Opinion

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Fatal attraction: the intuitive appeal of GMO opposition

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Public opposition to genetically modified organisms (GMOs) remains strong. By contrast, studies demonstrate again and again that GM crops make a valuable contribution to the development of a sustainable type of agriculture. The discrepancy between public opinion and the scientific evidence requires an explanation. We argue that intuitive expectations about the world render the human mind vulnerable to particular misrepresentations of GMOs. We explain how the involvement of particular intuitions accounts for the popularity, persistence, and typical features of GM opposition and tackle possible objections to our approach. To conclude, we discuss the implications for science education, science communication, and the environmental movement.

Explaining public opposition to GMOs

Concerns about health, environmental, and socioeconomic hazards have resulted in a strong public opposition to GMOs [1–3]. These worries tend to have a large impact on national and international policies. For instance, in India, the government suspended the culture of *Bacillus thuringiensis*-engineered *Solanum melongena (Bt* brinjal), despite initial approval for commercialization [4]. In Europe, the lack of public support for GMOs has led to a *de facto* moratorium within the EU on new GM crops from 1999 to 2004 and has steered the development of an extremely strict and expensive regulatory framework concerning the import and cultivation of GM crops [5]. In Africa and Asia, the resistance to GMOs has had tragic consequences, costing thousands of lives [6,7].

However, research shows that cultivation of GM crops does not pose any specific health or environmental risks, but instead can bring benefits to local farmers [8–11]. The reason for the discrepancy between public opinion and scientific evidence needs clarification. Some people suggest that post-Christian beliefs or romantic notions of nature are responsible, whereas others blame the lack of direct benefits for Western consumers [6,12,13]. These accounts are definitely on the right track. Nonetheless, they fail to explain why opposition also occurs in non-Christian cultures, why people do not reject every technology that brings no immediate benefits, or why people prefer romantic views in the first place.

We suggest a cognitive approach to account for the opposition to GMOs. In other words, we use ideas from the cognitive sciences, evolutionary psychology, and cultural attraction to rationalize the popularity and typical features of this phenomenon. We argue that intuitions and emotions make the mind highly susceptible to particular negative representations of GMOs. We propose ways to rectify the current situation and improve science education and communication.

An intuitive understanding of GMOs

Although generally we feel as if we control willfully what we think and do, much of our thinking depends on intuitions, of which the working largely stays below the radar of conscious awareness [14]. Among other things, these intuitions, which evolved in response to particular adaptive situations, automatically shape expectations about the world or induce reflexive risk assessments [15]. Under ecologically relevant conditions, these intuitions tend to generate rational responses [16] but, when confronted with abstract and complex situations, these intuitions tend to break down [17]. For instance, people are more easily scared by spiders than by cars, although in modern society the number of mortal car accidents is much higher [18]. As to our understanding of the world, cognitive predispositions can result in deeply engrained biases that, if not dealt with by education, lead to persistent resistance to counter-intuitive scientific theories in adulthood. Dualist intuitions, for instance, make it difficult to accept that mental states result from physical processes [19]. Nevertheless, our thinking relies on at least two types of reasoning processes. In addition to the fast and automatic intuitions described above, humans can resort to an effortful and reflective type of reasoning that allows them to consciously evaluate and relate different information types [14,20,21]. By exercising this reflective capability, and thanks to the development and use of social and epistemic methods, tools, and practices, scientists have been able to tweak and build on their intuitions and, thus, to gain a more objective and scientific understanding of the world [22–24].

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Box 1. The role of intuitions in cultural domains

The opposition to GMOs is not the only complex of beliefs that piggybacks upon folk intuitions. For instance, religious beliefs are typically explained in terms of the appeal they exert on ordinary human cognition that includes essentialist reasoning, a hyperactive agency detection system, and an intuitive theory of mind [32–34]. In addition, pseudoscience taps into these and other intuitions, a trait that can persist in the face of scientific discovery. Creationism is anchored in essentialist, teleological, and intentional intuitions. Moreover, creationists even explicitly call upon these intuitions to bolster their case [51]. Pattern recognition leads us to over-detect correlations and causation, leaving the mind susceptible to all kinds of superstition, such as fear of black cats or walking under ladders. Furthermore, medical pseudoscience owes its success largely to placebo thinking by which people who are ill can get better merely by thinking that they will [52]. In fact, intuitions affect a wide range of social and cultural domains, such as social institutions and the development of science [52–54]. The cases of GMO opposition and pseudoscience demonstrate that intuitions can even favor the distribution of beliefs that are flatly contradicted by evidence.

The intuitive mind is not well equipped to address intricate questions, such as 'what is biotechnology?', 'how does it work?', or, most importantly, 'is it dangerous?' The ability to understand such issues and, hence, to have a subsequent objective and rational judgment requires an important effort and, even then, the mind is still liable to relapse into biased thinking. Lay people are often unable or are simply not interested in investing large amounts of time and energy to acquire a profound grasp of complex technologies. Therefore, when lay people are confronted with and have to evaluate information about GMOs and the risks involved, they will predominantly rely on their intuitive mind. As a result, lay people tend to prefer GMO representations that are most in line with their intuitive expectations and, thus, are easier to understand and remember. Anti-GMO groups have successfully tapped into people's intuitions to promote their cause, thus making their campaign highly attractive to the human mind (Box 1).

We explore below which intuitions make people vulnerable to GMO antagonism, and show how our approach explains the popularity, persistence, and typical features of the GMO hostility; we also briefly counter some objections that might be raised. Finally, the implications for science education, communication, and the environmentalist movement are discussed.

The intuitive appeal of anti-GMO representations

Folk biology

The human mind intuitively understands how the biological world functions. One constituent of this folk biology is psychological essentialism [25] that amounts to the belief that organisms hold an unobservable, immutable core determining their identity and, thus, their development and behavior. Psychological essentialism makes sense evolutionarily because it allows individuals to categorize automatically the biological world. As such, valuable information becomes immediately available, enabling apt responses to living entities in the environment. For instance, when one is confronted with a tiger, the immediate realization that one is coping with a specimen of the category 'tiger' and, thus, that with its mighty claws and sharp fangs it might catch and eat its prey, is a more adaptive reaction than to reassess each and every encountered stripy feline [26]. Nevertheless, despite the obvious adaptive rationality of this cognitive predisposition, psychological essentialism regularly interferes with a scientifically informed biological understanding [27]. Notoriously, it impedes people's understanding of basic aspects of evolutionary theory and, moreover, it also affects people's comprehension of GMOs, primarily because they interpret DNA as the essence of organisms [28]. In a US survey, more than half of the respondents did not reject the idea that tomatoes of the which the genome had been modified by insertion of catfish DNA would taste like fish [29]. Apparently, people assumed that the fish's essence had been introduced into these tomatoes, including a fishy taste. That people systematically prefer cisgenic over transgenic organisms provides another indication of an essentialist bias [3]. In their campaigns, opponents of GMOs explicitly appeal to these essentialist intuitions by distributing edited images of tomatoes with fish tails or by claiming that biotech companies insert scorpion DNA elements into corn (*Zea mays*) to produce crispy cornflakes. The notion that growing GM crops with herbicide tolerance will promote so-called superweeds falls back to the same misconception that a weed can be characterized by a single gene. On the contrary, typical weed characteristics such as withstanding harsh environments, competing for light, water, and minerals, and fast reproduction are the result of the interplay of numerous genes.

Teleological and intentional intuitions

Another aspect of the intuitive mind that affects people's preferences for particular GMO representations and the perception of the risks involved are teleological and intentional intuitions. These intuitions tend to translate in religious beliefs, but they can also contribute to a quasi-religious view on nature [30,31]. Indeed, large parts of Europe, where resistance against GM food is strong, are highly secular. In the cognitive science of religion, religion is commonly assumed to be a byproduct generated by the peculiarities of our mental make-up that includes essentialist thinking, but that is also highly receptive to the feeling that the world has been designed for a particular purpose [32–35]. This design illusion has effectively been debunked by evolutionary theory, but the mix of essentialist, teleological, and intentional biases continues to allure many people into believing that a certain order exists in nature that should not be meddled with. Indeed, genetic engineering is considered to be the opposite of 'natural' [3,36]. GMO opponents accuse scientists who produce transgenic plants of 'playing God' and condemn their acts as 'against nature'. Biotech food is often referred to as 'Frankenfood', suggesting that, as with Mary Shelley's artificial creature, the technology will escape the control of the haughty scientists and result in horrific environmental doom scenarios.

Emotions

A category of mental features that particularly interferes with people's risk assessment of GMOs are emotions. Disgust is especially important in this context. In

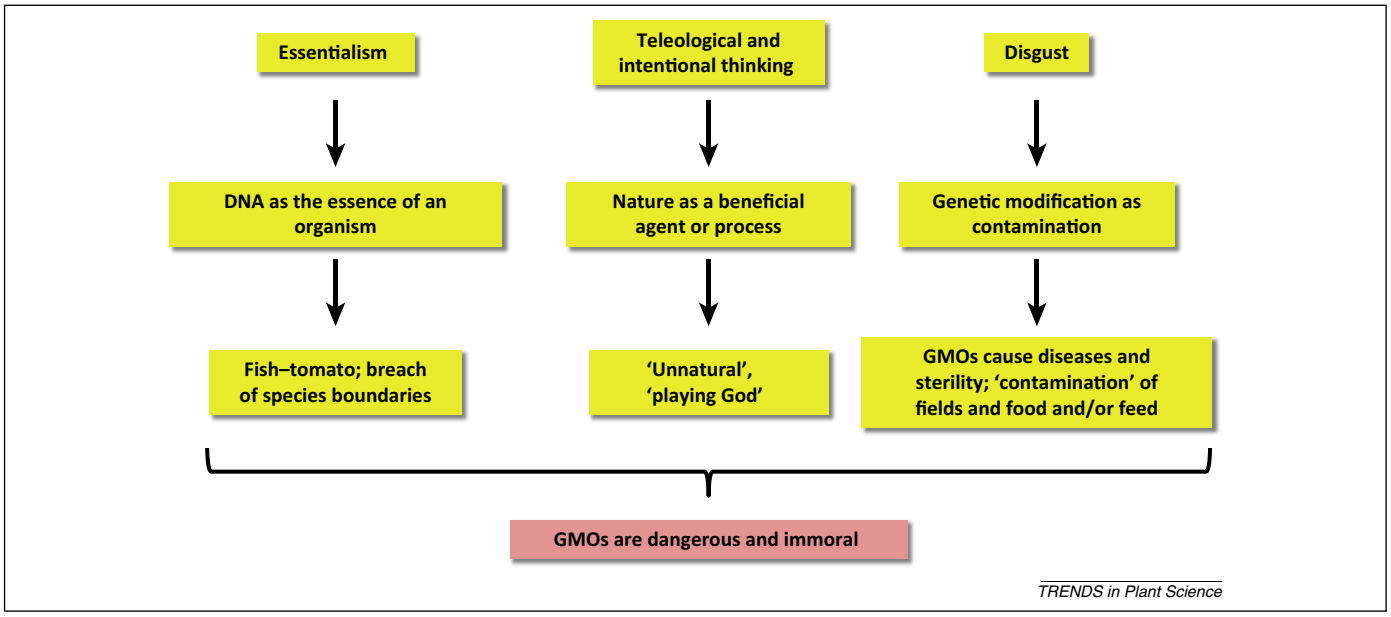

Figure 1. Unsubstantiated negative representations of GMOs tapping into intuitive preferences.

particular, revulsion may influence the reactions to GMOs because people object more to GM food than to GMOs developed for other applications [37]. Disgust evolved probably in response to adaptive problems related to pathogen and poison avoidance [38–40]. The evolutionary rationale explains why the emotion is on a hair trigger: to forego a nutritious meal because it is erroneously considered toxic or contaminated is potentially far less harming than to consume spoiled food under the misguided assumption that it is perfectly edible [40]. Hence, distaste can be elicited by food that is completely innocuous. Indeed, food taboos offer clear examples of disgust regulated by cultural conventions, often involving meat derived from animals that are fit for human consumption, but that are considered vile and dirty. In experiments, scientists induce revulsion by presenting orange juice stirred with a sterilized cockroach or dog feces-like shaped caramelized biscuit spread [41]. In the case of GM food, feelings of disgust possibly arise because of psychological essentialism by which people intuitively interpret gene modification as an unwarranted and contaminating intervention into the essence of an organism, rendering the organism impure and, therefore, no longer consumable. The effect will probably be enhanced when the introduced DNA derives from a different species, or a species that is considered dirty. Anti-GMO activists bombard the public with edited images that imply that GM food cannot be trusted, such as tomatoes with syringes or suspiciously blue biotech strawberries amid fresh red ones. *Bt* crops are described as poisonous and instigate the fear that biotech crops will 'contaminate' the surrounding environment. Moreover, disgust also affects our moral judgment [38,40,42]. Hence, the emotion incites people to condemn not only the GM food itself but also the producers and developers of GM products as immoral. Linking socioeconomic abuses to GM products has become today's major focus of the anti-GMO critique. To trigger moral disgust, stories are brought up of big multinationals that chain farmers to ruthless contracts and patents, or even push resource-poor farmers into debt and suicide after they have been 'seduced' to buy the 'killer' seeds. Plant biotech research institutes are pictured as a scientific community that burns tax money while becoming totally dependent on research contracts with big industry. The current socioeconomic implantation of GM technology into agriculture merits further analysis because this issue raises important questions about the place and role of science in our complex society. For instance, how should science relate to industry? Nevertheless, the current situation is certainly not as black-and-white as activists maintain, and it is plainly wrong to name a single breeding technology as the cause of these complex issues.

How the opposition to GMOs does – and does not – take shape

Some representations are more popular than others. The popularity of a representation is determined by the relevance of the information it purveys. Whether information is relevant depends on its ability to capture attention and the ease by which the mind can process it. The more information is in line with our intuitive expectations, the more easily it is apprehended, remembered, and, thus, communicated. Because intuitions are universally shared, appropriate representations stand a greater chance of becoming widely distributed and culturally stable. At the population level, an outline emerges in which representations converge into and stabilize around hypothetical points termed cultural attractors [43,44]. This pattern of attraction also occurs in the case of the GMO opposition. The negative representations produced by anti-GMO activists happen to reflect essentialist and intentional understandings of nature and suggest contamination, hence becoming highly salient to the corresponding intuitions (Figure 1). Owing to their aggregated relevance, these depictions will tend to outcompete the demonstrations of scientists and other experts that require an enhanced cognitive effort. As such, the anti-GMO campaign has been

Box 2. Reasonable doubt?

The influence of intuitions largely accounts for the typical features and popularity of the opposition to GMOs. Moreover, many of the arguments leveled against GMOs articulate concerns that clearly arise from intuitions and emotions. Other arguments only become relevant in the context of GMOs because people seek ways to rationalize their intuitively felt resistance. In turn, some of these arguments tap into and exploit moral concerns about fairness (i.e., multinationals exploit small farmers) and environment (i.e., GMOs kill butterflies) that can consequently become amplified with intuitively appealing allegations about sickness and unnaturalness. Arguments against GMOs sound even more convincing when they come from an allegedly trustworthy source, such as an environmentalist organization or a friend, or when they are popular among the social group one wants to be part of. Hence, people oppose GMOs for reasons other than mere intuitive appeal, such as trust and conformity. Are there any reasonable scientific worries to account for the opposition against GMOs? Some reports and studies have claimed that GMOs *per se* badly affect health, environment, and small farmers in developing countries. These studies, however, turned out to be unsubstantiated. Anti-GMO activists continue to refer to these studies. As such, they cloak their arguments under a scientific veil, thus exploiting the cultural authority of science. In this regard, the opposition to GMOs resembles pseudosciences, such as 'scientific' creationism and homeopathy, that mimic science in an attempt to gain respectability [52]. At the same time, anti-GMO activists also adopt pseudoscientific tactics to undermine the authority and autonomy of the science that contradicts their claims, for instance by overstating the impact of industry on plant sciences. As a result, people may wrongly assume that there are good scientific reasons to oppose GMOs.

For sure, our cognitive analysis does not render every public concern unfounded *a priori*. Some of these apprehensions can be legitimate. For instance, herbicide resistance in weeds has indeed become a problem in areas such as the USA and Argentina where farmers have over-relied on a single herbicide-resistant crop that was tolerant to glyphosate. However, these concerns are typically unrelated to the technology of genetic modification, and instead result from unsound agricultural practices and policy that also can cause problems in the case of 'conventional' crops. Moreover, whether a particular GM application has unwanted effects needs to be tested on a case-by-case basis, thereby focusing not on the technology, but on the resulting product.

extremely successful, not only to the surprise of scientists, but also of the instigators themselves [45].

The preferential adoption of negative GMO representations takes place reflexively, instantaneously, and largely under the radar of conscious awareness. However, the resulting negative affect is consciously registered and, consequently, prompts people to justify their feelings. A form of motivated reasoning emerges in which arguments become highly prominent that are applicable equally to other technologies but are suddenly ignored. The alleged unnaturalness of genetic engineering or the involvement of multinationals can equally easily be applied against medical biotech applications, but only seem to be relevant in the case of GMOs. Other arguments make sense because they are attuned to particular components of the mind's intuitive appraisal. To a mind that is primed with feelings of disgust, it seems evident that GMOs can provoke sickness or contaminate the environment (Box 2).

Nevertheless, intuitions interact with other sensitivities and with the cultural environment. For instance, people who may reap direct and considerable benefits from the development and commercialization of GM products will become apt to adopt more positive viewpoints. Moreover, they may trust information sources such as scientific reports that demonstrate that GMOs are safe and even beneficial. As such, the human mind is not predetermined to think that GMOs are poisonous, disgusting, or unnatural. However, once these negative representations become culturally available, for instance because of intense campaigning by environmental groups or lack of any strong cultural counterforces, the human mind will be highly susceptible to them. Furthermore, because cultural attraction addresses statistical effects, we can expect intragroup varieties in the adoption of negative representations of GMOs. In a culture that predominantly opposes GMOs, members will also be present that are pro, and vice versa. Indeed, the opposition to GMOs is not everywhere as strong as it is in Europe, although it is more common than people tend to think.

Concluding remarks and implications

The human mind comprises evolved intuitions that shape and constrain cultural preferences. In the case of GMOs, folk biology, religious intuitions, and emotions such as disgust leave the mind readily seduced by representations of GMOs as abnormal or toxic. By pointing out how public aversion to GMOs thrives on such preferences, it is understandable why people continue to resort systematically to concerns about GMOs that are scientifically unsubstantiated. With such a perspective that is not intended to characterize public worries in general as irrational, we hope that a cognitive understanding can contribute to a better insight into and perhaps a more lenient attitude toward the anxieties of the public. In addition, we expect to open the eyes of those who reject GMOs as a whole – and hope to let them realize that their concerns arise from sources that cannot be trusted *prima facie*, and that the risks and benefits can only be assessed on a case-by-case basis, depending on the result and not the process [46].

Education can, at least to some extent, abate the intuitive appeal of negative GMO representations. Instruction of young people about biotechnology and its implications will require educational strategies that specifically target and tweak intuitive modes of thinking. However, this method of immunizing minds is certainly not foolproof. Intuitive thinking remains a trap, even to the minds of experts. At the same time, scientists and institutions, companies and governments that communicate about GMOs and their potential risks can also appeal to the intuitive mind. Although GMOs are at a disadvantage because they are commonly associated with unnaturalness and trigger disgust, emphasis on the benefits would effectively induce sympathy [37,47]. Even though individual people may not always experience a personal advantage by purchasing and/or consuming GMOs, it will certainly help to inform the public that, for example, (i) *Bt* corn contains less mycotoxins and is thus healthier than conventional maize [48]; (ii) herbicide-resistant crops require less tilling and, thus, improve the soil quality; (iii) *Bt* crops enhance insect biodiversity [49]; (iv) biotech crops help reduce poverty in India [50], and so on.

Finally, our approach suggests that people who are genuinely concerned about the environment may intuitively adopt strategies that have the opposite impact on what

they set out to achieve. GMOs can be a formidable tool in the realization of a sustainable form of agriculture. By leading people to choose the wrong adversaries and to urge policy makers to take counter-effective measures, negative GMO representations may indeed exert a fatal attraction.

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