Herd Behavior

TATSUYA KAMEDA and REID HASTIE

Abstract

There are many manifestations of herding in the human species—one of the most socially interdependent species on the earth. *Herding* here refers to an alignment of thoughts or behaviors of individuals in a group through local interactions among individuals rather through than some purposeful coordination by a central authority in the group. Herding underlies many collective phenomena in the Internet era, ranging from everyday social behavior, consumer choices, economic bubbles, and political movements. Accumulating evidence in various behavioral science disciplines suggests that we humans are equipped with neural, psychological, and behavioral mechanisms that constitute our highly socially sensitive minds. These built-in mechanisms are evolutionary products that have promoted our survival. Yet, these adaptive tools can cause serious errors in modern environments, in which interconnectivities of individuals are much denser and externalities accruing from individual behaviors are much greater and more far-reaching, compared to primordial environments in which the human mind evolved. Growing evidence in the behavioral sciences also suggests that the two contrasting collective phenomena in humans, maladaptive herding and the wisdom of crowds, are based on similar underlying mechanisms. In this sense, the two apparently opposite macro phenomena may be seen as twins produced and governed by the social receptivity of our minds. Given this commonality, understanding the neural, psychological, and behavioral mechanisms that could distinguish these twins will be one of the most important challenges for behavioral sciences in the next decade.

In an increasingly connected world, an event in one place, be it economic, political, or social, can cause large-scale chain reactions across many other places. We have abundant examples of this sort, including the recent global financial crisis, the spread of civil uprisings in the Middle East, the widespread adoption of technological innovations such as the iPad, and so on. Until recently, such mass phenomena have been studied sporadically across social science disciplines without much mutual communication. Yet, with advances in technology and new theoretical frameworks, these mass phenomena are becoming a focus of substantial interdisciplinary interests (Akerlof & Shiller, 2009). An umbrella concept, "herding," has facilitated such cross-disciplinary communication over the past 5 years.

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HERD BEHAVIOR: A DEFINITION AND EXAMPLES

What is meant by herding? *Herding* refers to an alignment of thoughts or behaviors of individuals in a group. Most importantly, such convergence often emerges through local interactions among agents rather than through purposeful coordination by a central authority or a leading figure in the group. In other words, the apparent coordination of the herd is an emergent property of local interactions (Raafat, Chater, & Frith, 2009).

Textbook examples of herding in the social science literature include riots, panics, fads, mass hysterias, urban legends, economic bubbles, and so on (Smelser, 1963; Turner & Killian, 1993). However, besides these familiar examples, recent research suggests that herding may encompass a much wider range of our social behaviors than had been previously thought.

Crimes

Proliferation of crimes in a city may be seen as an example of herding. One of the most striking aspects of crime is that crime rates vary dramatically across time and space. For example, homicide rates across nations ranged from 6.1 cases per million in Japan, 12.6 in Sweden, to 98.0 in the United States in 1990. Within the United States, rates of serious crimes in the year ranged from 0.008 per capita in Ridgewood Village, New Jersey to 0.384 in nearby Atlantic City (Glaeser, Bruce Sacerdote, & Scheinkman, 1996). Such high variances are observed within cities as well, where one street can have much higher crime rates than streets just a few blocks away.

One obvious explanation for such variety may be that socioeconomic conditions also vary over time and space, creating temporal and geographical clusters of crime. However, an econometric analysis by Edward Glaeser and others showed that less than 30% of the variation in cross-city or cross-district crime rates could be explained by the local socioeconomic differences. These researchers developed a model in which agents' decisions about crime were a function of their own attributes (e.g., socioeconomic as well as psychological attributes) and of their neighbor's decisions about criminal activities. Glaeser and others then estimated impacts of the second element of the model (i.e., social influence from neighbors) for a variety of crimes in the United States in 1985, in 1970, and across New York City in 1985. The results showed that a positive interaction among agents' decisions about crime was the only viable explanation for the large residual variance not explained by the local socioeconomic conditions. More specifically, the local social influence was strong for larceny and auto theft; moderate for assault, burglary, and robbery; and weak for arson, murder, and rape. These results suggest that one agent's decision to commit crimes (especially minor crimes) affects his or her neighbor's decisions, which constitutes a positive feedback loop for the collective. The large variations in crime rates across time and space seem to emerge as aggregated outcomes of such individual local decisions.

Obesity

Recent research suggests that obesity may be contagious as well. Using a data set from a longitudinal survey on cardiovascular disease (the Framingham Heart Study; see http://www.framinghamheartstudy.org/), Nicholas Christakis and James Fowler (2007) examined how social relations in a community affect obesity. The original survey traced health states of people residing in Framingham, Massachusetts, over 32 years. Christakis and Fowler focused on family and friendship relations among the participants, and applied longitudinal statistical models to examine whether weight gain in one person was associated with weight gains in his or her friends, siblings, spouse, and neighbors.

Results of the network analysis revealed that obese people (defined as those with a body mass index >30) and nonobese people formed different clusters and that social influences through the network extended up to three degrees of separation. In other words, the average obese person was more likely to have obese friends, friends of friends, and friends of friends of friends than was the average nonobese person. Moreover, a person's chances of becoming obese increased by 57% if he or she had a friend who became obese in the time period, by 40% if a sibling became obese, and by 37% if a spouse became obese. These patterns suggest that obesity spreads through social network similar to a pathogen. A person's overeating behavior is affected through the social network, even if one may not know another overeater directly. Segmentations of obese and nonobese people in a community seem to emerge as aggregated consequences of local influences (see also Lyons, 2011, for criticisms of the social network analysis employed by Christakis and Fowler).

Happiness

Happy people and unhappy people also seem to inhabit different clusters in a community. A reanalysis of the Framingham Heart Study data set suggested that these clusters did not simply reflect a tendency for individuals to associate with similar individuals. Instead, these macro patterns resulted from spread of happiness and unhappiness through the social network, just as in the case of obesity. According to the analysis, the probability that one was happy increased by 25% if a friend who lived within a mile became happy, and these local influences also extended up to three degrees of separation. Thus, similar to obesity, happiness also seems to be contagious (Fowler & Christakis, 2008).

WHY DOES HERDING OCCUR?—POTENTIAL MECHANISMS

The earlier examples suggest that herding is a robust phenomenon, characterizing a wide range of social behaviors in our life. If so, what are the neural, psychological, or sociological mechanisms that produce herding?

EMOTIONAL CONTAGION, FACIAL MIMICRY, AND MIRROR NEURONS

As implied by the saying that your smile makes others happy, humans often reproduce others' emotions in themselves. This phenomenon, which is called *emotional contagion* (Hatfield, Cacioppo, & Rapson, 1994), has long been known among psychotherapists who treat depressed clients. Therapists, especially those who are inexperienced, sometimes "catch" their clients' emotions expressed during interviews, and feel themselves depressed afterwards. Elaine Hatfield and her colleagues see emotional contagion as a primitive, automatic, and unconscious process. It occurs through a series of steps: when a receiver is interacting with a sender, he or she first perceives the emotional expressions of the sender. The receiver then automatically transfers the perceived emotional expressions to his or her bodily expressions (e.g., facial expressions, postures). Through the process of afferent feedback, these mimicked bodily expressions are translated into the receiver feeling the same emotion that the sender experienced, which leads to emotional convergence among the sender and the receiver.

Indeed, it can easily be demonstrated that we have a tendency to mimic the facial expressions of others in everyday social interactions. Research suggests that such facial mimicry is an automatic, reflex-like process, in which the observer's facial expression matches the observed facial expression (e.g., happy, sad, fearful, angry, disgusted faces) rather quickly—typically within less than a second (Hess & Blairy, 2001). Such automatic mimicry extends to bodily posture, voice pitch, and so on, and is known to emerge very early in human development. Even 12- to 21-day-old infants imitate both facial and manual gestures displayed by an adult model (Meltzoff & Moore, 1977).

Furthermore, recent developments in neuroscience suggest that there may be a biological system in our brains that helps us to mirror others' actions. One of the most intriguing recent findings in brain science is the discovery of "mirror neurons." In the late 1980s when Giacomo Rizzolatti and others were recording electrical activity in the brain of a macaque, these researchers found neurons that fired both when the animal acted and when the animal observed the same action performed by another. The same neurons fired when the monkey grasped something with its hand, *and* when the monkey observed the experimenter grasping it. However, these neurons did not discharge in response to simple presentation of food or other interesting objects. The neuron "mirrored" the motor behavior of the other, as though the observer were itself executing the motor act. Although it remains controversial, some recent data suggest that a similar "mirror neuron system" exists in human brains as well (Rizzolatti & Craighero, 2004).

Taken together, these psychological, behavioral, and neural findings strongly suggest that mimicking others may be a fundamentally human activity.

Social Norms, Mutual Expectations, and Shared Stories

Another mechanism for herding involves more conscious, deliberate, and controlled psychological processes, that are distinguishable from our automatic "aping" propensities as reviewed earlier. These processes have been studied mainly by social psychologists.

Classic experimental demonstrations of such herd behaviors in social psychology include the famous line-comparison perception study by Solomon Asch, where subjects conformed to an erroneous majority view to avoid potential embarrassment or other social consequences in a group (Asch, 1956); the optical judgment study by Muzfer Sherif demonstrating that individual perceptions of the autokinetic illusion converged to a shared social reality through communication (i.e., everybody in the same group ended up experiencing a similar optical illusion Sherif, 1936), and so on.

A key element underlying these herd behaviors is a fundamental characteristic of our mind, which may be labeled docility or receptivity to social norms (Kameda & Tindale, 2006; Simon, 1990). Herbert Simon defined this concept as our tendency to depend on others' suggestions, recommendation, persuasion, and information obtained through social channels as a major basis of choice. Compared to other gregarious species, humans are unique in developing social norms and mutually shared expectations, which inform us about what action is normal, appropriate, or fair in a given social situation. As seen in the Asch experiment, the human mind is built to be receptive to social norms, and tends to self-censor actions in order to avoid violating norms. Notice that the high receptivity to social norms is also fundamental to our ability to learn culturally. Humans are a cultural species that can take full advantage of socially acquired knowledge. Without docility by learners to their "cultural parents," such cognitive capacities would be highly limited (Tomasello, 1999).

The human mind is also built to think in terms of, and be influenced by, narratives or stories (sequences of events with an internal logic and dynamics: Shank & Abelson, 1977). Stories, especially stories shared in a community or across a whole society, lead us to see, interpret, have feelings about, and react to experiences from a shared perspective (see Akerlof & Shiller, 2009, for interesting recent examples of influential political-economic stories).

This characteristic social receptivity of individual minds can yield effects that are visible at the societal level. In the aforementioned case of contagious obesity, for example, one may decide to eat more because the action seems to be normal given one's spouse's or friend's eating practices, which in turn provides a normative signal for another's overeating. Our actions have spillover effects (which economists call externalities) on others, which can lead to spiraling proliferations of action across a whole society (Granovetter, 1978).

Rational Conformity and Information Cascades

Sometimes it is rational to conform to a majority behavior in a group, even if one would otherwise choose differently. Hans Christian Andersen's "The Emperor's New Clothes" provides a case in point. To recall, an emperor who cares greatly about his appearance and attire hires two tailors who promise him the finest suit of clothes made from a fabric invisible to anyone who is inferior or "just hopelessly stupid." The Emperor cannot see the cloth himself, but pretends as if he can for fear of appearing unfit for his exalted position or stupid, and is joined in this pretense by his ministers, subordinates, and subjects. Notice that the "spiral of silence" (Noelle-Neumann, 1993) occurs because it is rational to keep quiet given another's silence. Standing up to tell the truth is risky given a possibility (even if it may be small) that the cloth may be visible to another's eyes. This situation is also called *pluralistic ignorance* in social psychology (Katz & Allport, 1931) that occurs when a majority of group members privately reject a norm, but assume (incorrectly) that most others accept it; no one believes, but everyone thinks that everyone else believes. If such a perception holds for everybody simultaneously, this constitutes an equilibrium where one's unilateral deviations (seem to) work against oneself. A bank run that is triggered initially by some groundless rumor provides a similar example, where the (ungrounded) prophecy of bankruptcy can be self-fulfilling through a positive feedback loop (Merton, 1968).

Information cascades are another example of rational conformity. An information cascade occurs when it is optimal for an individual, who has observed the "consensus" prior actions of others, to follow the predecessors' actions regardless of the private information known to that individual. Some forms of herding behaviors in financial markets, legal decision making (Farnsworth, 2007), and other collective endeavors can be understood as manifestions of cascades. Sushil Bikhchandani and others illustrated this process with an example of a paper submission to an academic journal (Bikhchandani, Hirshleifer, & Welch, 1992). A referee in a first journal reads the submitted paper, assesses its quality, and makes a decision about whether to accept or reject it. Now suppose that a referee at a second journal learns that the paper was rejected by the first journal. Assuming that the referee cannot evaluate the paper's quality perfectly, knowledge of the previous rejection should (rationally) make the referee lean toward rejection. If the paper is rejected at the second journal, this process can continue at other journals, yielding a chain of rejections. Economists proposed a model that showed that, at some stage in a sequential-choice task, a rational decision maker should ignore his or her private information and act only on the public information obtained from previous decisions. Once this stage is reached, all decision makers thereafter in the sequence should do the same, producing an information cascade. And if the earlier decisions in the sequence happen to be erroneous (e.g., rejecting a high-quality paper), the cascade leads to undesirable outcomes (Anderson & Holt, 2008; Banerjee, 1992).

HERDING AND THE WISDOM OF CROWDS

The mechanisms reviewed, ranging from unconscious, automatic mimicry to reasoned, deliberate conformity to rational herding, are fundamental building blocks of collective phenomena. The robustness of these mechanisms, raises a question about nature of herding: Is herding always problematic, as is implied by some popular images (e.g., mass hysterias, mobs, panics, fads, economic bubbles, and groupthink)? What about "the wisdom of crowds," a contrasting image of collective behavior, popularized by James Surowiecki? While herding in humans often refers to defective social processes that degrade toward suboptimal performance, the "wisdom of crowds" implies intelligent group processes that can have collective benefits (Surowiecki, 2004). How can we reconcile the two contrasting images of collective action?

Group Decision Making by Honeybees

It seems instructive to extend our scope to include herd behavior by nonhuman animals that also live collective lives. Although humans are a gregarious species, we are arguably not the most gregarious species of all. Our rivals in this respect are eusocial animals, including, for example, bees, ants, termites, and naked mole rats. Eusocial species are colonial animals that live in multigenerational genetically related groups, in which the vast majority of individuals cooperate to aid a relatively few reproductive group members. They often exhibit extreme task specialization, which makes colonies efficient in gathering resources.

The puzzle of these species is how they can achieve such high efficiencies collectively, despite the fact that they have relatively much smaller brains as compared to humans. More specifically, how do they avoid defective social processes leading to problematic herd behavior? We examine group decision making by honeybees to address these questions.

In late spring or early summer, as a large hive outgrows its nest, a colony of honey bees often divides itself. The queen leaves with about two-third of the worker bees to create a new colony, and a daughter queen stays in the old nest with the rest of the worker bees. The swarm leaving the colony must find a new home in a short time, which is essential to their survival. The moving swarm, which is composed of 10,000 or so bees, clusters on a tree branch, while several hundred scout bees search the neighborhood for a new home. These scout bees fly out to inspect potential nest sites, and upon returning to the swarm, perform waggle dances to advertise any good sites they have discovered. The duration of the dance depends on a bee's perception of the site's quality. Other scout bees that have not flown out yet, as well as those that have stopped dancing, observe these dances and decide where to visit. In these decisions, the bees are likely to visit and inspect the sites that have been advertised strongly by many predecessors. This process constitutes a positive feedback loop. Thomas Seeley and others, who conducted a series of experiments with honeybees in natural settings, found that the bees usually choose the best nest site. Even though none of the bees visit all the potential nest sites individually, they can aggregate partial individual information to form a collective wisdom that enables optimal decisions (Seeley, 2010).

Although the bees' performance is impressive, the puzzle still remains. How do the bees solve the problem of interdependency? As we have seen, the bees communicate their findings via waggle dances that are performed sequentially by scout bees. This could create statistical dependencies among decision makers, in which initial errors committed by earlier scouts can carry over and be amplified in the sequence. In this sense, the honeybee group decision-making system may be susceptible to the erroneous information cascade (Kameda, Wisdom, Toyokawa, & Inukai, 2012).

A recent paper has addressed this question theoretically with a computer simulation model (List, Elsholtz, & Seeley, 2009). In line with the previous empirical observations, the model assumes that scout bees are dependent on other bees in that they give more attention to nest sites strongly advertised by their predecessors. The bees essentially conform to a majority view in their decisions about where to visit. However, simultaneously, the model assumes that the bees are independent in assessing the quality of the visited site. The duration of the scout's dance, which indexes the strength of the bee's preference for the site, is *not* affected by others' waggle dances, but is determined *solely* by the scout's own perception of the site's quality. The computer simulation results showed that, when a suitable mixture of *conformity and independence* exists, the honeybee group decision-making process works well. Of course, this particular mix of conformity and independence solves the rational information cascade problem.

Collective Wisdom on the Internet?

Honeybee nest search provides an impressive example of how animals that have only limited cognitive capacity as individuals can make “wise” decisions collectively as a swarm. It is also important to note that the “swarm intelligence” (Krause, Ruxton, & Krause, 2009) in honeybees emerges not from some purposeful coordination by a central authority (e.g., the queen) but through local interactions among the bees—a key element in the definition of herding, as discussed earlier in this essay. Interestingly, the honeybee nest-search situation seems to have counterparts in modern human societies, where individuals can use public information as well as private information to make a well-informed decision. Examples include information search on the Internet when buying books or music, choosing a restaurant for dinner, deciding which hotel to stay at, and so on. Potential options are quite large in number, yet our time budget for private information search is limited. In these occasions, we often visit relevant websites (e.g., Amazon, Yelp) to see how others have decided. Do these social information-pooling systems on the Internet, in which individuals informed by predecessors’ experiences report their own new experiences to share with others, yield collective wisdom as in the honeybee case?

A recent experiment on a “cultural market” by Matthew Salganik and others examines this question (Salganik, Dodds, & Watts, 2006). In cultural markets, sales volumes of hit songs, books, and movies are many times greater than sales for a typical product. This might imply that the hits are qualitatively different from “the rest,” yet experts can rarely predict which cultural products will succeed. Why is predicting hits so difficult?

Intrigued by the unpredictability of cultural markets, these researchers created an experimental music market, where a total of 14,341 participants downloaded previously unknown songs under one of two conditions—the “social influence” condition or the “independent” condition. In both conditions, participants could listen to any song they were interested in to have a direct experience of the product. On top of the individual learning opportunity, participants in the “social influence” condition were provided information about how many times each song had been downloaded by other participants. Notice that there is a structural similarity between the social influence condition and the honeybee nest search situation. In both situations, agents had to make choices between unfamiliar options that could differ in quality. Also, when making individual decisions, social frequency information (predecessors' behaviors) was available, in addition to the opportunities for individual information search.

The experiment revealed that inequality in overall download counts among songs was much greater in the social influence condition, as compared to the independent condition in which participants could not access the social-frequency information. Obviously, participants in the social influence condition copied predecessors' choices, which produced a "rich get richer" outcome. Thus, the experiment replicated the robust phenomenon in cultural markets that hit songs are many times more successful than average.

Furthermore, the most popular songs (with the highest download frequencies) in the independent condition did not necessarily match the most popular songs in the social influence condition. Mapping of the songs in terms of popularity ranking between the two conditions was moderate—the most popular songs in the independent condition never did badly in the social influence condition, and the least popular songs never did extremely well either. However, almost any other result could happen. The success of a song in the social influence condition was path-dependent and susceptible to random fluctuations. This may explain why it is difficult for even experts to predict which products will succeed in cultural markets.

Overall, how did the human performance in the experimental music market compare to the honeybee performance in nest search? A tentative answer does not seem to be flattering to humans. Honeybees mix dependence and independence in nest search. They conform to predecessors to decide which sites to visit, but assess the quality of the visited sites independently from predecessors' evaluations. This leads to the typical swarm's high performance. On the other hand, human participants in the experimental music market seemed to fail to separate the two aspects and relied too much on others' choices. Of course, the inherent subjectivity of music preferences means that the quality of experimental cultural market outcomes cannot be assessed objectively (as can the nest choice decisions). Yet, the lack of correspondence in song popularity between the independent and the social influence conditions suggests that such subjective preferences are unstable and nonoptimal. In this sense, the hypersusceptibility of mass behavior to social influence is problematic not only for marketers of cultural products but also in other sociopolitical domains where no demonstrably correct answer exists (see Hastie & Kameda, 2005; Kameda, Tsukasaki, Hastie, & Berg, 2011; Toyokawa, Kim, & Kameda, 2014, for assessments of the "wisdom of crowds" when decision quality can be assessed objectively).

CONCLUSION

In this essay, we have reviewed various manifestations of herding in humans. As we have seen, humans are a highly socially receptive species, as compared to other gregarious animals. Accumulating evidence from various behavioral science disciplines strongly suggests that we humans are equipped with neural, psychological, and behavioral mechanisms that support this receptiveness—our abilities to learn from and be influenced by others. It is no doubt that these capacities are mechanisms, selected by evolution, that have served our survival and contributed to our adaptive success on the earth. Yet, these adaptive tools can cause serious errors in modern environments, in which interconnectivities of individuals are much denser and externalities accruing from individual behaviors are greater and more far-reaching, as compared to ancient environments in which the human mind evolved.

Interestingly, growing evidence in the behavioral sciences also suggests that the two contrasting collective phenomena in humans, maladaptive herding and the wisdom of crowds, are both produced by similar basic mechanisms (Kameda *et al.*, 2011, 2012). In this sense, the two apparently opposite macro phenomena may be seen as twins produced and governed by our basic human social receptivity. Given this commonality, understanding the neural, psychological, and behavioral mechanisms that could help distinguish these twins will be one of the most important challenges for behavioral sciences in the next decade.

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TATSUYA KAMEDA SHORT BIOGRAPHY

Tatsuya Kameda is currently a professor of Social Psychology at the University of Tokyo after spending 20 years as a professor of behavioral science at Hokkaido University. He led the Global COE (Centers of Excellence) project funded by the Japanese Government (2007–2012), as a director of the Center for Experimental Research in Social Sciences at Hokkaido University. He studies social behavior from the adaptationist perspective, through combining evolutionary games and agent-based simulations with behavioral, cognitive, and fMRI experiments (http://lynx.let.hokudai.ac.jp/~kameda/). He was a Fulbright Research Fellow at the University of Colorado at Boulder (1997–1998), a Deutscher Akademischer Austausch Dienst Research Fellow at Max Planck Institute for Human Development in Berlin (2001), and a Residential Fellow at the Center for Advanced Study in the Behavioral Sciences at Stanford University (2008–2009).

REID HASTIE SHORT BIOGRAPHY

Reid Hastie is the Ralph and Dorothy Keller Distinguished Service Professor of Behavioral Science at the University of Chicago. His primary research interests are concern individual and group judgment and decision making. He is the author of *Rational Choice in an Uncertain World* (with Robyn Dawes) and *Wiser: Getting beyond groupthink to make groups smarter* (with Cass Sunstein).

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War and Social Movements *(Political Science)*, Sidney Tarrow
The Social Science of Sustainability *(Political Science)*, Johannes Urpelainen
Theory of Mind *(Psychology)*, Henry Wellman