

Fear-Driven Inference: Mechanisms of Gut Overreaction

Paul Thagard and A. David Nussbaum

Abstract Model-based reasoning requires not only inferences about what is happening, but also evaluations of the desirability of what is happening. Emotions are a key part of such assessments, but sometimes they can lead people astray, as in motivated inference when people believe what fits with their desires. In contrast to motivated inference, fear-driven inference generates beliefs that people do not want to be true. Although paradoxical, this kind of inference is common in many domains, including romantic relationships, health, parenting, politics, and economics. This paper proposes that fear-driven inference results from gut overreactions, in which a feeling that something is wrong is erroneously taken as evidence that something really is wrong. We discuss psychological and neural mechanisms by which gut overreactions can lead to fear-driven inference, and show how a computer model of emotional coherence can explain both fear-driven and motivated inference.

1 Introduction

Trifles light as air are to the jealous confirmations strong (Iago, in *Othello*).

In Shakespeare's play, Othello is led on the basis of flimsy evidence to conclude that his wife Desdemona is unfaithful to him. This belief is highly distressing to him, but he cannot help becoming increasingly convinced by a supposition that he does not want to be true. Othello's conclusion is an instance of *fear-driven*

P. Thagard (✉)
University of Waterloo, Waterloo, Canada
e-mail: pthagard@uwaterloo.ca

A. D. Nussbaum
University of Chicago, Chicago, USA
e-mail: a.nussbaum@chicagobooth.edu

inference, in which people believe something, not just despite the fact they fear it to be true, but partly *because* they fear it to be true. This article identifies instances of fear-driven inference in several domains, and proposes psychological and neural mechanisms that explain how people can paradoxically be inclined to believe just what they least want to believe.

Researchers have identified many kinds of cognitive and emotional biases that distort human thinking, such as representativeness, anchoring, confirmation bias, and motivated inference [1–3]. Motivated inference occurs when people reach conclusions unduly driven by their personal goals rather than by the available evidence [4–6]. This kind of thinking might be called *desire-driven* inference, but it is more complex than mere wishful thinking in which people believe something just because they want it to be true. Motivated inference is more subtle in that desires lead to prejudiced selection and weighting of evidence.

Elster [7] has noticed a much less well-known kind of biased inference in which people reach conclusions that go against their desire. He calls it *countermotivated* inference, indicating that people make inferences contrary to their motivations. We propose the term *fear-driven inference* because it points to the kinds of psychological and neural mechanisms based on negative emotions that can lead people to reach conclusions that run contrary to their interests. In the nineteenth century, Mill [8, pp. 482–483] recognized this kind of inference in his *System of Logic* when he wrote:

The most common case [of bias] is that in which we are biased by our wishes; but the liability is almost as great to the undue adoption of a conclusion which is disagreeable to us, as of one which is agreeable, if it be of a nature to bring into action any of the stronger passions. Persons of timid character are the more predisposed to believe any statement, the more it is calculated to alarm them. Indeed it is a psychological law, deducible from the most general laws of the mental constitution of man, that any strong passion renders us credulous as to the existence of objects suitable to excite it.

Such thinking was recognized even earlier in the fable “Le Loup et le Renard” by the seventeenth-century writer Fontaine [9], who wrote: “Chacun croit fort aisément ce qu’il craint et ce qu’il désire.” Mele [10] used the term “twisted self-deception” for self-deception that involves the acquisition of an unwanted belief, another kind of fear-driven inference.

2 Emotions and Rationality

Are people rational or emotional? Much recent research in psychology, neuroscience, and economics challenges the dichotomous presupposition of this question, showing that emotional reactions to situations are often a key part of rationality. Discussions of feeling as information [11, 12], emotional intelligence [13], the affect heuristic [14], and the somatic marker hypothesis [15] all describe ways in which emotional reactions can efficiently summarize complex evaluations of situations and provide a guide to action.

However, the recognition of emotion as often a valuable contributor to rationality should not obscure the many occasions when emotions contribute to irrational behavior. Obvious examples include the irrational exuberance [16] of financial bubbles such as the dot.com boom of the 1990s and the housing debacle of the mid-2000s, as well as destructive emotions such as racial hatred and cravings for addictive drugs. In order to sort out the ways that emotions can contribute to rational and irrational thinking and behavior, we need to gain a deeper understanding of how emotions are an integral part of judgment and decision making.

This paper identifies a pattern of emotional irrationality that we call *gut overreaction*, in which an amplifying feedback loop between judgments and emotions can lead both to excessively positive assessments and to excessively negative ones. Such overreactions occur in many spheres of human life, unduly influencing financial decisions, personal relationships, and medical behavior. We will first illustrate the operation of gut overreactions in *fear-driven inference*. In common cases in personal relationships including both romantic and parental ones, people experience irrationally negative emotions. Then we will show how the same underlying neuropsychological mechanism of gut overreaction can lead to irrationally positive emotions of the sort that occur in financial bubbles and romantic infatuation. Finally, we discuss psychological and social techniques for avoiding and overcoming the irrational results of gut overreactions.

3 Fear-Driven Inference

Shakespeare's Othello becomes obsessively worried that his wife Desdemona is unfaithful to him, despite the flimsiness of evidence planted by the evil Iago. Such irrational jealousy is sufficiently common that it has been dubbed the *Othello syndrome* [17], also known as morbid jealousy. What is amazing about this pattern of thinking is that it is doubly irrational, going both against the available evidence and against the best interests of the reasoner. Not only does Othello have more evidence that his wife loves him than that she is cheating, he is made deeply miserable by the thought that she is cheating on him. Why would people go against both the evidence and their own interests?

The Othello syndrome may be rare, but a similar phenomenon occurs in many parents of adolescents. Parents naturally worry about what their teenagers are up to, and failures to call or return home when expected may prompt parents to intense anxiety about what might have happened to their children. Such anxiety is commonly recognized after the fact as excessive, if parents have adequate evidence from their children's previous behavior to infer a benign explanation for their current lapses. As in Othello's jealousy, overanxious parents engage in inference that goes against the available evidence that probably nothing bad has happened to their children and, also against the parent's own self-interest of being

calm and confident. Such parental anxiety is both evidentially irrational and highly unpleasant.

Fear-driven inference arises in many other domains that are sufficiently important to people to generate anxiety. For example, people naturally care about their health, which can lead them to think they are more sick than they actually are. Hypochondriacs (and even ordinary people such as medical students whose training acquaints them with hundreds of obscure diseases) may infer from some minor symptom that they have a serious disease, without considering the full range of evidence and alternative hypotheses. People believe that they have a disease not just despite the fear that they have the disease, but because of the fear.

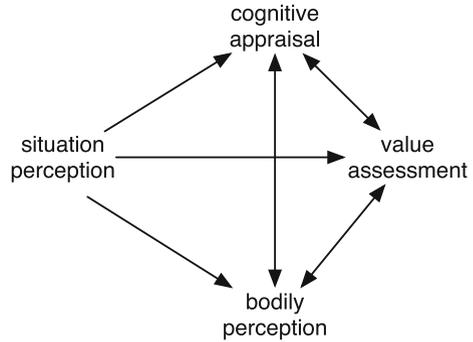
Other instances of fear-driven inference occur in thinking about careers, economics, politics, and religion. An academic who submits a paper for publication and gets no response to it for a long time may start to infer that the journal is just not interested in the paper, even though there are many other explanations for editorial delay. Investors may swing from irrational exuberance about stocks or other financial concerns to irrational despair that results from the fact that they fear financial disaster. Fear-driven inference is rampant in politics as seen in the popularity of conspiracy theories and other kinds of paranoia: people are sometimes inclined to believe the worst because it scares them, although motivated inference can also contribute to beliefs in conspiracies. Finally, belief in religion is often supported by motivated inferences concerning benign gods or blissful afterlives [18], but it can also be fear-driven when inspired by worries about vengeful deities and eternal punishment. In both motivated and fear-driven inference, feelings are *misinformation*.

4 Gut Overreaction

Why are people prone to fear-driven inference? It is much easier to understand the psychological basis of *motivated inference*, in which people distort their judgments because of their underlying personal goals [5, 6]. Motivated inference is an emotional bias that undercuts rationality, and can be observed in many kinds of interpersonal and practical judgments. For example, people buying lottery tickets may understand that the expected value of winning is very low, but nevertheless be convinced that this is their lucky day. The underlying psychological mechanism of motivated inference may be a kind of emotional coherence in which our goals and values naturally but illegitimately influence what we come to believe [18, 19]. But emotional coherence cannot explain cases such as the Othello syndrome and parental overanxiety, where the distressing emotional results clearly go against the goals of the worriers. A different psychological mechanism must be at work.

We propose that the mechanism underlying fear-driven inference is gut overreaction, which involves an ongoing feedback loop between judgment and emotional response. Current emotion theories tend to divide into two camps, one that considers emotions to be akin to judgments [20], and the other that considers

Fig. 1 Emotion as an integrated process of assessment of value deriving from both cognitive appraisal and bodily perception



emotions to be reactions to bodily states [21]. This division, however, can be reconciled by considering the brain as reacting to situations in ways that take into account both cognitive appraisal of situations and perception of bodily states, as in the EMOCON model of Thagard and Aubie [22, 23]. A simplified version of this model, omitting neural details, is shown in Fig. 1. From this perspective, jealous spouses and anxious parents are experiencing worry because of both their appraisal of their situations *and* their internal perception of bodily changes.

If emotions involve neural integration of both cognitive appraisal and physiological perception, then it becomes evident how gut overreaction can occur. Consider the feedback loop shown in Fig. 2a, intended to explain Othello’s fear-driven inference that Desdemona is unfaithful to him. The suggestion due to Iago’s misinformation may lead Othello to suspect that Desdemona is cheating, but this makes him feel bad which in turn makes him even more suspicious of her. That she is unfaithful causes him to feel bad about her, which in an ongoing loop makes him more suspicious of her. The general case is shown in Fig. 2b, which applies equally well to parental anxiety. Thinking that things are bad (with children or anything else that matters) causes you to feel bad, which in turn leads you to become more convinced that things are bad. The amplifying interactions shown in Fig. 2 are usually described as a positive feedback loop, but we avoid that term “positive” here because of confusion with positive emotions. In fear-driven inference, the amplifying feedback loop between inference and emotional reaction leads to negative emotions such as anxiety and anger. Let us now consider how gut overreaction can also produce excessively positive emotions.

Fig. 2 Amplifying feedback loop producing negative emotions

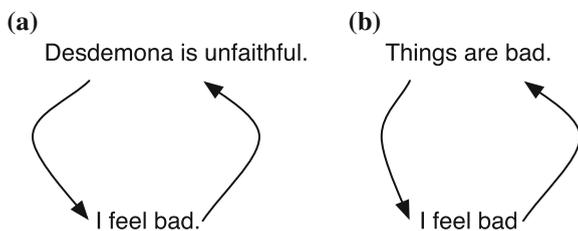
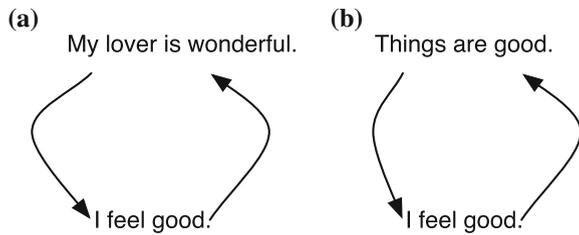


Fig. 3 Amplifying feedback loop producing positive emotions



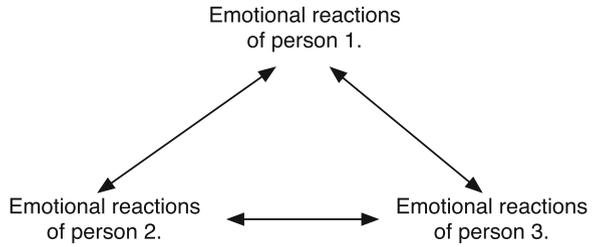
5 Positive Overreactions

The early stages of romantic love are often attended by wildly enthusiastic emotional experiences such as obsessive feelings of joy and passion [24]. We conjecture that such infatuation is the result of the kind of amplifying feedback loop shown in Fig. 3a, in which the judgment that a romantic object is wonderful makes someone feel good, and the feeling itself is taken as support for the judgment that the loved one really is wonderful. The result can be an exaggeratedly positive attitude that may lead to disillusionment, or in a happier course of romantic development, to a more stable sort of companionate love that can develop after a year or so of infatuation.

Figure 3b shows the general pattern, which applies to many phenomena ranging from financial bubbles to religious experience. In an economic boom in stocks, housing, or commodities, prices keep going up and up. Cool heads advise that what goes up must come down, but they are ignored in what the economist Shiller [16] called *irrational exuberance*. This description was originally applied to the dot.com boom of the late 1990s, but fits equally well the housing and financial bubbles of the 2000s. Ideally, people making a decision whether to buy a stock, house, derivative, or commodity should do a duly diligent assessment of the probable costs and benefits of the purchase. But in a highly complex world such assessments are difficult to make, so people naturally fall back on their “gut reactions” that tell them how they feel about the purchase. When such emotions are based on a wealth of accumulated experience, the gut reaction can constitute a reasonable judgment. But the amplifying feedback loop shown in Fig. 3a shows how the emotional estimation of the purchase can fail to reflect reality, if people feel good about the opportunity because of their judgments, but their positive judgments are largely tied to their feeling good.

In both romantic infatuation and financial bubbles, irrational exuberance can be a group phenomenon, in which one person’s exuberance feeds back into another’s, as shown in Fig. 4. If the people can perceive each other directly, then the interpersonal emotional feedback can involve mechanisms such as emotional contagion [25] or activation of mirror neurons [26]. Alternatively, social feedback can be indirect, as in stock market prices. Either way, amplifying social feedback increases the amplifying psychological feedback shown in Fig. 3.

Fig. 4 Social amplifying feedback loops produce spread of emotions



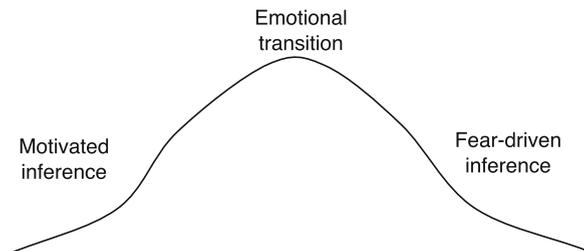
If we are correct, then gut overreaction is one of the psychological mechanisms underlying financial bubbles, as people feel better and better about feeling better and better. Of course, it is not the only relevant mechanism, as people’s emotional reactions also derive from the perfectly reasonable recognition that prices have been going up, and from the motivated inference that prices will go up because they want them to go up. But the amplifying feedback loop between judgment and feeling can intensify and prolong the conviction that things can only get better.

Sadly, when things turn sour in the economy or personal relationships, people can swing from positive gut overreaction to negative overreaction, when the one amplifying feedback loop is supplanted by another. This transformation occurs when a blowup shifts romantic infatuation into disillusionment, and when a financial crash swings a bubble into an economic crisis. Akerlof and Schiller [27] discuss the importance of having a “confidence multiplier” operating in an economy, in which confidence breeds confidence and despair breeds despair. Gut overreaction may be one of the psychological mechanisms underlying this multiplier. Figure 5 illustrates the transition that can take place in people when events and new information cause a critical transition from motivated inference to fear-driven inference, producing a swing from irrational exuberance to excessive despair.

6 Computer Simulation of Fear-Driven Inference

In order to explore the effects of gut overreactions on inference, we have performed computer simulations of the effects of amplifying feedback loops on inferential dynamics. Consider the highly simplified version of Othello’s case

Fig. 5 Emotional transition resulting from shift away from motivated inference to fear-driven inference, turning financial or romantic bubbles into busts



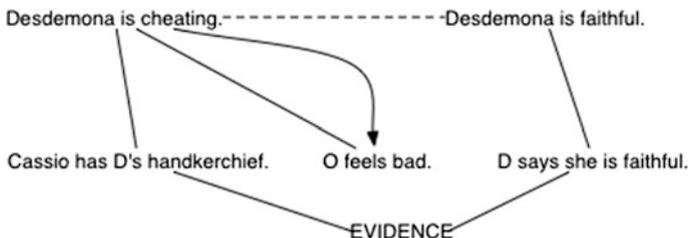


Fig. 6 Structure of neural network simulation of Othello’s fear-driven inference. The *dotted line* indicates an inhibitory connection between two contradictory hypotheses. The straight *solid lines* are excitatory connections based on evidence relations. The *curved pointed line* indicates an emotional connection

shown in Fig. 6. In this simulation, there are two pieces of evidence: Desdemona’s handkerchief has turned up in the possession of Cassio, yet Desdemona says she is faithful. That Desdemona is cheating with Cassio explains his having her handkerchief, and the contradictory hypothesis that she is faithful explains why she says she is faithful. Just based on this information, there is no reason to infer either that she is cheating that or she is faithful, and simulation using the neural network simulator HOTCO (hot coherence, [18]) yields equal activation for both hypotheses. However, there is a different result when HOTCO adds the node for feeling bad, which gets emotional activation from its association with the node that Desdemona is cheating. Then feeling bad irrationally becomes evidence that gets explained by the hypothesis that Desdemona is cheating, which becomes a kind of self-supporting hypothesis. In this way, the HOTCO simulation produces fear-driven inference by a kind of gut overreaction. In an alternative simulation, an “O feels good” node could support the motivated inference that Desdemona is faithful. Whether the “O feels good node” or the “O feels bad” node becomes activated can depend on many factors including social circumstances such as conversations and personality components such as neuroticism and low self-esteem.

7 Neural Mechanism

From the perspective of conventional theories of rationality based on probability and utility theory, fear-driven inference is bizarre. Theories of rationality assume a firewall between probabilities and utilities, which are calculated independently of each other and only brought together in calculations of expected utility through the classic equation that multiplies them. The brain, however, does not appear to separate probabilities and utilities nearly so rigorously. Evidence for interactions comes from psychological experiments that show that people use emotions to estimate probabilities [28] and that motivations affect belief [5]. What are the

neural mechanisms that produce mingling of probabilities and utilities and can yield fear-driven inference?

Little research has been done on the neural correlates of belief, but Sam Harris and his colleagues have some interesting preliminary results [29, 30]. They found that the neural correlates of belief included brain areas associated with emotional processing, such as the ventromedial prefrontal cortex (for belief) and the anterior insula (for disbelief). Hence it is not surprising that the brain confuses emotional arousal with believability. In the case of scary hypotheses such as spousal infidelity, offspring mishaps, medical threats, or economic dangers, the arousal generated by fear may be confused with arousal generated by conviction based on evidence. Important domains such as family relations, health, and economic well-being naturally yield high activations in brain areas relevant to processing emotional information. Such activations can lead to fear-driven inferences when arousal is misinterpreted as probability rather than as disutility.

It is actually a strength, not a weakness, of the brain that it integrates cognition with emotion. Emotions provide focus on what is important to an organism, serving such important roles as ensuring that inferences will be made about goal-relevant information rather than about trivialities and providing an immediate connection between belief and action. Modern mathematical theories of probability and utility only arose in the seventeenth and eighteenth centuries [31], so it is not surprising that human thinking still often relies on cruder non-differentiated processes of belief assessment.

8 Controlling Gut Overreactions

If gut overreaction is a contributing factor to irrationality, what can be done about it? If our analysis is correct, there are many psychological and social ways to reduce the excessive effects of negative and positive emotions. Because bodily perception is part of the genesis of emotional reactions according to the EMOCON model, physiological interventions such as meditation are appropriate. Also potentially useful are drugs that alter levels of neurotransmitters, such as anti-anxiety medications and anti-depressants. At the more cognitive level, people can ask themselves: am I feeling good (or bad) about X because it really is good? The neural processes involved in emotional reactions to a situation are mostly inaccessible to conscious control, but techniques such as cognitive therapy can be used to examine the basis of the appraisals that are one of the factors that go into emotional reactions. Ideally, in keeping with the finding about depression that the best treatment involves both medication and therapy, attempts to modulate gut overreactions should operate both physiologically and cognitively. One useful tool for identifying the emotional background to inferences is the technique of cognitive-affecting mapping which displays the emotional values and connections of key concepts ([32], ch. 17).

Also important are social processes shown in Fig. 4. Group members can have amplifying feedback influences on each other, but other people who are less prone to overreaction or less involved can have dampening effects on an individual's own tendency to become excessively exuberant or despondent about a situation.

9 Conclusion

We have conjectured that gut overreactions produced by an amplifying feedback loop between judgments and emotions can be an important factor in many kinds of irrationality operating in spheres that range from personal relationships to economic dynamics. Wishful thinking, understood at a deeper psychological level as motivated inference, has an important counterpoint in fearful thinking, which we have analyzed as fear-driven inference deriving from gut overreactions. Such overreactions produce feelings as misinformation. Much research remains to be done to provide evidential evaluation concerning the neural feedback processes we have hypothesized and concerning the psychological effects of these processes.

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