A,49} < 0} - 0.041 \hat{x}_{B,49} I_{\hat{x}_{A,49} > 0} \quad (R^2 = .674). \quad (9)$$

All coefficients are significant at a *p* value below .02. As shown, the absolute magnitude of the effect of  $\hat{x}_{B,49}$  is much larger for

negative values of  $\hat{x}_{A,49}$  than for positive values.<sup>7</sup> The negative effect for positive values of  $\hat{x}_{A,49}$  occurs because when  $\hat{x}_{A,49}$  is positive, the estimate is likely to regress to the mean (zero) if A samples, and a high value of  $\hat{x}_{B,49}$  implies that sampling is more likely.

In summary, the model of interdependent sampling predicts that the influence of others on the attitude of A will be larger when the attitude of A is negative than when it is positive. Existing theories of social influence do not necessarily predict such an asymmetry. If Individual A is motivated to comply with B, B's attitude will influence A's attitude regardless of whether A's attitude is positive or negative. Similarly, if A believes that B's attitude is informative, A will be influenced by B's attitude if A's attitude is positive as well as if it is negative. Most existing formal models of social influence also assume that the impact of others' attitudes is symmetric rather than asymmetric. For example, in the social impact model (Nowak et al., 1990), the impact of the attitudes of others on A's attitude is assumed to vary with the number of individuals who hold an attitude similar or different from A, their persuasiveness, and their distance from A. However, the impact of others is not assumed to depend on whether A's attitude is negative or positive. Several other formal models assume that A's attitude is a weighted average of A's own past attitude and the attitude of others (French, 1956; Friedkin, 1998; Harary, 1959; Marsden & Friedkin, 1993). These models also imply that the influence of the attitude of others is independent of A's attitude.

The asymmetry predicted by the model of interdependent sampling implies that it is possible to distinguish the model from alternative explanations using only panel data on attitudes. Few studies have examined whether social influence is asymmetric in the predicted way, however. To provide some preliminary evidence on whether such an asymmetry exists, we reanalyzed Newcomb's (1961) longitudinal data on students' attitudes toward each other. Students in this study were recruited to live in an off-campus fraternity house supervised by Theodore Newcomb. None of the students knew each other prior to the study. During each of the first 16 weeks of the study (except for Week 9), each student was asked to assess his "favorableness of feeling" toward the other students. These measures were then translated into ranks on a scale from 1 (*most favorable*) to 16 (*least favorable*; Newcomb, 1961, pp. 32–34). On the basis of these data, it is possible to examine whether the rank a student  $i$  assigns to a student  $j$  in period  $t + 1$  depends on the rank assigned to  $j$  by other students in period  $t$ .

Because students are more likely to be influenced by students they like than by students they dislike, we focus on how students are influenced by the rank assigned by the student they like the best (i.e., the student they assigned a rank of 1).<sup>8</sup> Specifically, for each student  $i$  we examine whether the rank assigned by student  $i$  to student  $j$  in period  $t + 1$  is influenced by the rank assigned in period  $t$  to student  $j$  by the student that  $i$  liked the best in period  $t$ , denoted student  $B(i)$ . To do so, we retrieved data<sup>9</sup> on (a) the rank assigned by student  $i$  to student  $j$  in period  $t + 1$ , denoted  $R_{i,j,t+1}$ ; (b) the rank assigned by student  $i$  to student  $j$  in period  $t$ , denoted  $R_{i,j,t}$ ; and (c) the rank assigned by student  $B(i)$  to student  $j$  in period  $t$ , denoted  $R_{B(i),j,t}$ . Because there are 17 students, 15 possible assignments of  $j$  other than  $i$  and  $B(i)$ , and 14 time periods, this results in 3,570 observations.<sup>10</sup>

To examine whether the impact of  $R_{B(i),j,t}$  is asymmetric, we estimated, by OLS, the following linear regression:

$$R_{i,j,t+1} = \alpha + \beta_1 R_{i,j,t} + \beta_2 R_{B(i),j,t} I_{R_{i,j,t} < 9} + \beta_3 R_{B(i),j,t} I_{R_{i,j,t} \geq 9} + \epsilon \quad (10)$$

Here  $I_{R_{i,j,t} < 9}$  is an indicator variable equal to 1 if the rank assigned by  $i$  to  $j$ ,  $R_{i,j,t}$ , is below 9 and zero otherwise, and  $I_{R_{i,j,t} \geq 9}$  is defined similarly. The estimates are

$$R_{i,j,t+1} = 0.951 + 0.789 R_{i,j,t} + 0.093 R_{B(i),j,t} I_{R_{i,j,t} < 9} + 0.111 R_{B(i),j,t} I_{R_{i,j,t} \geq 9} \quad (R^2 = .724). \quad (11)$$

In line with the predictions of the model, the effect of the ranking assigned by student  $B(i)$  to  $j$  ( $R_{B(i),j,t}$ ) is larger when  $i$  has a relatively negative attitude toward  $j$  (the rank assigned by  $i$  to  $j$  is at or above 9) than when  $i$  has a relatively positive attitude toward  $j$  (the rank assigned by  $i$  to  $j$  is below 9). A similar pattern emerges if the effect of the ranking assigned by student  $B(i)$  to  $j$  is estimated for more than two intervals of the rank assigned by  $i$  to  $j$ . Figure 7 shows the estimated coefficients for the effect of the ranking of student  $B(i)$  ( $R_{B(i),j,t}$ ) for five different intervals of the rank assigned by  $i$  to  $j$ . The estimated coefficient is largest when the attitude of  $i$  is most negative (the rank assigned by  $i$  to  $j$  is 14, 15, or 16), and it is smallest when the attitude of  $i$  is most positive (the rank assigned by  $i$  to  $j$  is 2, 3, or 4).<sup>11</sup>

It is difficult to test whether the difference between the estimated coefficients is significant. Standard  $t$  tests show that all coefficients are significantly different from zero at a  $p$  value below .01. Moreover, when the rank assigned by  $i$  to  $j$  is 2, 3, or 4, the coefficient of  $R_{B(i),j,t}$  is significantly lower (at a  $p$  value of .05) than when the rank assigned by  $i$  to  $j$  is 14, 15, or 16. But such tests rely on the assumption of independent observations, which is violated in this context because the different ranks assigned by any given individual cannot be independent. The fact that the pattern in the estimated coefficients is consistent with the prediction of the model, however, suggests that interdependent sampling might have been important in this context. Note that such interdependent sampling is more likely to occur in later weeks, when students have developed stronger and more consistent ties with one or a few students (Doreian, Kapuscinski, Krackhardt, & Szczypula, 1996, Figure 3; Newcomb, 1961, chap. 8) who can introduce them to

<sup>7</sup> More generally, if Assumptions 1–4 in the general model in Appendix B hold, the model of interdependent sampling implies (see Appendix D)  $\frac{E(\hat{x}_{A,t+1} - \hat{x}_{A,t} | \hat{x}_{A,t}, \hat{x}_{B,t}^*)}{E(\hat{x}_{A,t+1} - \hat{x}_{A,t} | \hat{x}_{A,t}, \hat{x}_{B,t})} > \frac{E(\hat{x}_{A,t+1} - \hat{x}_{A,t}^* | \hat{x}_{A,t}^*, \hat{x}_{B,t})}{E(\hat{x}_{A,t+1} - \hat{x}_{A,t}^* | \hat{x}_{A,t}^*, \hat{x}_{B,t})}$ , whenever  $\hat{x}_{A,t}^* > \hat{x}_{A,t}$  and  $\hat{x}_{B,t}^* > \hat{x}_{B,t}$ . In addition,  $\beta_{AB}$  should be negative and significant if we estimate, by OLS, the following linear regression:  $\ln|\hat{x}_{A,50} - \hat{x}_{B,49}| = \alpha + \beta_A \hat{x}_{A,49} + \beta_B \hat{x}_{B,49} + \beta_{AB} \hat{x}_{A,49} \hat{x}_{B,49}$ .

<sup>8</sup> Similar results hold if we examine the influence of the ranking assigned to B by a random student rather than the influence of the student that A likes the best.

<sup>9</sup> The data are from the 2nd year of the study. They can be found in Nordlie (1958, Appendix A). They are also available at <http://vlado.fmf.uni-lj.si/pub/networks/data/Ucinet/UciData.htm#newfrat>.

<sup>10</sup> There are 2 weeks between the eighth and the ninth time periods because data from Week 9 are missing.

<sup>11</sup> The reason does not seem to be that the ranks assigned by  $i$  and  $B(i)$  to  $j$  differ more when the rank assigned by  $i$  is high. The correlation between the absolute difference in their ranks and the rank assigned by  $i$  is close to zero and negative (–.07).

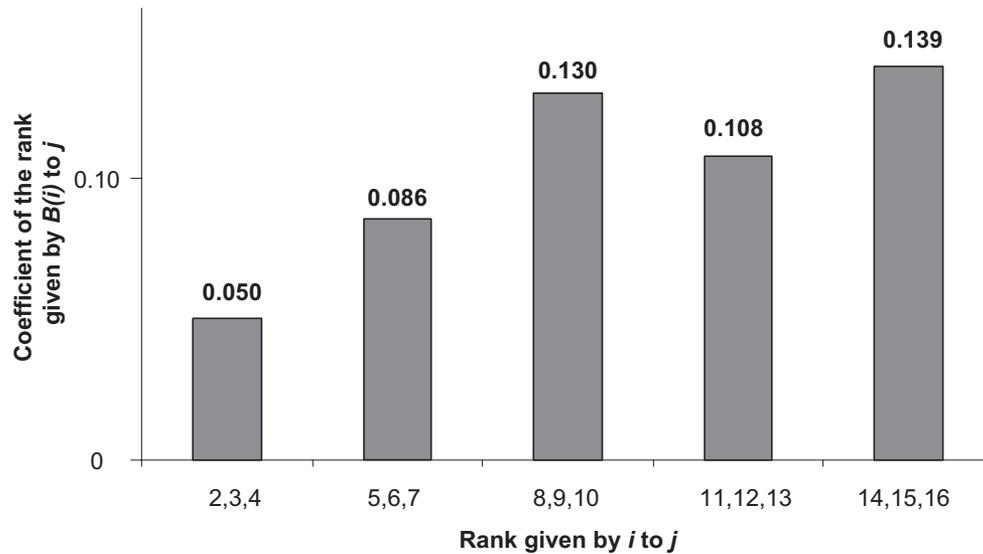


Figure 7. Estimated effect on the rank assigned by  $i$  to  $j$  in period  $t + 1$ , of the rank assigned by  $B(i)$  to  $j$  in period  $t$ , for different intervals of the rank assigned by  $i$  to  $j$  in period  $t$ . This figure is based on data from Newcomb (1961, described in Nordlie, 1958).

others. Consistent with this argument, there is a stronger asymmetric pattern in the last 7 weeks of the experiment: The coefficients for  $R_{B(i),j,t}$  for the different intervals of the rank assigned by  $i$  to  $j$  are then 0.005 (when the rank given by  $i$  to  $j$  is 2, 3, or 4), 0.052, 0.096, 0.101, and 0.130.

A recent natural experiment by Sacerdote (2001), using randomly assigned roommates at Dartmouth, also found an asymmetric effect consistent with the model. Sacerdote examined the effect of different combinations of own and roommate academic background, where the background was classified into the 25% least academic, 50% middle, and 25% most academic. He found that students with the least academic background were more influenced by their roommates than students with the most academic background were. Specifically, consistent with Equation 7, the absolute difference in the effect on own grade point average was substantially larger between combinations in which own = bottom 25% and roommate = top 25% and combinations in which own = bottom 25% and roommate = bottom 25% than between combinations in which own = top 25% and roommate = top 25% and combinations in which own = top 25% and roommate = bottom 25% (Sacerdote, 2001, Table VI). Zimmerman (2003) found a similar pattern (albeit not significant) in a study at a different college. Gruber-Baldini, Schaie, and Willis (1995) also showed that the verbal ability of married spouses grew more similar over time, but only because the verbal ability of the initially least able spouse increased over time. A possible alternative explanation of these results is that it is easier to raise than to reduce the ability or motivation of others.<sup>12</sup>

#### Reinterpretation of Existing Findings

Several field studies have found that individuals are most likely to be influenced by attractive or powerful others whom they interact with frequently (Cohn, Yee, & Brown, 1961; Festinger et al., 1950; Lott & Lott, 1965; Newcomb, 1943; Turner, 1991). The

model of interdependent sampling offers a simple alternative explanation for the influence of these and other moderating variables. It also suggests a different explanation for why attitudes toward others often are reciprocal and transitive (Holland & Leinhardt, 1970; D. A. Kenny & La Voie, 1982; Doreian et al., 1996).

#### Attraction and Power

Why are individuals more influenced by attractive individuals and individuals they are dependent on? One possibility is that individuals are more likely to publicly comply with the opinions of such people. Alternatively, the opinions of such people may be regarded as more informative. If individuals identify with people they are attracted to, they may also be more likely to adopt their attitudes. In contrast to these explanations, the model of interdependent sampling suggests that individuals may be influenced by attractive and powerful others because individuals are more likely to join the activities suggested by such people.

Suppose you are attending a conference in a city you know well and you want to dine with a colleague. If you are dependent on or fond of this colleague, you may want to join him or her even if you do not believe that the restaurant he or she wants to go to is good. By attending the restaurant again, you get new information about the restaurant, which could change your attitude. This might not have happened if you were not dependent on him or her or if you did not like him or her. In this case, you might not have joined him or her unless you believed the restaurant was good.

As this example illustrates, the probability that A will sample when B wants to may vary with how dependent A is on B or how

<sup>12</sup> An asymmetry can occur whenever it is easier to influence others in one direction. For example, it is probably easier to influence others to start smoking than to stop, which explains that social influence effects are stronger for initiation than for cessation (Ennett & Bauman, 1994).

attracted A is to B. For example, in a study of a summer camp, Lippitt, Polansky, and Rosen (1952) showed that individuals were more likely to join the activities suggested by powerful and attractive individuals. Studies have also shown that individuals are more likely to comply with the requests of people they like (for a review, see Cialdini & Trost, 1998). To illustrate the implications of this, suppose that A always samples when A wants to but only samples with probability  $r$  when A does not want to but B wants to. Here  $r$  can be seen as a measure of the power or attraction of B: A is more likely to sample when B wants to when the value of  $r$  is high. Simulations show that the higher the value of  $r$ , the higher the correlation of the attitudes of A and B.

This prediction is consistent with empirical evidence showing that individuals are more likely to change their attitudes in the direction of the attitudes of powerful and attractive individuals. For example, Cohn et al. (1961) showed that the food and activity preferences of children at a summer camp changed in the direction of the preferences of the individuals they nominated as best friends. Similarly, Lott and Lott (1961) found a correlation of .57 between conformity to the norms of the group and a measure of how attractive the individual found the group. Several other field studies and experiments have also shown that individuals are more likely to conform to the opinions of powerful and attractive individuals (for reviews, see Hogg, 1992; Lott & Lott, 1965; Turner, 1991; Walster & Abrahams, 1972).

More generally, the model of interdependent sampling suggests that individual attributes such as power, expertise, and ingroup membership may be a basis of influence partly because people with such attributes can influence the sampling decisions of others. If A believes that B is an expert, A may be more likely to join the activities suggested by B. A may also be more likely to join the activities suggested by B if B belongs to his or her ingroup than if B belongs to his or her outgroup (Denrell, 2005). If so, the experiences of A, and thus his or her attitude, will be more strongly influenced by members of ingroups than by members of outgroups.

If influence of authorities or experts is, in part, due to their influence over sampling, this suggests that their influence should vary with their control over the sampling decisions of others. For example, the influence of parents on the attitudes of their children should decline when their influence on the sampling decisions of children declines, which typically happens during adolescence. This is consistent with evidence demonstrating that the influence of parents on children, as measured by the proportion of variance in personality and attitudes explained by a shared environment for twins, declines as children age and is negligible during adulthood (Harris, 1995; McCartney, Harris, & Bernieri, 1990). If influence of individuals with power or high status is partly due to their control over sampling, this also implies that they will have less influence over attitudes in domains in which they do not control sampling. According to the model, a manager is more likely to influence work-related attitudes than other attitudes. The model also implies that individuals with power and high status who lack control over the sampling processes of others will have less influence over the attitudes of others.

Because the model of interdependent sampling relies on a different mechanism, it also implies that social influence may occur even in situations in which existing theories are not applicable. If B has control over sampling, it is not necessary that A identifies with B, that A wants to comply with B, or that A regards the

opinions of B as informative. This suggests the possibility that individuals without high status, power, or expertise can sometimes influence the attitudes of others.

Consider, for example, the influence of children on the attitudes of parents. Although much research has focused on the influence of parents on the attitudes and values of their children, research has shown that children also have an influence on the attitudes and values of their parents (Glass, Bengtson, & Dunham, 1986). One possible source of such influence is children's control over sampling. As illustrated in research on decisions within the family, even young children can influence the choice of restaurants (Labrecque & Ricard, 2001), TV viewing (Chaffee, McLeod, & Atkin, 1971), and purchasing decisions (Foxman, Tansuhaj, & Ekström, 1989). In such situations, children may have an indirect influence over the attitudes of parents. Even if parents would rather go to different restaurants or see different programs, they may often defer to the wishes of their children. As a result, parents will sample many activities that their children like. In doing so, it is possible that parents discover that they like such movies or restaurants more than they previously thought. If so, the attitudes of parents will become positively correlated with the attitudes of their children. More generally, the model suggests that the attitude of Individual B may influence the attitude of Individual A whenever A has to follow the activities of B for whatever reason. An anthropologist or an undercover cop, following a group of individuals, is exposed to the activities those individuals prefer and might change his or her preferences in their direction.

### *Frequent Interactions*

Several field studies have shown that individuals are most likely to be influenced by others they interact with frequently. For example, the political attitudes of individuals are most influenced by those they frequently discuss politics with (C. B. Kenny, 1994), and members of organizations are most influenced by those they frequently communicate with and are friends with (Friedkin, 1984; Ibarra & Andrews, 1993; Lazer, 2001; Meyer, 1994; Pollock et al., 2000; Rice & Aydin, 1991). Twin studies have also shown that twins who frequently interact are more similar in their personalities (Kaprio, Koskenvuo, & Rose, 1990; Rose & Kaprio, 1988; Rose, Koskenvuo, Kaprio, Sarna, & Langinvainio, 1988).

Existing theories suggest several reasons why individuals would be most influenced by those they interact with frequently (Latané, 1981). Individuals may learn to rely on the opinions of those they frequently talk with or may identify with them. Individuals may also become more positive toward attitudes they are frequently exposed to (Zajonc, 1968). The model of interdependent sampling suggests a complementary explanation. In this model, A's attitude becomes correlated with B's attitude only if B frequently influences the sampling decisions of A. This requires frequent social interactions between A and B, during which B can expose A to activities that B enjoys. The model thus implies that individuals will be less influenced by others they seldom interact with.

The importance of frequent interactions in the model of interdependent sampling also implies that members of a group that is cohesive, in the sense that its members mainly interact with each other, will have more similar attitudes. Individuals who frequently interact with members of different groups, and whose sampling decisions thus may be influenced by members of different groups,

will develop attitudes that are only weakly correlated with any group. To illustrate this, consider a group of four individuals, in which Individuals 1 and 2 live in Building A, whereas Individuals 3 and 4 live in Building B. Suppose that the probability that an individual will interact with another individual from the same building is  $m$ . If  $m$  is close to 1, individuals are likely to interact extensively with individuals from the same building. Simulations show that the correlations of the attitudes of individuals within the same building will be higher if  $m$  is large.<sup>13</sup>

This is consistent with the empirical findings of Festinger et al. (1950, pp. 92–96) that cohesive courts had fewer individuals who deviated from the most common attitude. Cohesion was measured by the proportion of friends that belongs to the group or court (Festinger et al., 1950, pp. 91–92). This measure captures the extent of interaction and attraction within, as opposed to outside, the group. The correlation between the cohesiveness of a court and the number of deviates from the typical pattern of attitude and activity was  $-.76$  (Festinger et al., 1950, pp. 92–96; see Lott & Lott, 1965, for a review of similar findings). Although this finding was taken as evidence for the operation of group standards, it is also consistent with a model of interdependent sampling. The model is also consistent with the finding that individuals who expressed deviant attitudes had their social lives concentrated outside the dormitory (Festinger et al., 1950, p. 113) and were more likely to be isolated, in the sense of receiving as well as giving fewer sociometric nominations (Festinger et al., 1950, p. 105). Similarly, Newcomb's (1943) study of changes in political attitudes among female students who attended a liberal college found that the women who did not change their political attitudes to conform to the majority were less engaged in the activities of the school, less popular in school, and more tied to their families.

### *Reciprocity in Attraction*

Studies of attraction and sociometric choices in groups and organizations have often found that attractions are reciprocal: If Individual A is attracted to B, B is likely to be attracted to A (Doreian et al., 1996; D. A. Kenny & La Voie, 1982; Priest & Sawyer, 1967; Wasserman, 1980). These findings have usually been explained with balance theory (Heider, 1958). In this view, it is assumed that individuals have a psychological tendency to like individuals who like them. The fact that B likes A will directly increase A's evaluation of B. Alternatively, reciprocity could be explained by similarities in attitudes. If attractions depend on similarity in attitudes (Byrne, 1971), A will tend to like B when their attitudes are similar. In this case, B will also tend to like A, because A has attitudes similar to B.

The model of interdependent sampling suggests a different underlying mechanism. Suppose A forms an impression of B and B forms an impression of A. In such situations, it is sometimes plausible to assume that A and B are likely to meet if one of them wants to. Even if B has a negative impression of A, B may meet A if A has a positive impression of B. In some settings B may be able to avoid this. In other settings, such as in teacher–student interactions, this may be more difficult. If A likes B, A may stop by B's office and B may have to endure such interactions, at least briefly, to avoid being impolite. The model of interdependent sampling then implies that the impression of A of B and the impression of B of A will be positively correlated—that is, the

model predicts reciprocated attractions. The reason for why this occurs is related to the contact hypothesis: If B gets further contact with A, B's attitude to A may become more positive (Allport, 1954; Pettigrew, 1998; Pettigrew & Tropp, 2006). However, in the model of interdependent sampling such an effect of contact is not assumed but follows from the assumption that individuals avoid interacting with those they have a negative attitude toward (cf. Denrell, 2005). Moreover, contact, by itself, is not enough to generate reciprocated attractions. The key mechanism in the model is that the probability of contact depends on the attitudes of both individuals.

### *Transitivity in Attraction*

Another finding in studies of attraction is that friendship ties tend to be transitive. If Individual A is attracted to B and B is attracted to C, A also tends to be attracted to C (Doreian et al., 1996; Hallinan, 1974; Holland & Leinhardt, 1970). Explanations of such transitivity tend to emphasize balance theory (Heider, 1958), although similarities in attitudes, and their effect on attraction (Byrne, 1971), could provide an alternative explanation, if the similarity relation is transitive. The model of interdependent sampling suggests an alternative explanation. Suppose A and B are friends. Consider their attitudes toward another individual, C. If the probability that A will come into contact with C is an increasing function of B's attitude toward C, the attitudes of A and B will become correlated. A is more likely to like C if B does so. Such an explanation is consistent with findings from studies of shared friends among couples. When a dating relationship becomes more serious, individuals are more likely to have contacts with the friends of their partners (Milardo, 1982), especially if the partners move in together (Kalmijn, 2003). They are also more likely to like the friends of their partners (Parks, Stan, & Eggert, 1983). In particular, Kalmijn (2003) showed that the number of shared friends increases significantly after a couple move in together.

The model also predicts an asymmetry in the development of transitive friendship ties. According to the model, transitive ties are mainly expected if A is attracted to B. In this case, A is likely to become exposed to the friends of B. If A is not attracted to B, A is not likely to interact with B, and the model predicts little or no convergence toward balance. This is consistent with findings from studies of transitive triples in Newcomb's (1961) data. As suggested by Newcomb (1968) and as demonstrated in the reanalysis of Newcomb's (1961) data by Doreian and Krackhardt (2001), the number of balanced and imbalanced triples in which A liked B changed in accordance with the predictions of balance theory, but this was not true if A disliked B.

<sup>13</sup> In each period, we pick a random individual. With probability  $m$  this individual interacts with the other individual from the same building—and otherwise with an individual from the other building. During the interaction, the two individuals decide whether to sample and update their attitudes if they do sample (the attitudes of the other individuals do not change in this period). The probability of sampling and attitude formation are assumed to follow the assumptions of the basic model. The correlation is .97 between  $m$  and the correlation of the attitudes of the individuals within the same building.

### *Uncertainty*

Finally, the model of interdependent sampling is also consistent with the argument that social influence effects are more likely to occur in situations in which individuals are uncertain about the appropriate attitude or the correct judgment (Festinger, 1954; Turner, 1991). Clearly, if there were no randomness in the model and individuals knew the distribution and expected value of the random variables they are learning about, sampling could not influence beliefs, and interdependent sampling could not generate a social influence effect. The model also implies that there is a stronger social influence effect if the random variables that individuals are learning about are more variable. Specifically, the correlation between the attitudes of two individuals is an increasing function of the standard deviation of the random variable  $X$  that they are learning about. If the standard deviation of  $X$  is 0.5, the correlation after 50 periods will be only .16, whereas it will be .34 if the standard deviation is 1.

### Discussion of the Assumptions of the Model

The model of interdependent sampling cannot explain all instances of social influence. It relies on a number of assumptions about how individuals form attitudes and learn from experience, and the conclusions of the model apply only to situations in which these assumptions hold. In this section, we discuss the assumptions of the model and how they influence the results. We first examine how the magnitude of the effect varies with the parameters of the model. We then discuss alternative assumptions about attitude formation and sampling.

### *The Effect of the Parameters of the Model*

A large social influence effect, through interdependent sampling, requires that a new experience can change a negative attitude to a positive one and that an individual is likely to avoid the attitude object if his or her attitude is negative. Specifically, a large effect occurs only if the values of two parameters of the model ( $b$  and  $S$ ) are large. Here  $b$  regulates how much the attitude changes in response to a new experience, and  $S$  regulates how sensitive sampling is to the attitude of the individual. To illustrate the effect of the two parameters, Figure 8 shows how the average correlation between the attitudes of two individuals (after 50 periods) varies with  $S$  for two values of  $b$ . If  $b = 0.5$ , the correlation is .34 when  $S = 4$ , whereas it is .19 when  $S = 2.5$ . The correlation is lower if  $b$  is closer to zero, that is, when a new experience does not change an individual's attitude much. For example, suppose  $b = 0.34$ , which is the average estimated value from seven experiments on belief and attitude formation reviewed in Denrell (2005). If  $S = 4$ , the correlation is .26, whereas it is only .12 if  $S = 2.5$ . A correlation of .12, however, is probably close to the contribution of social influence to the correlation in attitudes between socially proximate pairs. Field studies show that the correlation between attitudes of socially proximate individuals is typically modest, ranging from .2 to .5 (e.g., Caspi, Herbener, & Ozer, 1992; Festinger et al., 1950; Jussim & Osgood, 1989; Kandel, 1978; Rozin, Riklis, & Margolis, 2004). Because similar attitudes can also be due to a shared environment or selection of similar others, these correlations also overestimate the effect of social influence.

In the basic model, both parameters ( $b$  and  $S$ ) are assumed to be constant. But it is possible that they may change with experience. A new experience may not change the attitude much if an individual has sampled an object many times. This is the case, for example, if the attitude is the average of all past experiences. More generally, the value of  $b$  may decline with experience (Denrell, 2005; Hertwig, Barron, Weber, & Erev, 2006; Hogarth & Einhorn, 1992). The value of  $S$  may also change with experience (Erev & Barron, 2005; Yechiam & Busemeyer, 2005). Individuals may initially be more likely to sample an object, even if they have a negative attitude toward it, to obtain further information about it. If they have sampled it many times and still have a negative attitude, they may be more likely to avoid it. These alternative assumptions will generally reduce the magnitude of the effect. However, Appendix C illustrates that the basic result holds even under these alternative assumptions and that the magnitude of the effect can still be sizeable.

### *The Influence of Past Attitudes on New Experiences*

The model assumes that an individual may change his or her attitude from negative to positive by sampling again. It is possible, however, that existing attitudes influence the perception, interpretation, and memory of new experiences. Memories of past experiences may cue the interpretation of new experiences (Kunda & Thagard, 1996), or individuals may mainly attend to or search for information consistent with past attitudes (Klayman & Ha, 1987). The basic result still holds even if past attitudes influence new experiences in these ways. If past attitudes strongly influence new experiences, however, the magnitude of the effect will be smaller. The effect of such an influence of past attitudes on new experiences is similar to the effect of a low value of  $b$ : It makes the current attitude more inert and less influenced by new observations, which reduces the magnitude of the effect. This is not surprising: When attitudes are inert and individuals interpret new observations as consistent with past attitudes, social influence effects should be small.

### *Correlation in Experiences*

The basic model assumed that the experiences of the two individuals were independent. We made this assumption to show that the individuals' attitudes would nevertheless become correlated, if their sampling processes were interdependent. In many situations, such as when two individuals go to a theater or a restaurant together, it is more realistic to assume that the experiences of individuals are correlated. This does not change the basic results. Of course, if their experiences are correlated, their attitudes will also become correlated, even if their sampling processes are independent. But a social influence effect, as defined above, occurs only if their sampling processes are interdependent.

To explain this, suppose that only Assumptions a–c of the basic model hold whereas the sampling processes of A and B are independent. If A and B have similar experiences, their attitudes will become positively correlated, but B's attitude does not influence A's attitude. Rather, A's attitude reflects only his or her own experiences, which are similar to B's. Thus, if B's attitude is set to  $-1$ , say, this will not change A's attitude. B's attitude only influences A's attitude if their sampling processes are also interdependent. In this case, the correlation between the attitudes of A

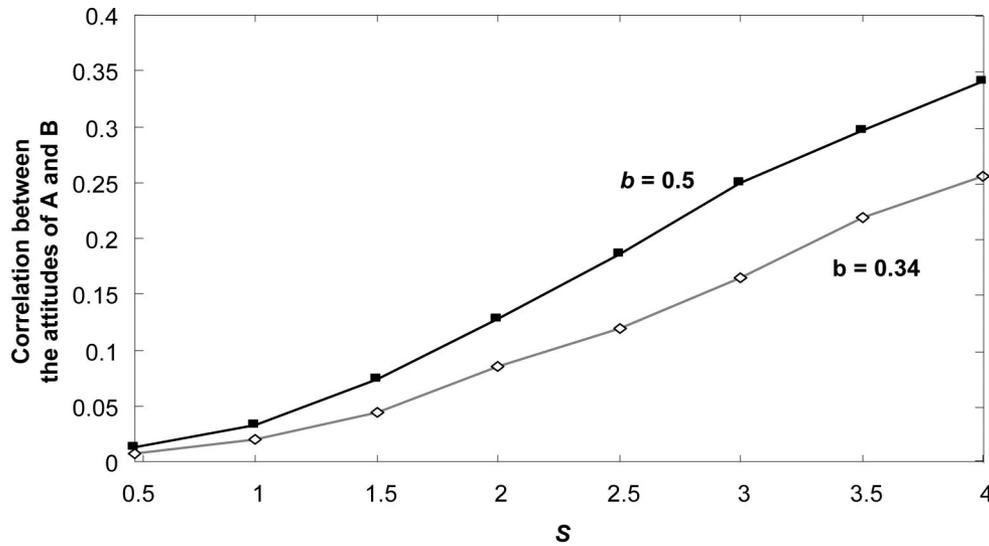


Figure 8. Effect of S and b on the average correlation between the attitudes of A and B at the end of Period 50 (each point is based on 100,000 simulation runs of the basic model).

and B is also higher than the correlation between their experiences. The correlation between the attitudes of the individuals can even be positive when the correlation between their experiences is negative. This is illustrated in Figure 9, which shows the development of the correlation between the attitudes of A and B for various values of the correlation between the experiences of A and B. The correlation between the attitudes in Period 50 is always higher than the correlation between the experiences. Moreover, if the correlation between the experiences is  $-0.2$ , the correlation between the attitudes will nevertheless be  $.1$  after 50 periods.

*Individual Desires to Sample*

The model assumes that an individual is more willing to sample objects or events he or she has a positive attitude toward. What happens if individuals were instead more likely to sample activities they have a negative attitude toward? This may happen when negative traits are rewarding for the individual forming the attitude (Peeters, 1983; Wentura, Rothermund, & Bak, 2000). For example, a journalist who uncovers negative information about a politician may want to look for more information and may want to meet the politician. As emphasized by Peeters (1983), a trait can be positive or negative for the individual forming an impression or can be positive or negative for the individual or object possessing the trait. The model presented here has focused on positivity and negativity in the first sense, when it is natural that negative attitudes lead to avoidance.

We can nevertheless extend the model to situations in which negative attitudes could lead to approach behavior. In fact, the basic result (Theorem 1) holds even if we instead assume that individuals are more willing to sample objects or events they have a negative attitude toward, that is, if  $P(\hat{x}_{A,t})$  is a decreasing function of  $\hat{x}_{A,t}$ .<sup>14</sup> However, the basic result does not hold if the probability that an individual is exposed to an object or event is independent of his or her attitude. The attitude of others will not influence, through interdependent sampling, an individual who samples or

receives information about objects irrespectively of what he or she thinks about them. The reason is that, in this case, additional sampling of the attitude object will not systematically change the attitude of the individual.

Several factors, in addition to the rewards associated with the attitude object, influence the desire to sample. Individuals may be motivated to develop an accurate impression. If so, they may sample objects whose attributes they are less certain of, and sampling decisions may be unrelated to the valence of the attitude. Unless individuals care only about accuracy, and never avoid unrewarding objects, this does not change the basic result, but it will reduce the magnitude of the correlation (see Appendix C). Moreover, the valence of the attitude could still influence sampling behavior, even if individuals were mainly motivated to develop an accurate impression. If individuals believe that negative traits are more diagnostic (Reeder & Brewer, 1979; Skowronski & Carlston, 1989), they may be more likely to sample objects they have a positive attitude toward (see Ybarra, 2002, for a review). If positive traits are instead perceived to be more diagnostic (such as in the competence domain, Skowronski & Carlston, 1989; Wojciszke, Brycz, & Borkenau, 1993), individuals may be more likely to sample objects they have a negative attitude toward. We do not wish to suggest, however, that the valence of the attitude always influences sampling behavior or that the attitude is the most important determinant of sampling behavior. There are many other determinants of sampling decisions (Fiedler & Juslin, 2006), including novelty, curiosity (Loewenstein, 1994), salience (Nisbett & Ross, 1980), and availability (Denrell, 2003; Tversky & Kahneman, 1973). These all compete for attention with the positivity bias and will moderate the effects discussed here.

<sup>14</sup> Specifically, Theorem 1 holds if  $\frac{dP(\hat{x}_{A,t})}{d\hat{x}_{A,t}} = \frac{dP(\hat{x}_{B,t})}{d\hat{x}_{B,t}} < 0$  and  $Q(\hat{x}_{A,t}, \hat{x}_{B,t})$  equals  $P(\hat{x}_{A,t}) + P(\hat{x}_{B,t}) - P(\hat{x}_{A,t})P(\hat{x}_{B,t})$ ,  $wP(\hat{x}_{A,t}) + (1-w)P(\hat{x}_{B,t})$ , or  $k\{P(\hat{x}_{A,t})[1 - P(\hat{x}_{B,t})] + [1 - P(\hat{x}_{A,t})]P(\hat{x}_{B,t})\} + P(\hat{x}_{A,t})P(\hat{x}_{B,t})$ .

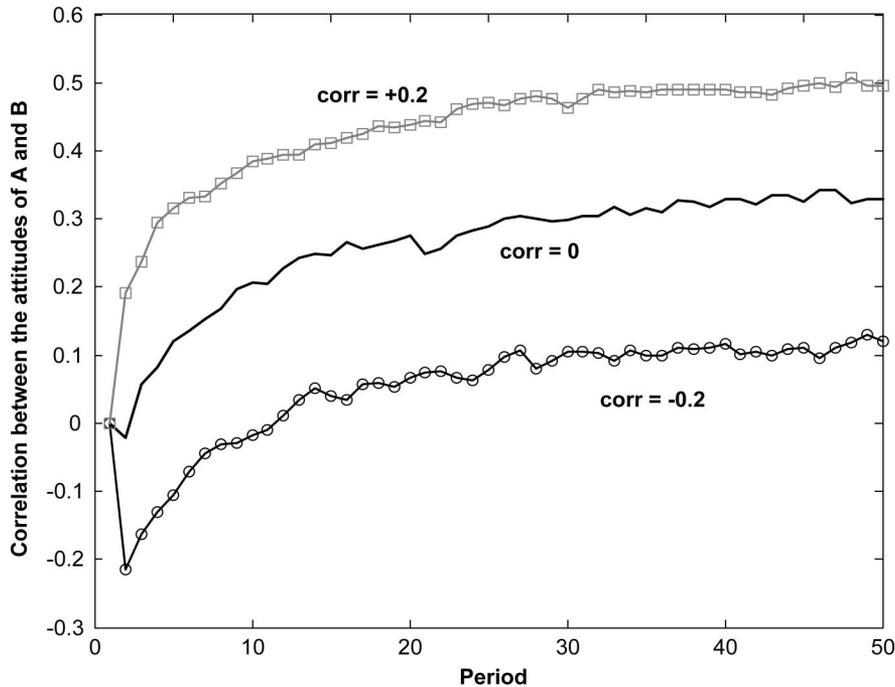


Figure 9. Development over time of the correlation between the attitudes of individuals A and B for different values of the correlation between their experiences ( $-0.2$ ,  $0$ , and  $+0.2$ ), based on 10,000 simulation runs of the basic model, with  $S = 4$  and  $b = 0.5$ .

### Joint Sampling Rule

Theorem 1 shows that interdependent sampling generates a social influence effect for several different joint sampling rules. These sampling rules all assume that an individual sometimes samples when he or she does not want to, if the other individual wants to. This condition is not only sufficient but also necessary. To understand why, consider what would happen if this condition were not met, that is, if the individuals sampled only when both of them wanted to. In this case, the model does not predict a social influence effect. The attitudes of the two individuals would not become correlated but would remain independent, as formalized in the following theorem:

*Theorem 2:* Suppose Assumptions 1, 2, and 3 of Theorem 1 hold. If A and B sample only when both of them want to, that is,  $Q(\hat{x}_{A,t}, \hat{x}_{B,t}) = P(\hat{x}_{A,t})P(\hat{x}_{B,t})$ , then, as  $t \rightarrow \infty$ , the attitudes of the two individuals are independent random variables with zero correlation (proof in Appendix B).

Theorem 2 implies that a social influence effect emerges through interdependent sampling only if an individual is sometimes willing to compromise and attend an event or expose himself or herself to an object he or she has a negative attitude toward, if the other individual wants to. This provides an important scope condition for the model: The model cannot explain social influence effects in situations in which two individuals sample only if both of them want to. Although this is an important limitation, there are probably few situations in which individuals follow only this sampling rule. In many social interactions, one would expect a

mixture of several different sampling rules. In some cases, two individuals may sample only if both of them want to. In other cases, both will sample if one of them wants to. If we observe a mix of these two rules, we should still expect a positive correlation.

The assumption that an individual may sample even if he or she does not want to, if the other wants to, also has implications for the type of social interaction the model applies to. Suppose Individual A samples an event many times, only because Individual B wants to attend. If all these experiences are negative for A and attending this event is the only social bond between A and B, it is possible that A and B will stop interacting. Moreover, unless A and B engage in other mutually enjoyable activities, it is unlikely that A will continue to compromise and attend the event. This example illustrates that the model is most directly applicable to an ongoing social interaction between two individuals, A and B, who have some mutual interests. Most of the time they may engage in activities they both enjoy. But sometimes A may agree to attend an activity A does not particularly enjoy, if B wants to attend.

In most illustrations of the model, we have assumed that the two individuals both participate in the decision about sampling. The model also applies to situations in which the decision about joint sampling is made by one of the individuals or by a third party. A partner in a couple may delegate the choice of activities to his or her partner. A parent may decide the activities of his or her two children and may take into account the preferences of both when making the decision. Finally, although we have assumed that the two individuals sample the same activity, the model also applies to situations in which two individuals sample distinct activities, if

their sampling processes are interdependent. To illustrate this, consider a couple. Every Wednesday night, one of the partners either attends a basketball game or stays at home, and the other partner either attends a jazz club or stays at home. Neither partner wants to stay home alone on Wednesday nights. If one of them goes out, so will the other. This implies that their sampling processes are interdependent, and their attitudes, about different activities, will become positively correlated.

### *Sampling From Memory or Reevaluation of Existing Information*

We have assumed that individuals sample activities or objects and that individuals change their attitudes on the basis of experiences with these activities and objects. Social influence through interdependent sampling, however, can also occur in other settings, when the sampled information is generated from memory in the course of a discussion. Consider two individuals who discuss the merits of decision alternatives by putting forward arguments in favor of those alternatives. Studies have shown that information exchanged in the course of such group discussion affects preferences for decision alternatives (Burnstein & Vinokur, 1975, 1977; Mojzisch & Schulz-Hardt, 2006; Stasser & Titus, 1985, 1987). Suppose that whenever an individual brings an argument into the discussion, both individuals independently evaluate the argument and update their attitudes about the decision alternatives accordingly. If individuals are more likely to put forward arguments in favor of the alternative they prefer (Dennis, 1996; Stasser & Titus, 1985, 1987), an argument is more likely to be brought up if any of them favors it, and a positive correlation will emerge between their attitudes, even if individuals evaluate arguments independently.

### Conclusion

“What happens to the mental life of the individual when he enters into association with others?” (Allport, 1968, p. 1). This is arguably one of the central questions in social psychology (Higgins, 2000). One way to approach this question is to examine how associations with others can change how individuals interpret the world around them. Much research on social influence has taken this approach. Here, we have focused instead on how the experiences, activities, and objects an individual is exposed to may change if he or she enters into association with others. The basic premise is that learning about the world is often a social activity and takes place through social interactions with others (Higgins, 2000, p. 6). As a result, the preferences of others influence decisions about sampling activities and objects. The model of interdependent sampling illustrates that such influence on sampling behavior is sufficient to generate a social influence effect. Even if the attitudes of others do not influence how an individual interprets a given experience, a social influence effect can occur if the process of sampling experiences is influenced by the attitudes of others.

The model provides another illustration of how sampling, rather than cognitive or motivational biases, could explain systematic biases in judgment (Denrell, 2005; Fiedler, 1996, 2000; Fiedler & Juslin, 2006). As illustrated by Denrell (2005), Fiedler (2000), and Fiedler and Walther (2004), ordinary learning processes may interact with the sampling environment to generate systematic biases

in impression formation. These models suggest that an analysis of the determinants of sampling may be as important for an understanding of impression and attitude formation as an analysis of internal cognitive and perceptual processes (Fiedler & Juslin, 2006). Most work in this tradition has focused on how availability, proximity, and frequency can generate a sampling bias (e.g., Denrell, 2003; Fiedler, 2000; Tversky & Kahneman, 1973). What we hope to convey in this article is that social interactions provide another source of sampling biases. Here we have focused on how the attitudes of others influence the behavior of individuals. It would be interesting to explore several other ways in which the activities and mental states of others influence the sampling behavior of an individual. The sampling processes of individuals can be competing, when they sample from the same pool of objects, as well as complementary. To examine this experimentally, one must go beyond traditional designs in which participants mainly react to information provided to them and allow participants to choose and influence their own and others' social situations (Snyder & Ickes, 1985, p. 915). In doing so, it would be possible to study in more detail how the fact that cognition occurs in a social setting influences beliefs and attitudes.

### References

- Abelson, R. P., & Bernstein, A. (1963). A computer simulation model of community referendum controversies. *Public Opinion Quarterly*, 27, 93–122.
- Allen, V. L. (1965). Situational factors in conformity. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 2, pp. 133–176). Orlando, FL: Academic Press.
- Allport, G. (1954). *The nature of prejudice*. Cambridge, MA: Addison-Wesley.
- Allport, G. W. (1968). The historical background of modern social psychology. In G. Lindzey & E. Aronson (Eds.), *The handbook of social psychology* (Vol. 1, pp. 1–80). Reading, MA: Addison-Wesley.
- Anderson, L., & Holt, C. (1997). Information cascades in the laboratory. *American Economic Review*, 87, 847–862.
- Anderson, N. H. (1981). *Foundations of information integration theory*. New York: Academic Press.
- Arora, N., & Allenby, G. M. (1999). Measuring the influence of individual preference structures in group decision making. *Journal of Marketing Research*, 36, 476–487.
- Asch, S. E. (1955). Opinions and social pressure. *Scientific American*, 193, 31–35.
- Banerjee, A. (1993). The economics of rumors. *Review of Economic Studies*, 309–327.
- Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, 117, 497–529.
- Bem, D. J. (1972). Self-perception theory. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 6, pp. 1–62). New York: Academic Press.
- Bikhchandani, S., Hirshleifer, D., & Welch, I. (1992). A theory of fads, fashion, custom, and cultural change as informational cascades. *Journal of Political Economy*, 100, 992–1026.
- Bourgeois, M. J., & Bowen, A. M. (2001). Self-organization of alcohol-related attitudes and beliefs in a campus housing complex: An initial investigation. *Health Psychology*, 20, 434–437.
- Bowen, A. M., & Bourgeois, M. J. (2001). The contribution of pluralistic ignorance, dynamic social impact, and contact theories to attitudes toward lesbian, gay, and bisexual college students. *Journal of American College Health*, 50, 91–96.

- Burnstein, E., & Vinokur, A. (1975). What a person thinks upon learning he has chosen differently from others: Nice evidence for the persuasive-arguments explanation of choice shifts. *Journal of Experimental Social Psychology, 11*, 412–426.
- Burnstein, E., & Vinokur, A. (1977). Persuasive argumentation and social comparison as determinants of attitude polarization. *Journal of Experimental Social Psychology, 13*, 315–332.
- Bussemeyer, J. R., & Myung, I. J. (1992). An adaptive approach to human decision making: Learning theory, decision theory, and human performance. *Journal of Experimental Psychology: General, 121*, 177–194.
- Bussemeyer, J. R., & Stout, J. C. (2002). A contribution of cognitive decision models to clinical assessment: Decomposing performance on the Bechara gambling task. *Psychological Assessment, 14*, 253–262.
- Buss, A. H. (1986). *Social behavior and personality*. Hillsdale, NJ: Erlbaum.
- Byrne, D. (1971). *The attraction paradigm*. New York: Academic Press.
- Campbell, B. A. (1980). A theoretical approach to peer influence in adolescent socialization. *American Journal of Political Science, 24*, 324–344.
- Caspi, A., Herbener, E. S., & Ozer, D. J. (1992). Shared experiences and the similarity of personalities: A longitudinal study of married couples. *Journal of Personality and Social Psychology, 62*, 281–291.
- Chaffee, S. H., McLeod, J. M., & Atkin, C. K. (1971). Parental influences on adolescent media use. *American Behavioral Scientist, 14*, 323–340.
- Chaiken, S., Giner-Sorolla, R., & Chen, S. (1996). Beyond accuracy: Defense and impression motives in heuristic and systematic information processing. In P. M. Gollwitzer & J. A. Bargh (Eds.), *The psychology of action: Linking cognition and motivation to behavior* (pp. 553–578). New York: Guilford.
- Chen, S., Shechter, D., & Chaiken, S. (1996). Getting at the truth or getting along: Accuracy- versus impression-motivated heuristic and systematic processing. *Journal of Personality and Social Psychology, 71*, 262–275.
- Cialdini, R. B., & Goldstein, N. J. (2004). Social influence: Compliance and conformity. *Annual Review of Psychology, 55*, 591–621.
- Cialdini, R. B., & Trost, M. R. (1998). Social influence: Social norms, conformity, and compliance. In D. T. Gilbert, S. T. Fiske, & G. Lindzey (Eds.), *The handbook of social psychology* (Vol. II, pp. 151–192). Boston: McGraw-Hill.
- Cohn, T. S., Yee, W., & Brown, V. (1961). Attitude change and interpersonal attraction. *Journal of Social Psychology, 55*, 207–211.
- Coleman, J. S. (1964). *An introduction to mathematical sociology*. London: The Free Press of Glencoe, Collier-Macmillan Limited.
- Compromise, and pass the remote. (2005, December 15). *San Jose Mercury News*, p. 1E.
- Crandall, C. (1988). Social contagion of binge eating. *Journal of Personality and Social Psychology, 55*, 588–598.
- Davis, H. L. (1976). Decision making within the household. *Journal of Consumer Research, 2*, 241–260.
- Davis, J. L., & Rusbult, C. I. (2001). Attitude alignment in close relationships. *Journal of Personality and Social Psychology, 81*, 65–84.
- Daw, N. D., O'Doherty, J. P., Dayan, P., Seymour, B., & Dolan, R. J. (2006, June 15). Cortical substrates for exploratory decisions in humans. *Nature, 441*, 876–879.
- Dennis, A. R. (1996). Information exchange and use in small group decision making. *Small Group Research, 27*, 532–550.
- Denrell, J. (2003). Vicarious learning, under-sampling of failure, and the myths of management. *Organization Science, 14*, 227–243.
- Denrell, J. (2005). Why most people disapprove of me: Experience sampling in impression formation. *Psychological Review, 112*, 951–978.
- Denrell, J. (2007). Adaptive learning and risk taking. *Psychological Review, 114*, 177–187.
- Denrell, J., & March, J. G. (2001). Adaptation as information restriction: The hot stove effect. *Organization Science, 12*, 523–538.
- Deutsch, M., & Gerard, H. (1955). A study of normative and informational social influence upon individual judgment. *Journal of Abnormal and Social Psychology, 51*, 629–636.
- Dodds, P. S., & Watts, D. J. (2005). A generalized model of social and biological contagion. *Journal of Theoretical Biology, 232*, 587–604.
- Doreian, P., Kapuscinski, R., Krackhardt, D., & Szczypula, J. (1996). A brief history of balance through time. *Journal of Mathematical Sociology, 21*, 113–131.
- Doreian, P., & Krackhardt, D. (2001). Pre-transitive balance mechanisms for signed networks. *Journal of Mathematical Sociology, 25*, 43–67.
- Duncan, O. D., Haller, A. O., & Portes, A. (1968). Peer influences on aspirations: A reinterpretation. *American Journal of Sociology, 74*, 119–137.
- Eagley, A., & Chaiken, S. (1993). *The psychology of attitudes*. Fort Worth, TX: Harcourt Brace Jovanovich College Publishers.
- Eiser, R. J., Fazio, R. H., Stafford, T., & Prescott, T. (2003). Connectionist simulation of attitude learning: Asymmetries in the acquisition of positive and negative evaluations. *Personality and Social Psychology Bulletin, 29*, 1221–1235.
- Ennett, S. T., & Bauman, K. E. (1994). The contribution of influence and selection to adolescent peer group homogeneity: The case of adolescent cigarette smoking. *Journal of Personality and Social Psychology, 67*, 653–663.
- Erev, I., & Barron, G. (2005). On adaptation, maximization, and reinforcement learning among cognitive strategies. *Psychological Review, 112*, 912–931.
- Fazio, R. H. (1990). Multiple processes by which attitudes guide behavior: The MODE model as an integrative framework. In M. P. Zanna (Ed.), *Advances in experimental social psychology* (Vol. 23, pp. 75–109). New York: Academic Press.
- Fazio, R. H., Eiser, J. R., & Shook, N. J. (2004). Attitude formation through exploration: Valence asymmetries. *Journal of Personality and Social Psychology, 87*, 293–311.
- Fazio, R. H., & Zanna, M. P. (1981). Direct experience and attitude-behavior consistency. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 14, pp. 161–202). New York: Academic Press.
- Festinger, L. (1950). Informal social communication. *Psychological Review, 57*, 271–282.
- Festinger, L. (1954). A theory of social comparison processes. *Human Relations, 7*, 114–140.
- Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford, CA: Stanford University Press.
- Festinger, L., Schachter, S., & Back, K. W. (1950). *Social pressures in informal groups: A study of human factors in housing*. Stanford, CA: Stanford University Press.
- Fiedler, K. (1996). Explaining and simulating judgment biases as an aggregation phenomenon in probabilistic, multiple-cue environments. *Psychological Review, 103*, 193–214.
- Fiedler, K. (2000). Beware of samples: A cognitive-ecological sampling approach to judgment bias. *Psychological Review, 107*, 659–676.
- Fiedler, K., & Juslin, P. (2006). Taking the interface between mind and environment seriously. In K. Fiedler & P. Juslin (Eds.), *Information sampling and adaptive cognition* (pp. 3–29). Cambridge, England: Cambridge University Press.
- Fiedler, K., & Walther, E. (2004). *Stereotyping as inductive hypothesis testing*. New York: Psychology Press.
- Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.
- Fiske, S. T. (1982). Schema-triggered affect: Applications to social perception. In M. S. Clark & S. T. Fiske (Eds.), *Affect and cognition: The 17th Annual Carnegie Symposium on Cognition* (pp. 55–78). Hillsdale, NJ: Erlbaum.

- Forgas, J. P., & Williams, K. D. (2001). Social influence: Introduction and overview. In J. P. Forgas & K. D. Williams (Eds.), *Social influence: Direct and indirect process* (pp. 3–24). Philadelphia: Psychology Press.
- Foxman, E. R., Tansuhaj, P. S., & Ekström, K. M. (1989). Family members' perceptions of adolescents' influence in family decision making. *Journal of Consumer Research*, *15*, 482–491.
- French, J. R. P., Jr. (1956). A formal theory of social power. *Psychological Review*, *63*, 181–194.
- Friedkin, N. E. (1984). Structural cohesion and equivalence explanations of social homogeneity. *Sociological Methods & Research*, *12*, 235–261.
- Friedkin, N. E. (1998). *A structural theory of social influence*. Cambridge, England: Cambridge University Press.
- Glass, J., Bengtson, V. L., & Dunham, C. C. (1986). Attitude similarity in three generation families: Socialization, status inheritance, or reciprocal influence? *American Sociological Review*, *51*, 685–698.
- Gouldner, A. W. (1960). The norm of reciprocity: A preliminary statement. *American Sociological Review*, *25*, 161–178.
- Gruber-Baldini, A. L., Schaie, K. W., & Willis, S. L. (1995). Similarity in married couples: A longitudinal study of mental abilities and rigidity-flexibility. *Journal of Personality and Social Psychology*, *69*, 191–203.
- Hallinan, M. T. (1974). *The structure of positive sentiment*. Amsterdam: Elsevier.
- Harary, F. (1959). A criterion for unanimity in French's theory of social power. In D. Cartwright (Ed.), *Studies in social power* (pp. 168–182). Ann Arbor, MI: Institute for Social Research.
- Harris, J. R. (1995). Where is the child's environment? A group socialization theory of development. *Psychological Review*, *102*, 458–489.
- Heider, F. (1958). *The psychology of interpersonal relations*. New York: Wiley.
- Hertwig, R., Barron, G., Weber, E. U., & Erev, I. (2006). Risky prospects: When valued through a window of sampled experiences. In K. Fiedler & P. Juslin (Eds.), *Information sampling and adaptive cognition* (pp. 72–91). Cambridge, England: Cambridge University Press.
- Higgins, E. T. (2000). Social cognition: Learning about what matters in the social world. *European Journal of Social Psychology*, *30*, 3–39.
- Hogarth, R. M., & Einhorn, H. J. (1992). Order effects in belief updating: The belief-adjustment model. *Cognitive Psychology*, *24*, 1–55.
- Hogg, M. A. (1992). *The social psychology of group cohesiveness: From attraction to social identity*. New York: New York University Press.
- Hogg, M., & Abrams, D. (1988). *Social identifications*. London: Routledge.
- Hogg, M. A., & Turner, J. C. (1987). Social identity and conformity: A theory of referent informational influence. In W. Doise & S. Moscovici (Eds.), *Current issues in European social psychology* (Vol. 2, pp. 139–182). New York: Cambridge University Press.
- Holland, P., & Leinhardt, S. (1970). A method for detecting structure in sociometric data. *American Journal of Sociology*, *76*, 492–513.
- Huckfeldt, R., & Sprague, J. (1991). Discussant effects on vote choice: Intimacy, structure, and interdependence. *Journal of Politics*, *53*, 122–158.
- Huckfeldt, R., & Sprague, J. (1995). *Citizens, politics, and social communication*. New York: Cambridge University Press.
- Ibarra, H., & Andrews, S. B. (1993). Power, social influence, and sense making: Effects of network centrality and proximity on employee perception. *Administrative Science Quarterly*, *38*, 277–303.
- Jussim, L., & Osgood, D. W. (1989). Influence and similarity among friends: An integrative model applied to incarcerated adolescents. *Social Psychology Quarterly*, *52*, 98–112.
- Kalmijn, M. (2003). Shared friendship networks over the life course: An analysis of survey data on married and cohabiting couples. *Social Networks*, *25*, 231–249.
- Kandel, D. B. (1978). Homophily, selection, and socialization in adolescent friendships. *American Journal of Sociology*, *84*, 427–436.
- Kaprio, J., Koskenvuo, M., & Rose, R. J. (1990). Change in cohabitation and intrapair similarity of monozygotic (MZ) cotwins for alcohol use, extraversion and neuroticism. *Behavior Genetics*, *20*, 265–276.
- Karlin, S., & Rubin, H. (1956). Distributions possessing a monotone likelihood ratio. *Journal of the American Statistical Association*, *51*, 637–643.
- Karlin, S., & Taylor, H. M. (1975). *A first course in stochastic processes*. San Diego, CA: Academic Press.
- Kashima, Y., & Kerekes, A. R. Z. (1994). A distributed memory model for averaging phenomena in person impression formation. *Journal of Experimental Social Psychology*, *30*, 407–455.
- Katz, E., & Lazarsfeld, P. (1955). *Personal influence*. New York: The Free Press.
- Kelman, H. C. (1958). Compliance, identification, and internalization: Three processes of attitude change. *Journal of Conflict Resolution*, *2*, 51–60.
- Kenny, C. B. (1994). The microenvironment of attitude change. *Journal of Politics*, *56*, 715–728.
- Kenny, D. A., & La Voie, L. (1982). Reciprocity of interpersonal attraction: A confirmed hypothesis. *Social Psychology Quarterly*, *45*, 54–58.
- Klayman, J., & Ha, Y.-W. (1987). Confirmation, disconfirmation, and information in hypothesis testing. *Psychological Review*, *94*, 211–228.
- Kunda, Z., & Thagard, P. (1996). Forming impressions from stereotypes, traits, and behaviors: A parallel-constraint-satisfaction theory. *Psychological Review*, *103*, 284–308.
- Kuran, T. (1998). *Private truths, public lies: The social consequences of preference falsification*. Cambridge, MA: Harvard University Press.
- Labrecque, J., & Ricard, L. (2001). Children's influence on family decision-making: A restaurant study. *Journal of Business Research*, *54*, 173–176.
- Latané, B. (1981). The psychology of social impact. *American Psychologist*, *36*, 343–365.
- Lazer, D. (2001). The co-evolution of individual and network. *Journal of Mathematical Sociology*, *25*, 69–108.
- Lippitt, R., Polansky, N., & Rosen, S. (1952). The dynamics of power: A field study of social influence in groups of children. *Human Relations*, *5*, 37–64.
- Loewenstein, G. (1994). The psychology of curiosity: A review and reinterpretation. *Psychological Bulletin*, *116*, 75–98.
- Lott, A. J., & Lott, B. E. (1961). Group cohesiveness, communication level, and conformity. *Journal of Abnormal and Social Psychology*, *62*, 408–412.
- Lott, A. J., & Lott, B. E. (1965). Group cohesiveness as interpersonal attraction: A review of relationships with antecedent and variables. *Psychological Bulletin*, *64*, 259–309.
- Luce, R. D. (1959). *Individual choice behavior: A theoretical analysis*. New York: Wiley.
- March, J. G. (1955). An introduction to the theory and measurement of influence. *American Political Science Review*, *49*, 431–451.
- March, J. G. (1996). Learning to be risk averse. *Psychological Review*, *103*, 309–319.
- Marsden, P., & Friedkin, N. (1993). Network studies of social influence. *Sociological Methods and Research*, *22*, 127–151.
- Martin, R., & Hewstone, M. (2003). Social influence. In M. Hogg & J. Cooper (Eds.), *Sage handbook of social psychology* (pp. 347–366). London: Sage.
- McCartney, K., Harris, M., & Bernieri, F. (1990). Growing up and growing apart: A developmental meta-analysis of twin studies. *Psychological Bulletin*, *107*, 226–237.
- Meyer, G. W. (1994). Social information processing and social networks: A test of social influence mechanisms. *Human Relations*, *47*, 1013–1048.
- Milardo, R. M. (1982). Friendship networks in developing relationships,

- converging and diverging social environments. *Social Psychology Quarterly*, 45, 162–172.
- Mojzisch, A., & Schulz-Hardt, S. (2006). Information sampling in group decision making: Sampling biases and their consequences. In K. Fiedler & P. Juslin (Eds.), *Information sampling and adaptive cognition* (pp. 299–326). Cambridge, England: Cambridge University Press.
- Newcomb, T. M. (1943). *Personality and social change: Attitude formation in a student community*. New York: Dryden Press.
- Newcomb, T. M. (1961). *The acquaintance process*. New York: Holt, Rinehart & Winston.
- Newcomb, T. M. (1968). Interpersonal balance. In R. P. Abelson, E. Aronson, W. J. McGuire, T. M. Newcomb, M. J. Rosenberg, & O. H. Tannenbaum (Eds.), *Theories of cognitive psychology* (pp. 28–51). Chicago: Rand McNally.
- Nisbett, R. E., & Ross, L. (1980). *Human inference: Strategies and shortcomings of social judgment*. Englewood Cliffs, NJ: Prentice-Hall.
- Nordlie, P. (1958). *A longitudinal study of interpersonal attraction in a natural group setting*. Unpublished doctoral dissertation, University of Michigan.
- Nowak, A., Szamrej, J., & Latané, B. (1990). From private attitude to public opinion: A dynamic theory of social impact. *Psychological Review*, 97, 362–376.
- Parks, M. R., Stan, C. M., & Eggert, L. L. (1983). Romantic involvement and social network involvement. *Social Psychology Quarterly*, 46, 116–131.
- Peeters, G. (1971). The positive–negative asymmetry: On cognitive consistency and positivity bias. *European Journal of Social Psychology*, 1, 455–474.
- Peeters, G. (1983). Relational and informational patterns in social cognition. In W. Doise & S. Moscovici (Eds.), *Current issues in European social psychology* (pp. 201–237). Cambridge, England: Cambridge University Press.
- Peeters, G., & Czapski, J. (1990). Positive-negative asymmetry in evaluations: The distinction between affective and informational negativity effects. *European Review of Social Psychology*, 1, 33–60.
- Pettigrew, T. F. (1998). Intergroup contact theory. *Annual Review of Psychology*, 49, 65–85.
- Pettigrew, T. F., & Tropp, L. R. (2006). A meta-analytic test of intergroup contact theory. *Journal of Personality and Social Psychology*, 90, 1–33.
- Pfeffer, J. (1980). A partial test of the social information processing model of job attitudes. *Human Relations*, 33, 457–476.
- Pollock, T. G., Whitbred, R. C., & Contractor, N. (2000). Social information processing and job characteristics: A simultaneous test of two theories with implications for job satisfaction. *Human Communication Research*, 26, 292–330.
- Pool, G. J., Wood, W., & Leck, K. (1998). The self-esteem motive in social influence: Agreement with valued majorities and disagreement with derogated minorities. *Journal of Personality and Social Psychology*, 75, 967–975.
- Price, R. A., & Vandenberg, S. G. (1980). Spouse similarity in American and Swedish couples. *Behavior Genetics*, 10, 59–71.
- Priest, R. T., & Sawyer, J. (1967). Proximity and peership: Bases of balance in interpersonal attraction. *American Journal of Sociology*, 72, 633–649.
- Reeder, G. D., & Brewer, M. B. (1979). A schematic model of dispositional attribution in interpersonal perception. *Psychological Review*, 86, 61–76.
- Rice, R. E., & Aydin, C. (1991). Attitudes toward new organizational technology: Network proximity as a mechanism for social information processing. *Administrative Science Quarterly*, 36, 219–244.
- Rose, R. J., & Kaprio, J. (1988). Frequency of social contact and intrapair resemblance of adult monozygotic cotwins—Or does shared experience influence personality after all? *Behavior Genetics*, 18, 309–328.
- Rose, R. J., Koskenvuo, M., Kaprio, J., Sarna, S., & Langinvainio, H. (1988). Shared genes, shared experience, and similarity of personality. Data from 14,288 adult Finnish cotwins. *Journal of Personal and Social Psychology*, 54, 161–171.
- Rozin, P., Riklis, J., & Margolis, L. (2004). Mutual exposure or close peer relationships do not seem to foster increased similarity in food, music, or television program preferences. *Appetite*, 42, 41–48.
- Sacerdote, B. (2001). Peer effects with random assignment: Results for Dartmouth roommates. *Quarterly Journal of Economics*, 116, 681–704.
- Schachter, S. (1951). Deviation, rejection and communication. *Journal of Abnormal and Social Psychology*, 46, 190–208.
- Skowronski, J. J., & Carlston, D. E. (1989). Negativity and extremity biases in impression formation: A review of explanations. *Psychological Bulletin*, 105, 131–142.
- Snyder, M. (1981). On the influence of individuals on situations. In N. Cantor & J. F. Kihlstrom (Eds.), *Personality, cognition, and social interaction* (pp. 309–329). Hillsdale, NJ: Erlbaum.
- Snyder, M. (1992). Motivational foundations of behavioral confirmation. *Advances in Experimental Social Psychology*, 25, 67–114.
- Snyder, M., & Ickes, W. (1985). Personality and social behavior. In G. Lindzey & E. Aronson (Eds.), *Handbook of social psychology* (3rd ed., Vol. 2, pp. 883–947). New York: Random House.
- Stangor, C., & McMillan, D. (1992). Memory for expectancy-congruent and expectancy-incongruent information: A review of the social and social developmental literatures. *Psychological Bulletin*, 111, 42–61.
- Stasser, G., & Titus, W. (1985). Pooling of unshared information in group decision making: Biased information sampling during discussion. *Journal of Personality and Social Psychology*, 48, 1467–1478.
- Stasser, G., & Titus, W. (1987). Effects of information load and percentage of shared information on the dissemination of unshared information during group discussion. *Journal of Personality and Social Psychology*, 53, 81–93.
- Sugrue, L. P., Corrado, G. S., & Newsome, W. T. (2005). Choosing the greater of two goods: Neural currencies for valuation and decision making. *Nature Reviews Neuroscience*, 6, 363–375.
- Sutton, R., & Barto, A. G. (1998). *Reinforcement learning*. Cambridge, MA: The MIT Press.
- Thorndike, E. L. (1911). *Animal intelligence*. New York: Macmillan.
- Tong, Y. L. (1980). *Probability inequalities in multivariate distributions*. New York: Academic Press.
- Turner, J. C. (1991). *Social influence*. Pacific Grove, CA: Brooks/Cole.
- Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology*, 5, 207–232.
- Van Overwalle, F., & Labiouse, C. (2004). A recurrent connectionist model of person impression formation. *Personality and Social Psychology Review*, 8, 28–61.
- Van Overwalle, F., & Siebler, F. (2005). A connectionist model of attitude formation and change. *Personality and Social Psychology Review*, 9, 231–274.
- Walster, E., & Abrahams, D. (1972). Interpersonal attraction and social influence. In J. T. Tedeschi (Ed.), *The social influence processes* (pp. 197–238). Chicago: Aldin Atherton.
- Wasserman, S. (1980). Analyzing social networks as stochastic processes. *Journal of American Statistical Association*, 75, 280–294.
- Wentura, D., Rothermund, K., & Bak, P. (2000). Automatic vigilance: The attention-grabbing power of approach- and avoidance-related social information. *Journal of Personality and Social Psychology*, 78, 1024–1037.
- Whyte, W. F. (1943). *Street corner society*. Chicago: University of Chicago Press.
- Wind, Y. (1976). Preference of relevant others and individual choice models. *Journal of Consumer Research*, 3, 50–57.
- Wojciszke, B., Brycz, H., & Borkenau, P. (1993). Effects of information content and evaluative extremity on positivity and negativity biases. *Journal of Personality and Social Psychology*, 64, 327–335.

Wood, W. (2000). Attitude change: Persuasion and social influence. *Annual Review of Psychology*, 51, 539–570.

Wood, W., Pool, G. J., Leck, K., & Purvis, D. (1996). Self-definition, defensive processing, and influence: The normative impact of majority and minority groups. *Journal of Personality and Social Psychology*, 71, 1181–1193.

Ybarra, O. (2002). Naive causal understanding of valenced behaviors and its implications for social information processing. *Psychological Bulletin*, 128, 421–441.

Yechiam, E., & Busemeyer, J. R. (2005). Comparison of basic assumptions embedded in learning models for experience-based decision making. *Psychonomic Bulletin and Review*, 12, 387–402.

Zajonc, R. B. (1968). Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology Monographs*, 9(2, Pt. 2), 1–27.

Zimmerman, D. J. (2003). Peer effects in academic outcomes: Evidence from a natural experiment. *Review of Economics and Statistics*, 85, 9–23.

Appendix A

Derivation of the Asymptotic Density

Let  $Z_A$  be the random variable that A’s attitude,  $\hat{X}_{A,t}$ , would converge to as  $t \rightarrow \infty$ , if instead of sequential sampling we assumed that the individual sampled the event in each period. Denote the joint asymptotic density of  $Z_A$  and  $Z_B$  by  $g(z_A, z_B)$ . In addition, let  $Y_A$  and  $Y_B$  be the random variables that the attitudes,  $\hat{X}_{A,t}$  and  $\hat{X}_{B,t}$ , converge to as  $t \rightarrow \infty$ . To derive the asymptotic joint density of  $Y_A$  and  $Y_B$ , note that the process can be viewed as a semi-Markov process (cf. Denrell, 2005). The (continuous) state space is the set of estimates,  $(\hat{x}_{A,t}, \hat{x}_{B,t}) \in R^2$ . Because transitions between these states depend only on the existing state, transitions are Markovian and durations between transitions follow a geometric probability distribution with mean  $w(z_A, z_B) = 1/P(\text{both sample})$ .

Using the theory of semi-Markov processes (e.g., Karlin & Taylor, 1975), we can show that the asymptotic density of the proportion of time that the process spends in state  $(y_A, y_B)$  is

$$h(y_A, y_B) = \frac{w(y_A, y_B)g(y_A, y_B)}{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} w(y_A, y_B)g(y_A, y_B)dy_A dy_B}, \tag{A1}$$

where  $g(z_A, z_B)$  is the asymptotic joint density of the underlying Markov process. Moreover,

$$w(y_A, y_B) = 1 / \left( \frac{1}{1 + e^{-Sy_A}} + \frac{1}{1 + e^{-Sy_B}} - \frac{1}{1 + e^{-Sy_A}} \frac{1}{1 + e^{-Sy_B}} \right), \tag{A2}$$

which can be simplified to

$$w(y_A, y_B) = 1 + \frac{e^{-Sy_A}e^{-Sy_B}}{1 + e^{-Sy_A} + e^{-Sy_B}}. \tag{A3}$$

If  $X_{A,t}$  is a normally distributed variable with a mean of zero and a variance of  $\sigma^2$ ,  $Z_A$  is normally distributed with a mean of zero and a variance of  $v = b\sigma^2/(2 - b)$ . Because  $Z_A$  and  $Z_B$  are independent, we get

$$g(z_A, z_B) = \frac{1}{2\pi v} e^{-z_A^2/2v} e^{-z_B^2/2v}. \tag{A4}$$

The density  $h(y_A, y_B)$  is thus

$$h(y_A, y_B) = \frac{\left( 1 + \frac{e^{-Sy_A - Sy_B}}{1 + e^{-Sy_A} + e^{-Sy_B}} \right) \frac{1}{2\pi v} e^{-y_A^2/2v} e^{-y_B^2/2v}}{\iint \left( 1 + \frac{e^{-Sy_A - Sy_B}}{1 + e^{-Sy_A} + e^{-Sy_B}} \right) \frac{1}{2\pi v} e^{-y_A^2/2v} e^{-y_B^2/2v} dy_A dy_B}. \tag{A5}$$

Appendix B

General Model

The general model makes the following four assumptions:

1. *Experiences.* The experiences of the two individuals,  $X_{A,t}$  and  $X_{B,t}$ , are independent random variables with arbitrary (continuous) densities,  $f_A(x_{A,t})$  and  $f_B(x_{B,t})$ .
2. *Attitude formation.* The attitude in period  $t + 1$ ,  $\hat{x}_{A,t+1}$ , is a weighted combination of the  $N$  most recent experi-

ences,  $\hat{x}_{A,t+1} = b_1 X_{A,1} + b_2 X_{A,2} + \dots + b_N X_{A,N}$ , where  $X_{A,1}$  is the most recent experience,  $N < \infty$ ,  $b_i \in [0, 1)$ , and  $\sum_{i=1}^N b_i = 1$ .

3. *Individual desires to sample.* The probability that A

(Appendixes continue)

wants to sample is  $P(\hat{x}_{A,t}) > 0$ , where  $P(\cdot)$  is a continuous function and  $dP(\hat{x}_{A,t})/d\hat{x}_{A,t} > 0$ .

4. *Final decision about sampling in period t.* Let  $Q(\hat{x}_{A,t}, \hat{x}_{B,t})$  denote the probability that A and B will sample in period  $t + 1$ . It is assumed that  $Q(\hat{x}_{A,t}, \hat{x}_{B,t}) > 0$  for all  $\hat{x}_{A,t}$  and  $\hat{x}_{B,t}$ . It is also assumed that

$$\frac{Q(\hat{x}_{A,t}, \hat{x}_{B,t}^*)}{Q(\hat{x}_{A,t}, \hat{x}_{B,t})} > \frac{Q(\hat{x}_{A,t}^*, \hat{x}_{B,t}^*)}{Q(\hat{x}_{A,t}^*, \hat{x}_{B,t})}, \tag{B1}$$

whenever  $\hat{x}_{A,t}^* > \hat{x}_{A,t}$  and  $\hat{x}_{B,t}^* > \hat{x}_{B,t}$ . This can also be written as

$$\frac{Q(\hat{x}_{A,t}, \hat{x}_{B,t}^*) - Q(\hat{x}_{A,t}, \hat{x}_{B,t})}{Q(\hat{x}_{A,t}, \hat{x}_{B,t})} > \frac{Q(\hat{x}_{A,t}^*, \hat{x}_{B,t}^*) - Q(\hat{x}_{A,t}^*, \hat{x}_{B,t})}{Q(\hat{x}_{A,t}^*, \hat{x}_{B,t})}. \tag{B2}$$

That is, the relative increase in the probability of sampling, from the case in which both attitudes are low to the case in which the attitude of B is high, is larger than the relative increase in the probability of sampling from the case in which the attitude of A is high and the attitude of B is low to the case in which the attitude of B is also high.

If  $Q(\cdot)$  is twice continuously differentiable, Equation B1 is equivalent to

$$\begin{aligned} & \frac{\partial^2}{\partial \hat{x}_{A,t} \partial \hat{x}_{B,t}} \ln[Q(\hat{x}_{A,t}, \hat{x}_{B,t})] \\ &= \frac{\frac{\partial^2 Q(\hat{x}_{A,t}, \hat{x}_{B,t})}{\partial \hat{x}_{A,t} \partial \hat{x}_{B,t}} Q(\hat{x}_{A,t}, \hat{x}_{B,t}) - \frac{\partial Q(\hat{x}_{A,t}, \hat{x}_{B,t})}{\partial \hat{x}_{A,t}} \frac{\partial Q(\hat{x}_{A,t}, \hat{x}_{B,t})}{\partial \hat{x}_{B,t}}}{Q(\hat{x}_{A,t}, \hat{x}_{B,t})^2} < 0 \end{aligned} \tag{B3}$$

(e.g., Karlin & Rubin, 1956, p. 639).

This assumption includes the case in which both individuals sample if one of them wants to. In this case, the probability of sampling is  $Q(\hat{x}_{A,t}, \hat{x}_{B,t}) = P(\hat{x}_{A,t}) + P(\hat{x}_{B,t}) - P(\hat{x}_{A,t})P(\hat{x}_{B,t})$ , and

$$\begin{aligned} \frac{dP(\hat{x}_{A,t})}{d\hat{x}_{A,t}} &= \frac{dP(\hat{x}_{B,t})}{d\hat{x}_{B,t}} > 0 \text{ and} \\ \frac{\partial^2 Q(\hat{x}_{A,t}, \hat{x}_{B,t})}{\partial \hat{x}_{B,t} \partial \hat{x}_{A,t}} &= - \frac{dP(\hat{x}_{A,t})}{d\hat{x}_{A,t}} \frac{dP(\hat{x}_{B,t})}{d\hat{x}_{B,t}} < 0. \end{aligned}$$

As a result,  $\frac{\partial^2}{\partial \hat{x}_{B,t} \partial \hat{x}_{A,t}} \ln[Q(\hat{x}_{A,t}, \hat{x}_{B,t})] < 0$ . Suppose that they both sample with a probability of 1 if both of them want to but only sample with a probability of  $k \in (0,1]$  if only one of them wants to. The probability that they sample is then

$$\begin{aligned} Q(\hat{x}_{A,t}, \hat{x}_{B,t}) &= k\{P(\hat{x}_{A,t})[1 - P(\hat{x}_{B,t})] + [1 - P(\hat{x}_{A,t})]P(\hat{x}_{B,t})\} \\ &\quad + P(\hat{x}_{A,t})P(\hat{x}_{B,t}). \end{aligned} \tag{B4}$$

In this case,

$$\begin{aligned} & \frac{\partial^2 Q(\hat{x}_{A,t}, \hat{x}_{B,t})}{\partial \hat{x}_{B,t} \partial \hat{x}_{A,t}} Q(\hat{x}_{A,t}, \hat{x}_{B,t}) - \frac{\partial Q(\hat{x}_{A,t}, \hat{x}_{B,t})}{\partial \hat{x}_{B,t}} \frac{\partial Q(\hat{x}_{A,t}, \hat{x}_{B,t})}{\partial \hat{x}_{A,t}} \\ &= -k^2 \frac{dP(\hat{x}_{A,t})}{d\hat{x}_{A,t}} \frac{dP(\hat{x}_{B,t})}{d\hat{x}_{B,t}} < 0. \end{aligned} \tag{B5}$$

The assumption regarding the function  $Q(\cdot)$  also includes the case in which  $Q(\hat{x}_{A,t}, \hat{x}_{B,t}) = wP(\hat{x}_{A,t}) + (1 - w)P(\hat{x}_{B,t})$ . In this case,

$$\begin{aligned} & \frac{\partial Q(\hat{x}_{A,t}, \hat{x}_{B,t})}{\partial \hat{x}_{A,t}} \frac{\partial Q(\hat{x}_{A,t}, \hat{x}_{B,t})}{\partial \hat{x}_{B,t}} > 0 \text{ and } \frac{\partial^2 Q(\hat{x}_{A,t}, \hat{x}_{B,t})}{\partial \hat{x}_{B,t} \partial \hat{x}_{A,t}} = 0, \text{ which implies} \\ & \frac{\partial^2}{\partial \hat{x}_{B,t} \partial \hat{x}_{A,t}} \ln[Q(\hat{x}_{A,t}, \hat{x}_{B,t})] < 0. \text{ Finally, this assumption includes the} \\ & \text{case in which } u = w\hat{x}_{A,t} + (1 - w)\hat{x}_{B,t}, \text{ and } Q(\hat{x}_{A,t}, \hat{x}_{B,t}) = R(u), \\ & \text{where } R(\cdot) \text{ is the logistic function } (1/[1 + \text{Exp}(-Su)]), \text{ or} \\ & R(\cdot) \text{ is the cumulative normal distribution function. For} \\ & \text{both these cases, } d^2 \ln[R(u)]/du^2 < 0, \text{ which implies } \frac{\partial^2}{\partial \hat{x}_{B,t} \partial \hat{x}_{A,t}} \\ & \ln[Q(\hat{x}_{A,t}, \hat{x}_{B,t})] < 0. \end{aligned}$$

### Asymptotic Joint Density

Let  $Z_A$  be the random variable that A's attitude,  $\hat{X}_{A,t}$ , would converge to as  $t \rightarrow \infty$ , if instead of sequential sampling we assumed that the individuals sampled in each period. Let  $g_A(z_A)$  be the density of  $Z_A$ . Because under the assumption of constant sampling the individuals' attitudes would be independent, their joint density can be written as  $g_A(z_A)g_B(z_B)$ . Let  $Y_A$  be the random variable that the attitude  $\hat{X}_{A,t}$  converges to as  $t \rightarrow \infty$ , under the assumption of sequential sampling. Following the same steps as in Appendix A, the asymptotic joint density of the attitudes can be written as

$$\begin{aligned} h(y_A, y_B) &= \frac{1}{Q(y_A, y_B)} g_A(y_A) g_B(y_B) \\ &= \frac{1}{\int \int \frac{1}{Q(y_A, y_B)} g_A(y_A) g_B(y_B) dy_A dy_B}. \end{aligned} \tag{B6}$$

*Theorem 1:* Let  $Y_A$  and  $Y_B$  denote the attitudes of A and B as  $t \rightarrow \infty$ . Then, under Assumptions 1–4, we have  $\text{Corr}(Y_A, Y_B) > 0$ .

*Proof.* Two random variables with joint density  $h(y_A, y_B)$  have a positive covariance if the following condition holds

$$h(y_A^*, y_B^*) h(y_A, y_B) > h(y_A^*, y_B) h(y_A, y_B^*), \tag{B7}$$

whenever  $y_A^* > y_A$  and  $y_B^* > y_B$  (e.g., Tong, 1980, Theorem 5.1.1, p. 80). Thus  $\text{Corr}(Y_A, Y_B) > 0$  whenever

$$\frac{g_A(y_A^*) g_B(y_B^*)}{Q(y_A^*, y_B^*)} \frac{g_A(y_A) g_B(y_B)}{Q(y_A, y_B)} > \frac{g_A(y_A^*) g_B(y_B)}{Q(y_A^*, y_B)} \frac{g_A(y_A) g_B(y_B^*)}{Q(y_A, y_B^*)}, \tag{B8}$$

or

$$\frac{Q(y_A, y_B^*)}{Q(y_A, y_B)} > \frac{Q(y_A^*, y_B^*)}{Q(y_A^*, y_B)}. \tag{B9}$$

*QED.*

*Theorem 2:* Suppose Assumptions 1, 2, and 3 of Theorem 1 hold. If A and B sample only when both of them want to, that

is,  $Q(\hat{x}_{A,t}, \hat{x}_{B,t}) = P(\hat{x}_{A,t})P(\hat{x}_{B,t})$ , then, as  $t \rightarrow \infty$ , the attitudes of the two individuals are independent random variables with zero correlation.

*Proof.* In this case, the asymptotic joint density is

$$h(y_A, y_B) = \frac{1}{P(y_A)P(y_B)g_A(y_A)g_B(y_B)}, \quad (B10)$$

$$\int \int \frac{1}{P(y_A)P(y_B)g_A(y_A)g_B(y_B)} dy_A dy_B$$

which is equivalent to

$$h(y_A, y_B) = \frac{\frac{1}{P(y_A)g_A(y_A)}}{\int \frac{1}{P(y_A)g_A(y_A)} dy_A} \frac{\frac{1}{P(y_B)g_B(y_B)}}{\int \frac{1}{P(y_B)g_B(y_B)} dy_B}, \quad (B11)$$

that is, it can be written as the product of two densities. As a result,  $Y_A$  is independent of  $Y_B$ . *QED.*

### Appendix C

#### Alternative Model

The alternative model makes the following four assumptions.

1. *Experiences.* The experiences of A,  $X_{A,t}$ ,  $t = 1, \dots$ , are independent normally distributed random variables with a mean of  $m_A$  and a standard deviation of 1. Similarly, the experiences of B,  $X_{B,t}$ ,  $t = 1, \dots$ , are independent normally distributed random variables with a mean of  $m_B$  and a standard deviation of 1. Finally,  $m_A$  and  $m_B$  are independent and each is drawn from a normal distribution with a mean of zero and a standard deviation of  $\sigma$ .
2. *Attitude formation.* The attitude of Individual A is the average of all his or her experiences so far.
3. *Individual desires to sample.* Individual A wants to attend the event only if his or her attitude is sufficiently positive. Formally, Individual A wants to attend whenever his or her attitude is above some threshold,  $c_{t,A}$ . Initially the threshold is assumed to be low because A will not avoid the event after just one or two negative experiences. If A's attitude is still negative after several observations, A will avoid the event. To model such a change in the threshold, we assume that  $c_{t,A} = -\alpha/n$ , where  $n$  is the number of observations made so far. This implies that A will only avoid the event after the first period if A's first experience is below  $-\alpha$ . If A's attitude is based on numerous experiences, A will avoid the event whenever A's attitude is negative.
4. *Joint decision about sampling in period t.* Both attend the event if one of them wants to.

This model also generates a positive correlation between the attitudes of A and B. For example, suppose that  $\sigma = 0.5$  and  $\alpha = 1.5$ . This implies that the average experiences ( $m_A$  and  $m_B$ ) tend to lie between 0.5 and  $-0.5$ . Moreover, the vast majority of all pairs continue to sample after the first observation. Only those individuals with an initial observation below  $-1.5$  want to avoid sampling, which is a rare event (its probability is 9%). Nevertheless, the average correlation between the attitudes of A and B after Period 50 is .30 (on the basis of 100,000 simulations). The correlation would be higher if the value of  $\alpha$  were lower, because avoidance is more likely then (the correlation is .40 if  $\alpha = 0.5$ ). The correlation would be lower if  $\sigma$ , the standard deviation in  $m_A$ , was larger, because this implies that the differences in their experiences are larger (the correlation is .14 if  $\sigma = 1$ ).

The reason for the positive correlation is the same as in the basic model: Whenever the attitude of B is positive, it is more likely that A will take another sample and change a negative attitude into a positive one. In contrast to the basic model, the attitudes of A and B eventually become stable in this model. The two individuals either stop sampling forever, which implies that their attitudes remain negative, or their attitudes converge to the average experiences ( $m_A$  and  $m_B$ ). This alternative model shows that the assumption that individuals avoid sampling as soon as their attitudes are negative is not necessary for a substantial social influence effect to emerge (as was the case in the above model, where  $S$  needed to be large). What is required is that sampling eventually becomes unlikely if the attitude is negative (i.e.,  $c_{t,A} \rightarrow 0$ , as  $t \rightarrow \infty$ ). The model also shows that a sizeable correlation can emerge even if the average experiences of the two individuals ( $m_A$  and  $m_B$ ) differ.

(Appendixes continue)

## Appendix D

## Empirical Implications

The expected value of  $\hat{x}_{A,t+1}$  given  $\hat{x}_{A,t}$  and  $\hat{x}_{B,t}$  is

$$E(\hat{x}_{A,t+1}|\hat{x}_{A,t}, \hat{x}_{B,t}) = Q(\hat{x}_{A,t}, \hat{x}_{B,t})[bE(X) + (1-b)\hat{x}_{A,t}] \\ + [1 - Q(\hat{x}_{A,t}, \hat{x}_{B,t})]\hat{x}_{A,t}, \quad (D1)$$

which implies

$$E(\hat{x}_{A,t+1}|\hat{x}_{A,t}, \hat{x}_{B,t}) = \hat{x}_{A,t} + bQ(\hat{x}_{A,t}, \hat{x}_{B,t})[E(X) - \hat{x}_{A,t}]. \quad (D2)$$

As a result, if  $Q(\hat{x}_{A,t}, \hat{x}_{B,t})$  is a strictly increasing function of both arguments and  $\hat{x}_{A,t}^* > \hat{x}_{A,t}$  and  $\hat{x}_{B,t}^* > \hat{x}_{B,t}$ ,

$$|E(\hat{x}_{A,t+1}|\hat{x}_{A,t}, \hat{x}_{B,t}^*) - E(\hat{x}_{A,t+1}|\hat{x}_{A,t}, \hat{x}_{B,t})| \\ = b|E(X) - \hat{x}_{A,t}| [Q(\hat{x}_{A,t}, \hat{x}_{B,t}^*) - Q(\hat{x}_{A,t}, \hat{x}_{B,t})]. \quad (D3)$$

Similarly,

$$|E(\hat{x}_{A,t+1}|\hat{x}_{A,t}^*, \hat{x}_{B,t}^*) - E(\hat{x}_{A,t+1}|\hat{x}_{A,t}^*, \hat{x}_{B,t})| \\ = b|E(X) - \hat{x}_{A,t}^*| [Q(\hat{x}_{A,t}, \hat{x}_{B,t}^*) - Q(\hat{x}_{A,t}^*, \hat{x}_{B,t})]. \quad (D4)$$

This implies that the inequality

$$|E(\hat{x}_{A,t+1}|\hat{x}_{A,t}, \hat{x}_{B,t}^*) - E(\hat{x}_{A,t+1}|\hat{x}_{A,t}, \hat{x}_{B,t})| \\ > |E(\hat{x}_{A,t+1}|\hat{x}_{A,t}^*, \hat{x}_{B,t}^*) - E(\hat{x}_{A,t+1}|\hat{x}_{A,t}^*, \hat{x}_{B,t})| \quad (D5)$$

holds whenever  $|E(X) - \hat{x}_{A,t}| = |E(X) - \hat{x}_{A,t}^*|$  and

$$Q(\hat{x}_{A,t}, \hat{x}_{B,t}^*) - Q(\hat{x}_{A,t}, \hat{x}_{B,t}) > Q(\hat{x}_{A,t}^*, \hat{x}_{B,t}^*) - Q(\hat{x}_{A,t}^*, \hat{x}_{B,t}). \quad (D6)$$

When  $Q(\cdot)$  is twice continuously differentiable, this latter inequality is equivalent to  $\partial^2 Q(\hat{x}_{A,t}, \hat{x}_{B,t})/\partial \hat{x}_{A,t} \partial \hat{x}_{B,t} < 0$ , which holds for the basic model.

More generally, because  $E(\hat{x}_{A,t+1} - \hat{x}_{A,t}|\hat{x}_{A,t}, \hat{x}_{B,t}) = bQ(\hat{x}_{A,t}, \hat{x}_{B,t})[E(X) - \hat{x}_{A,t}]$ , it follows that the inequality

$$\frac{E(\hat{x}_{A,t+1} - \hat{x}_{A,t}|\hat{x}_{A,t}, \hat{x}_{B,t}^*)}{E(\hat{x}_{A,t+1} - \hat{x}_{A,t}|\hat{x}_{A,t}, \hat{x}_{B,t})} > \frac{E(\hat{x}_{A,t+1} - \hat{x}_{A,t}^*|\hat{x}_{A,t}^*, \hat{x}_{B,t}^*)}{E(\hat{x}_{A,t+1} - \hat{x}_{A,t}^*|\hat{x}_{A,t}^*, \hat{x}_{B,t})} \quad (D7)$$

holds whenever Equation B1 holds.

Finally,

$$\ln[E(|\hat{x}_{A,t+1} - \hat{x}_{A,t}| |\hat{x}_{A,t}, \hat{x}_{B,t})] = \ln(b) + \ln Q(\hat{x}_{A,t}, \hat{x}_{B,t}) \\ + \ln|E(X) - \hat{x}_{A,t}|, \quad (D8)$$

and

$\partial^2 \ln[E(|\hat{x}_{A,t+1} - \hat{x}_{A,t}| |\hat{x}_{A,t}, \hat{x}_{B,t})]/\partial \hat{x}_{B,t} \partial \hat{x}_{A,t} = \partial^2 \ln Q(\hat{x}_{A,t}, \hat{x}_{B,t})/\partial \hat{x}_{B,t} \partial \hat{x}_{A,t}$ , which is negative whenever Equation B1 holds. Empirically, this implies that  $\beta_{AB}$  should be negative and significant if the following regression is estimated by OLS:

$$\ln|\hat{x}_{A,50} - \hat{x}_{A,49}| = \alpha + \beta_A \hat{x}_{A,49} + \beta_B \hat{x}_{B,49} + \beta_{AB} \hat{x}_{A,49} \hat{x}_{B,49}. \quad (D9)$$

Received December 21, 2005

Revision received August 29, 2006

Accepted September 23, 2006 ■