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Information Cascades and Rational Conformity

Information Cascades, Herding Behaviour, Conformity, Bayes' Rule, Rationality

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An information cascade is a pattern of matching decisions. A cascade can occur when people observe and follow "the crowd," which can be rational if the information revealed in earlier decisions outweighs one's own private information.

Introduction

When individuals obtain private information and make publicly observed decisions in a sequence, the first decisions tend to reveal private "signals." If early decisions show a clear pattern, the information inferred from these actions may outweigh any one person's private information. This inference can cause people to "follow the crowd," even when the group consensus conflicts with their own private information. This type of sequential conformity is termed an "informational cascade" in a seminal paper by Bikhchandani, Hirschleifer, and Welch (1992). For example, consider an employer who interviews a job applicant and forms a good impression. The employer, however, does not offer the job after discovering that the worker has been turned down previously by other employers. Even though this decision is in conflict with the employer's own information, it may be rational if the employer concludes that the other interviews went badly, and that the aggregate information implied by past interviews more than offsets the employer's own positive evaluation. Notice that even a qualified applicant may make a bad impression on any given day, and hence, may end up having trouble finding a job after several unsuccessful attempts. Bannerjee (1992) uses the term "herd behaviour" to describe similar patterns of conformity that arise in models where individuals must decide which type of financial asset to purchase. Indeed much of the interest in cascade behaviour arises from attempts to explain fads in investment behaviour.

Conformity Incentives

There may, of course be non-informational factors that produce conformity in social interactions. Sometimes people prefer to behave like the others in a group, and such behaviour has even been recommended:

> "To do *exactly as your neighbours* do is the only sensible rule…" (Emily Post, 1927, Chapter 33).

There may be social stigmas and punishments associated with nonconformity. For example, an economic forecaster may prefer the chance of being wrong with everybody else to the risk of providing a deviant forecast that turns out to be the only incorrect guess:

> "Worldly wisdom teaches that it is better for reputation to fail conventionally than to succeed unconventionally." (John Maynard Keynes, 1965, p. 158)

Some research suggests that people prefer to maintain the *status quo* (Samuelson and Zeckhauser, 1988). For example, subjects in experiments were provided with a scenario in which they inherit a portfolio of cash and securities and are asked whether to leave the portfolio intact or to change it by investing in other securities. There was a strong tendency for individuals to retain portfolio A when it was listed as the current portfolio, and to retain portfolio B when it was listed as the current portfolio. A similar tendency was observed in response to other matched pairs of questions that alternated descriptions of the previous choice. Such a "status quo bias" may explain herding behaviour in sequential decision situations. These decision patterns do not allow us to distinguish between behaviour based on a preference for conformity and behaviour that is motivated by information inferred from prior decisions. In particular, the person inheriting a portfolio from a rich uncle might conclude that the uncle's wealth was due to wise portfolio choices that should be imitated. Laboratory experiments can be used to set up and control information flows in order to distinguish among alternative explanations of herding behaviour.

Rational Information Cascades

A numerical example can be used to illustrate the concept of a rational information cascade (Anderson and Holt, 1997). In this example, there are two equally likely events, A and B, that might represent whether a particular patent is marketable or not. Decision makers obtain private signals, *a* and *b*, which are correlated with the event. In particular, $pr(a|A) = pr(b|B) = 2/3$, so the error rate is 1/3 for each signal. For example, the signal might be the result of a consultation with outside experts. The key assumption of this model is that each person's private signal is correlated with the event but is independent of the other signals. After observing their signals, individuals are approached one by one in a sequence and are asked to make a prediction about which event has occurred. People find out the prior predictions, if any, made by others, but they cannot observe others' private signals. Thus the prediction made by the first person is based only on that person's signal and hence, will "reveal" the signal, since the signal is more likely to be correct than not.

Suppose the first person sees a *b* signal and publicly predicts event B. If the second person in the sequence sees a *b* signal, it is rational for this person to also predict B. If the second person sees an *a* signal, the observed and inferred signals essentially cancel each other, and each state is equally likely. We observe from laboratory experiments that individuals almost always use their own information in such cases, and therefore, the second decision will reveal the person's private signal, whether or not it conforms to the first prediction. When the first two individuals in the sequence observe the same signal, e.g. *b*, their decisions will also match. In this case, the information inferred from the matching decisions is greater than the information contained in any one private signal. In particular, if the first two people choose B, then the third person should also choose B, even if that person's private signal is *a*. Information cascades form in this manner, and the effect is that all subsequent decision makers will follow a pattern established by the first ones in the sequence.

This example was used by Anderson and Holt (1997) in a laboratory experiment in which subjects were paid a cash reward for each correct prediction. The events were referred to as "urn A" and "urn B." Each urn was a cup with three coloured balls, which we will refer to as "*a*" or "*b*" signals. There were two *a* balls and one *b* ball in urn A, and there were two *b* balls and one *a* ball in urn B.

Urn A: *a, a, b* Urn B: *b, b, a*

A random device was used to select the urn, with each event being equally likely, and therefore, each of the six balls listed above is equally likely, *ex ante*, to be drawn. Suppose that the draw is *b*. Since two of the three *b* balls are in urn B, it follows that the posterior probability of urn B given a draw of *b* is 2/3. (This is an example of the application of Bayes' rule, or more precisely the ball counting heuristic used here corresponds to the conditional probability calculations that are referred to as Bayes' rule. See Holt and Anderson (1996) for a discussion of how the simple counting heuristic can be used to make Bayesian calculations in more complicated settings. This paper provides an intuitive explanation of the mathematical expression of Bayes' rule.) Of course it is intuitively obvious that the probability of urn B is greater than ½ when the signal is *b*. Holt and Anderson (1996) show that the probability of urn B is still greater than ½ when first two predictions are B and the third person's signal is *a*. Thus, a cascade can begin with two matching decisions, and all subsequent decision makers should follow a pattern established in this manner. Information cascades may not form immediately if there is not an imbalance in predictions. Suppose, for example, that the first two predictions are A and B, so the third person would consider each urn to be equally likely, prior to seeing a private signal. If the third and fourth decision makers both predict B, then this imbalance in favour of B would cause the fifth person to predict B, regardless of that person's private signal.

The previous calculations are based on a model of perfect rationality. The purpose of an experiment is to determine how people actually behave in such situations. Anderson and Holt (1997) used the "ball and urn" setup described above in order to remove any preference for conformity that is not based on informational considerations. Subjects were placed in small cubicles and were shown a single ball drawn from the relevant urn, but they could not see which urn was being used.

Subjects were selected in a random order to make their predictions, which were announced by a neutral assistant who did not know the signals or which urn was being used. (Allowing subjects to announce their own predictions could have given them the chance to convey additional uncontrolled information by tone of voice, etc.) After all predictions had been announced, a non-decision-making subject serving as a "monitor" announced which urn had actually been used. Those with correct predictions were paid $2, and others earned nothing for that trial. There were fifteen trials and six decision-making subjects in each session. Altogether, there were twelve sessions in the experiment, each of which was conducted on a different day.

The sequences of draws made cascades possible in more than half of the trials, and cascades actually formed in about seventy percent of the trials in which they were possible. A particularly interesting trial is shown below:

Subject:	58	57	59	55	56	60
Observes:	*b*	*b*	*a*	*b*	*a*	*a*
Predicts:	B	B	B	B	B	B

Notice that three of the last four decision makers follow the pattern established by subjects 58 and 57, despite contradictory private information. In this case, all six individuals earned $2, since urn A was actually used for the draws. Generally, prior information is informative, and cascade behaviour tends to increase the accuracy of predictions and hence, to increase earnings. It is possible, however, for initial predictions to be incorrect, which may create an incorrect cascade. This occurred in another trial:

Subject:	57	58	59	55	60	56
Observes:	*a*	*a*	*a*	*a*	*a*	*a*
Predicts:	A	B	B	B	B	B

In this case the first person's prediction revealed their signal, but the second person made a serious error in predicting B after seeing an *a* signal and a prior A prediction. The third person predicted B, which was also an error, since previous predictions were balanced and their own signal suggested urn A. All of the remaining individuals predicted B, which turned out to be incorrect, since urn A was used.

The most common type of error occurred when a person saw a signal that was inconsistent with the implication of prior predictions. In this case, the optimal Bayesian prediction is to follow the established pattern, and subjects deviated in about ¼ of the cases where their own private information was inconsistent with this pattern. In summary, the general tendency was for subjects to use the information implied by previous decisions correctly, which produced rational information cascades with considerable frequency. There were, however, deviations that could either break a cascade or that could result in incorrect cascades, as shown above. Incorrect cascades also occasionally resulted from "unlucky" incorrect decisions observed by early decision makers.

This pattern of results was replicated by Hung and Plott (2001), who added some interesting treatment variations. In one of their experiments, the incentive structure was altered so that subjects received a positive payoff only if the majority of the group made the correct prediction. (This is somewhat like a jury whose decision is determined by a majority vote.) The effect was to reduce conformity for early decisions because individuals have an incentive to signal their information so that others can make better decisions. A second treatment rewarded conformity directly in the sense that subjects received a positive payoff only if their decision matched that of the majority.

Applications to Markets and Other Social Institutions

Strong movements in stock prices are sometimes attributed to herd-like behaviour. Keynes (1965) noted the similarity of investment decisions and a guessing game in which participants have to predict which contestant in a beauty contest will get the most votes. The fascinating aspect of this game is that each person has to think about who the others think is attractive, and also about who the others think others will find attractive, etc. Similarly, when investing in stocks, one would like to guess which enterprises will become popular with other investors, since a strong demand will raise the prices of those stocks. A herd-like response may move asset prices out of line with market fundamentals, which sets the stage for an equally strong stampede in the other direction. Such behaviour could be due to seemingly irrational "animal spirits," to use Keynes' colourful term, or it could be due to a rational tendency to follow others' decisions when they are based on independent sources of information. Christie and Huang (1995), for example, argue that it can be rational to follow others' decisions during surges or declines in stock prices, i.e. to rely on inferences derived from information that is aggregated by market prices.

Other applications are suggested by the Hung and Plott (2001) majority voting treatment. In a trial, for example, jurors may form independent judgements about the guilt or innocence of a defendant, but such judgements are often changed in the process of voting and deliberation. In this manner, herd behaviour can create the consensus needed to avoid a "hung jury." We have conducted some experiments (work in progress) that simulate the sequential jury voting set up, and strong patterns of cascade-like conformity are observed in many cases.

Decisions may occur in sequence in these applications, e.g. as stock purchases come across a ticker tape, but the order of decisions is not exogenously specified as it was in the experiments discussed above. The order of voting is not exogenous in jury voting unless the foreman chooses to take votes by going around the table. Similarly, stock purchases or responses to IPOs (initial public offerings) are not subject to order requirements. Plott, Wit and Yang (1997) report some parimutuel betting experiments with an endogenously determined order of play. The incentive structure is like that of a horse race in which the purse is divided among those who bet on the winning horse, in proportion to their bets. The experiment was presented as a choice between six assets, with only one of them offering positive earnings, depending on the realized state of nature. Investors had private, noisy information about the assets, and they could observe others' bets as they were made. A considerable amount of information aggregation was observed in these experiments; with the asset prices accurately indicating the correct state in most cases. In some cases, however, heavy purchases of an asset triggered more purchases, even though the asset being purchased turned out not to be the one that paid off. This corresponds to an incorrect cascade. The application of information cascade theory to asset markets in richer and more realistic settings is a prime area for future research.

Summary

Theoretical models of "herding" pertain to situations where individuals observe private signals that are correlated with some unknown event. Predictions about the event are made in sequence, with later decision makers being able to base their predictions on their own signal and on information inferred form prior decisions. The first few decisions tend to reveal the private signals, which may establish a pattern of matching predictions that others follow, even if the conforming predictions are different from the prediction that would be best given the person's own private signal. This type of "information cascade" can produce conformity that is rational, because the information content in prior decisions may outweigh that in one's own private signal. There is some laboratory evidence to support such theories of rational cascades, although individuals do make mistakes, and behaviour is sometimes pulled by biases and heuristics that may lead to non-Bayesian decisions.

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