2

The Concept of Herd Behaviour: Its Psychological and Neural Underpinnings

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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 success of technological innovations such as the iPad, and so on. Until recently, such mass phenomena have been studied rather sporadically in various social science disciplines without much mutual communication. Yet with advances in technology and new theoretical frameworks, these mass phenomena are becoming a focus of substantive interdisciplinary interests.[1] An umbrella concept, 'herding', has facilitated such cross-disciplinary communication over the last five years.

I. Herd Behaviour: A Definition and Examples

What is meant by herding? Herding refers to an alignment of thoughts or behaviours of individuals in a group. Most importantly, such convergence often emerges through local interactions among agents rather than some 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.[2]

Textbook examples of herding in the social science literature include riots, panics, fads, mass hysterias, urban legends, economic bubbles, and so on.[3] However, besides these familiar examples, recent research suggests that herding

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[1] Eg G. A. Akerlof and R. J. Shiller, *Animal Spirits: How Human Psychology Drives the Economy, and Why It Matters for Global Capitalism* (Princeton, NJ: Princeton University Press, 2009).

[2] R. M. Raafat, N. Chater, and C. Frith, 'Herding in Humans' (2009) 13 *Trends in Cognitive Sciences* 420–8.

[3] See N. J. Smelser, *Theory of Collective Behaviour* (Glencoe, Illinois: Free Press, 1963); R. H. Turner and L. M. Killian, *Collective Behaviour* (Englewood Cliffs, NJ: Prentice-Hall, 4th edn, 1993).

may encompass a much wider range of our social behaviours than had been previously thought.

1. Crimes

The 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 remarkably across time and space. For example, homicide rates across nations in 1990 ranged from 6.1 cases per million in Japan, to 12.6 in Sweden, to 98.0 in the United States. 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.[4] 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 high variances may be that socio-economic 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 per cent of the variation in cross-city or cross-district crime rates could be explained by the local socio-economic differences. These researchers developed a model in which agents' decisions about crime were a function of their own attributes (eg, socio-economic as well as psychological attributes) and of their neighbour's decisions about criminal activities. Glaeser and others then estimated impacts of the second element of the model (ie, social influence from neighbours) for a variety of crimes in the United States in 1985, in 1970, and across New York City in 1985. The overall results showed that positive interaction among agents' decisions about crime was the only viable explanation for the large residual variance not explainable by the local socio-economic 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 (relatively minor crimes in particular) affects his or her neighbour's decisions, which constitutes a positive feedback loop as a whole. The large variations in crime rates across time and space seem to emerge as aggregated outcomes of such individual local decisions.

2. Obesity

Recent research suggests that obesity may be contagious as well.[5] Using a data set from a longitudinal survey on cardiovascular disease (the Framingham Heart Study),[6] Nicholas Christakis and James Fowler examined how social

[4] E. L. Glaeser, B. Sacerdote, and J. A. Scheinkman, 'Crime and Social Interactions' (1996) 111 *Quarterly Journal of Economics* 507–48.

[5] N. A. Christakis and J. H. Fowler, 'The Spread of Obesity in a Large Social Network over 32 Years' (2007) 357 *New England Journal of Medicine* 370–9.

[6] See <http://www.framinghamheartstudy.org/>.

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 or 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 neighbours.

Results of the network analysis revealed that obese people (defined as those with a Body Mass Index greater than 30) and non-obese 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 non-obese person. Moreover, a person's chances of becoming obese increased by 57 per cent if he or she had a friend who became obese in the time period, by 40 per cent if a sibling became obese, and by 37 per cent if a spouse became obese. These patterns suggest that obesity spreads through social network like a pathogen. Another person's overeating behaviour affects one's overeating behaviour through the social network, even if he or she does not know the person directly. Segmentations of obese and non-obese people in a community seem to emerge as aggregated consequences of such local influences.

3. 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 per cent if a friend who lived within a mile became happy, and these local influences also extended up to three degrees of separation. Thus, like obesity, happiness also seems to be contagious.[7]

II. Why Does Herding Occur? Potential Mechanisms

The examples earlier suggest that herding is a robust phenomenon, characterizing a wide range of social behaviours in our life. If so, what are the neural, psychological, or sociological mechanisms that produce herding? This Section reviews potential mechanisms that are thought to underpin herding behaviour.

[7] J. H. Fowler and N. A. Christakis, 'Dynamic Spread of Happiness in a Large Social Network: Longitudinal Analysis over 20 Years in the Framingham Heart Study' (2008) 337 *British Medical Journal* 2338.

1. 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,[8] has long been known among psychotherapists who treat depressed clients. Therapists, especially those who are inexperienced, are sometimes 'caught' by 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, and argue that 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 (eg, facial expressions, postures). Through the process of afferent feedback, these copied bodily expressions are translated into the receiver feeling the same emotion that the sender experienced, which leads to emotional convergence between 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 (eg, happy, sad, fearful, angry, disgusted faces) rather quickly—typically within less than a second.[9] 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 can imitate both facial and manual gestures displayed by an adult model.[10]

Furthermore, recent developments in neuroscience suggest that there may be a system in our brains that helps us to mirror others' actions. One of the most important 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 of other interesting objects. The neuron 'mirrored' the motor behaviour of the other,

[8] E. Hatfield, J. T. Cacioppo, and R. L. Rapson, *Emotional Contagion* (New York: Cambridge University Press, 1994).

[9] U. Hess and S. Blairy, 'Facial Mimicry and Emotional Contagion to Dynamic Emotional Facial Expressions and their Influence on Decoding Accuracy' (2001) 40 *International Journal of Psychophysiology* 129–41.

[10] A. N. Meltzoff and M. K. Moore, 'Imitation of Facial and Manual Gestures by Human Neonates' (1977) 198 *Science* 75. This finding was replicated with neonatal chimpanzees, our closest relatives. At less than seven days of age, the chimpanzees could imitate human facial gestures (tongue protrusion and mouth opening): M. Myowa-Yamakoshi, M. Tomonaga, M. Tanaka, and T. Matsuzawa, 'Imitation in Neonatal Chimpanzees (Pan Troglodytes)' (2004) 7 *Developmental Science* 437–42.

as though the observer were in fact executing the motor act. Although it remains controversial, some recent data suggest that a similar 'mirror neuron system' may exist in human brains as well.[11]

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

2. Social norms, mutual expectations, and shared stories

Another mechanism for herding involves more conscious, deliberate, or controlled psychological processes, which 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 behaviours in social psychology include the famous line-comparison study by Solomon Asch where subjects conformed to an erroneous majority view to avoid potential embarrassment or other social sanctions in a group;[12] the optical illusion study by Muzfer Sherif demonstrating that individual perceptions of the illusion converged on a shared social reality (ie, everybody in the same group ended up seeing the identical optical illusion) through communication;[13] and so on.

A key element underlying these herd behaviours is a fundamental characteristic of our mind, which may be termed 'docility' or receptivity to social norms.[14] Herbert Simon defined this concept as our tendency to depend on others' suggestions, recommendations, 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 just in a given social situation. As seen in the Asch experiment, the human mind is built to be highly receptive to social norms, and tends to self-censor actions in advance in order to avoid deviating from norms.[15] 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).[16] Stories, especially stories

[11] G. Rizzolatti and L. Craighero, 'The Mirror-Neuron System' (2004) 27 *Annual Review of Neuroscience* 169–92.

[12] S. E. Asch, 'Studies of Independence and Conformity: A Minority of One against a Unanimous Majority' (1956) 70(9) *Psychological Monographs*.

[13] M. Sherif, *The Psychology of Social Norms* (New York: HarperCollins, 1936).

[14] H. A. Simon, 'A Mechanism for Social Selection and Successful Altruism' (1990) 21 *Science* 1665–8; T. Kameda and R. S. Tindale, 'Groups as Adaptive Devices: Human Docility and Group Aggregation Mechanisms in Evolutionary Context' in M. Schaller, J. A. Simpson, and D. T. Kenrick (eds), *Evolution and Social Psychology* (New York: Psychology Press, 2006) 317.

[15] 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', however, such cognitive capacities would be highly limited. See M. Tomasello, *The Cultural Origins of Human Cognition* (Cambridge, Mass: Harvard University Press, 1999).

[16] R. C. Shank and R. P. Abelson, *Scripts, Plans, Goals and Understanding* (New York: Wiley, 1977).

shared in a community or across a whole society, lead us to see, interpret, have feelings about, and react to things from the shared viewpoint.[17]

This characteristic 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 stage for another's overeating. Our actions have spill over effects (which economists often call externalities) on others, which can lead to spiralling proliferations of action across a whole society.[18]

3. Rational conformity and information cascades

Sometimes it is rational to conform to majority behaviour 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 unfit for his position or 'just hopelessly stupid'. The Emperor cannot see the cloth himself, but pretends as if he can for fear of appearing unfit for his position or stupid, and is joined in this pretence by his ministers, subordinates, and general citizens. Notice that the 'spiral of silence'[19] 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. And if such a perception holds for everybody simultaneously,[20] this constitutes an equilibrium where any unilateral deviations (seem to) work against the deviator. A bank run which is initially triggered by some groundless rumour provides a similar example, where the (ungrounded) prophecy of bankruptcy can be self-fulfilling through a positive feedback loop.[21]

Information cascades are another example of rational conformity. An information cascade occurs when it is optimal for an individual who has observed the 'consensus' actions of preceding others to follow the predecessors' actions regardless of the private information that the individual has. Sushil Bikhchandani and others illustrated this process by an example of a paper submission to an academic

[17] See G. A. Akerlof and R. J. Shiller, *Animal Spirits: How Human Psychology Drives the Economy, and Why It Matters for Global Capitalism* (Princeton, NJ: Princeton University Press, 2009) for interesting recent examples of influential political-economic stories.

[18] M. Granovetter, 'Threshold Models of Collective Behaviour' (1978) 83 *American Journal of Sociology* 1420–43.

[19] E. Noelle-Neumann, *The Spiral of Silence: Public Opinion – Our Social Skin* (Chicago: University of Chicago Press, 1993).

[20] This situation is called pluralistic ignorance in social psychology: a majority of group members privately reject a norm, but assume (incorrectly) that most others accept it. In other words, this is a situation where no one believes, but everyone thinks that everyone else believes. See D. Katz and F. H. Allport, *Students' Attitudes: A Report of the Syracuse University Reaction Study* (Syracuse, NY: Craftsman Press, 1931).

[21] R. K. Merton, *Social Theory and Social Structure* (New York: Free Press, 1968).

journal. A referee in a first journal reads the submitted paper, assesses its quality, and makes a decision about whether to accept or reject it. 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 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 which proved that, at some stage in a sequential-choice setting, a rational Bayesian 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, yielding an information cascade.[22] And if the earlier decisions in the sequence happen to be erroneous (eg, rejecting a high-quality paper), the cascade leads to undesirable outcomes.

Information cascades have been studied mainly by economists,[23] and are often associated with various herd behaviours in financial markets, legal decision-making,[24] and so on.

III. Herding and the Wisdom of Crowds

The mechanisms reviewed earlier, ranging from unconscious, automatic mimicry to more reasoned, deliberate conformity to rational herding, are fundamental building blocks of mass or group phenomena. The robustness of these mechanisms, which underlie a wide range of our social behaviours, raises a central question about the nature of herding: is herding always problematic, as is often implied by some popular images (eg, mass hysterias, mobs, panics, fads, economic bubbles, groupthink, etc)? This question becomes clear if we consider 'the wisdom of crowds', a totally different notion of group behaviour, popularized by James Surowiecki.[25] While herding in humans often refers to defective social processes that degrade toward suboptimal performance, the wisdom of crowds implies highly intelligent group processes that can lead to collective wisdom. How can we reconcile the two contrasting images of collectivities?

[22] S. Bikhchandani, D. Hirshleifer, and I. Welch, 'A Theory of Fads, Fashion, Custom, and Cultural Change as Informational Cascades' (1992) 100 *Journal of Political Economy* 992–1026; A. V. Banerjee, 'A Simple Model of Herd Behaviour' (1992) 107 *Quarterly Journal of Economics* 797–818.

[23] For reviews of laboratory studies, see L. R. Anderson and C. A. Holt, 'Information Cascade Experiments' in C. R. Plott and V. L. Smith (eds), *The Handbook of Experimental Economics Results* (Amsterdam, New York, Oxford, Tokyo: North Holland, 2008) 335–43.

[24] W. Farnsworth, *The Legal Analyst: A Toolkit for Thinking about the Law*. (Chicago: University of Chicago Press, 2007).

[25] J. Surowiecki, *The Wisdom of Crowds: Why the Many are Smarter than the Few and How Collective Wisdom Shapes Business, Economies, Societies and Nations* (New York: Doubleday, 2004).

1. Group decision-making by honeybees

To consider this question, it seems useful to extend our scope to include herd behaviour by non-human 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 bees, ants, termites, naked mole rats, etc. Eusocial species are colonial animal species that live in multigenerational family groups, in which the vast majority of individuals cooperate to aid relatively few reproductive group members. They often exhibit extreme task specialization, which makes colonies potentially very 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 behaviour? We will 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 honeybees often divides itself. The queen leaves with about two-thirds 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 critical to their survival. The leaving swarm, which is composed of 10,000 or so bees, typically clusters on a tree branch, while several hundred scout bees search the neighbourhood for a new home. These scout bees fly out to inspect potential nest sites, and, upon returning to the colony, perform waggle dances to advertize any good sites they have discovered. The duration of the dance depends on a bee's perception of the site's quality: the better the site, the longer the dance. 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 more likely to visit and inspect the sites which have been advertized 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 could choose the best nest site. Even though none of the bees visits all the potential nest sites individually, they can aggregate partial individual information to form a collective wisdom that enables high-quality decisions.[26]

Although the bees' performance is highly impressive, the puzzle still remains. How do the bees solve the problem of interdependency? As we have seen earlier, the bees communicate their findings via waggle dances which 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.

[26] T. D. Seeley, *Honeybee Democracy* (Princeton, NJ and Oxford: Princeton University Press, 2010).

A recent article has addressed this question theoretically via a computer simulation model. 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 advertized by their predecessors. The bees essentially conform to a majority view in their decisions about where to visit. But, 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 determined *solely* by her own perception of the site's quality. The computer simulation results showed that, when a suitable mixture of influence and independence exists, the honeybee group decision-making process works well.[27]

2. 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'[28] in honeybees emerges not from some purposeful coordination by a central authority (eg, the queen), but through local interactions among the bees—a key element in the definition of herding as discussed earlier in this Chapter. Interestingly, the honeybee nest-search situation seems to have similar 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 searching 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 searches is limited. In these occasions, we often visit relevant websites (eg, 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 focuses on this point.[29] In cultural markets, sales volumes of hit songs, books, and movies are many times greater than average. This may imply that 'the best' alternatives are qualitatively different from 'the rest', yet experts routinely fail to predict which cultural products will succeed. Why does this failure occur?

[27] C. List, C. Elsholtz, and T. D. Seeley, 'Independence and Interdependence in Collective Decision Making: an Agent-based Model' (2009) 364 *Philosophical Transactions of the Royal Society B* 755–62.

[28] J. Krause, G. D. Ruxton, and S. Krause, 'Swarm Intelligence in Animals and Humans' (2009) 25 *Trends in Ecology and Evolution* 28–34.

[29] M. J. Salganik, P. Sheridan Dodds, and D. Watts, 'Experimental Study of Inequality and Cultural Market' (2006) 311 *Science* 854–6.

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 social information about how many times each song had been downloaded by previous participants. Notice that there was 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' behaviours) was available, in addition to the opportunities for individual information search.

The experiment revealed several interesting results. First, 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 to the social-frequency information. Obviously, participants in the social influence condition copied predecessors' choices, which yielded 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.

Secondly, the most popular song (with the highest download frequency) in the independent condition did not necessarily correspond to the most popular ones in the social influence condition. Mapping of the songs in terms of popularity ranking between the two conditions was at most moderate—the most popular song in the independent condition never did very badly in the social influence condition, and the least popular song 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, which 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 the nest search? A tentative answer does not seem to be favourable to us. Honeybees mix dependence and independence in the 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 rely 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 the nest choice decisions can). Yet, the lack of correspondence in song-popularity between the independent and the social influence conditions suggests that such subjective preferences are unstable and fragile. In this sense, the hyper-susceptibility of mass behaviour to social influence is problematic not only for marketers of cultural products, but also in many socio-political domains where no demonstrably correct answer exists.

IV. Conclusion

In this Chapter, we have reviewed various manifestations of herding in humans. As we have seen, humans are a highly socially receptive species, as compared with other gregarious animals. Accumulating evidence in various behavioural science disciplines strongly suggests that we humans are equipped with neural, psychological, and behavioural mechanisms that underpin this receptiveness—our abilities to learn from and be influenced by others. It is no doubt that these built-in mechanisms are evolutionary products that have served our survival and fundamentally 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 behaviours are much greater and more far-reaching, as compared to ancient environments in which the human mind evolved.

Interestingly, growing evidence in the behavioural sciences also seems to suggest that the two contrasting collective phenomena in humans—maladaptive herding and the wisdom of crowds—are underpinned by similar basic mechanisms. In this sense, the two apparently opposite macro phenomena may be seen as twins produced and governed by the receptivity of our minds. Given this commonality, understanding the neural, psychological, and behavioural mechanisms that could help distinguish these twins will be one of the most important challenges for behavioural sciences in the next decade.[30]

[30] For further discussion, see T. Kameda, T. Tsukasaki, R. Hastie, and N. Berg, 'Democracy under Uncertainty: The Wisdom of Crowds and the Free-Rider Problem in Group Decision Making' (2011) 118 *Psychological Review* 76–96.