

## Are science festivals a good place to discuss heated topics?

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### Abstract

Public acceptance of vaccination and Genetically Modified (GM) food is low and opposition is stiff. During two science festivals in France, we discussed in small groups the scientific evidence and current consensus on the benefits of vaccination and GM food safety. Our interventions reinforced people's positive opinions on vaccination and produced a drastic positive shift of GM food opinions. Despite the controversial nature of the topics discussed, there were very few cases of backfire effects among the 175 participants who volunteered. These results should encourage scientists to engage more often with the public during science festivals, even on heated topics.

### Keywords

Popularization of science and technology; Public understanding of science and technology; Risk communication

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### Introduction

Despite the clear scientific consensus on Genetically Modified (GM) food safety and on the usefulness of vaccination, lay people's skepticism remains high [Gaskell et al., 1999; MacDonald, 2015; Scott, Inbar and Rozin, 2016; Yaqub et al., 2014]. The large discrepancy between the state of agreement in the scientific community and what the general population thinks has been referred to as the "consensus gap" [Cook et al., 2018]. This consensus gap is puzzling because public trust in science is high and remained stable since the 1970s [Funk, 2017]. But people are selective about their trust in the scientific community: Americans trust less scientists on GM food safety and vaccination than on non-controversial topics [Funk, 2017]. Americans also largely underestimate the scientific consensus, together with scientists' understanding of Genetically Modified Organisms (GMOs) and vaccination [Funk, 2017]. In France, where we conducted the two studies reported in this article, rejection of GM food is widespread [Bonny, 2003]: up to 84% of the population thinks that GM food is highly or moderately dangerous [Institut de Radioprotection et de Sûreté Nucléaire, 2017] and 79% of the public is worried that some GM food may be present in their diet [Institut d'études opinion et marketing en France et à l'international, 2012]. In the country of Louis Pasteur, public opinion

on vaccination is also surprisingly negative. Even if 75% of the population is in favor of vaccination [Gautier, Jestin and Chemlal, 2017], only 59% of them think that vaccines are safe [Larson et al., 2016]. Our intervention at science festivals primarily aims at filling this lack of trust.

Attempting to correct misconceptions by targeting people at science festivals may seem like an odd choice, as they are known to be more interested in science, more educated, and more deferential toward the scientific community [Jensen and Buckley, 2014; Kennedy, Jensen and Verbeke, 2018]. But these traits do not exempt lay science enthusiasts from holding false beliefs on scientific topics. For example, teachers reading the most about cognitive science and who are the most interested in evidence based education are more likely to spread neuromyths — misconceptions about how the brain is involved in learning — than less interested teachers [Dekker et al., 2012].

People coming to science festivals could be good targets for interventions on heated topics for at least two reasons. First, it should be easier to convince them with scientific arguments since they are eager to learn and trust scientists. Second, their scientific motivation makes them good intermediates to further transmit the arguments of our intervention in their social networks by chatting with their friends and family, or by sharing them on social media.

The role of peers to relay messages from media is well known in the area of public opinion [Katz and Lazarsfeld, 1955]. For example, efforts at convincing staunchly anti-vaccine individuals through campaigns of communication have largely failed [Dubé, Gagnon and MacDonald, 2015; Sadaf et al., 2013]. These failures could be due to the lack of trust that anti-vaccine individuals place in the medical establishment [Salmon et al., 2005; Yaqub et al., 2014]. As a result, people coming to science festivals, who are likely more trusted by their peers than mass media, may be in a good position to convince vaccine hesitant individuals [at least fence-sitters; see Leask, 2011], if only they are able to muster convincing arguments [Altay and Mercier, 2018]. Thus, by providing science lovers with facts about GM food and vaccination, we could strengthen their argumentative arsenal, and indirectly use their social network to spread scientific information.

In a nutshell, the intervention consisted of small discussion groups in which an experimenter explained the hierarchy of proofs (from rumors to meta-analyses and scientific consensus), highlighted the scientific consensus on vaccines' benefits and GM food safety, and answered the public's questions on these topics. The design of the intervention was based on two core ideas: (i) that, as suggested by the Gateway Belief Model, highlighting the scientific consensus can change people's minds, and (ii) that providing information in a dialogic context where arguments can be freely exchanged is a fertile ground for belief revision.

### *Gateway belief model*

According to the Gateway Belief Model in Science Communication, highlighting the scientific consensus can improve people's opinions on scientific topics and increase their public support [Ding et al., 2011; Dunwoody and Kohl, 2017; Kohl et al., 2016; Lewandowsky, Gignac and Vaughan, 2013; van der Linden,

Leiserowitz, Feinberg et al., 2015; van der Linden, Leiserowitz and Maibach, 2017]. The idea behind the model is simple: emphasizing the degree of agreement between scientists on a given topic will influence the public's perception of the consensus, which will in turn change people's belief on the topic and will finally motivate public action.

The Gateway Belief Model has been successfully applied to vaccination, as being exposed to the consensus on vaccination leads to more positive beliefs on vaccination [Clarke, McKeever et al., 2015; Dixon and Clarke, 2013; van der Linden, Clarke and Maibach, 2015]. Yet, applications of the model to GM food yielded mixed results. Two studies found that exposure to the scientific consensus had no effect on beliefs about GM food safety [Dixon, 2016; Landrum, Hallman and Jamieson, 2018], while one reported a significant effect [Kerr and Wilson, 2018]. These results could reflect a lack of trust, as acceptance of biotechnology positively correlates with deference to scientific authority [Brossard and Nisbet, 2007] and high trust in the government, GM organizations and GM regulations, together with positive attitudes towards science and technology, are associated with favorable opinions towards GM applications [Hanssen et al., 2018]. But laypeople do not place a lot of trust in GM food scientists [Funk, 2017] and up to 58% of the French population thinks that public authorities cannot be trusted to make good decisions on GM food [Ifop and Libération, 2000]. This lack of trust is the biggest limitation of the Gateway Belief Model: it can only function if people are deferent to scientific authority in the first place [Brossard and Nisbet, 2007; Chinn, Lane and Hart, 2018; Clarke, Dixon et al., 2015; Dixon, McKeever et al., 2015].

Some have debated the validity of the Gateway Belief Model [Kahan, 2017; Kahan, Peters et al., 2012] and warned that exposition to the scientific consensus may backfire among those who see the consensus as calling into question their core values, pushing them away from the consensus, and increasing attitude polarization [see the "Cultural Cognition Thesis" Kahan, Jenkins-Smith and Braman, 2011].

Despite the uncertainties surrounding the Gateway Belief Model, we chose to rely on this model because people coming to science festivals should be particularly receptive to the scientific consensus, as they typically trust the scientific community.

### *Argumentation*

The second core feature of our intervention is its interactive format: participants were free to give their opinion at any time, interrupt us, and discuss with each other. We repeatedly asked for participants' opinions to engage them in the discussion as much as possible. This format, often used in science festivals and educational workshops, could enable participants to make the best of their reasoning abilities.

Reasoning works best when used in a dialogical context in small groups of individuals holding conflicting opinions [Mercier and Sperber, 2011; Mercier and Sperber, 2017]. And numerous studies have shown that real life argumentation is a fertile ground for belief revision [for reviews see Mercier, 2016; Mercier and Landemore, 2012; for an application to vaccination see Chanel et al., 2011]. But

there is no consensus on the positive role that argumentation could play on heated topics. It has even been suggested that counter-argumentation on heated topics could also backfire, leading to attitude polarization [Ecker and Ang, 2019; Kahan, 2013; Nyhan and Reifler, 2010]. For example, providing people with information in a written format about the low risk and benefits of GM technology have been found to increase opinions' polarization [Frewer, Howard and Shepherd, 1998; Frewer, Scholderer and Bredahl, 2003; Scholderer and Frewer, 2003]. Still, on the whole, backfire effects remain the exception: as a rule, when people are presented with reliable information that challenges their opinion, they move in the direction of this information, not away from it [Guess and Coppock, 2018; Wood and Porter, 2019].

### *The present contribution*

Although scientific festivals are popular and represent a great opportunity for the scientific community to share its knowledge with the public, evaluations of interventions' impact during science festivals are rare [Bultitude, 2014]. But evidence suggests that interacting with scientists and engineers at science festivals positively affect the audience's experience of the event [Boyette and Ramsey, 2019]. And a recent study showed that discussing gene editing in humans during a science festival increased participants understanding of the topic, as well as the perceived moral acceptability of the technology [Rose et al., 2017]. Our study aims to extend these results to GM food and vaccination.

In the two studies reported here, we held 10 to 30 minutes discussions with small groups of volunteers from two science festivals. During these discussions, a group leader (among the authors) explained the hierarchy of proofs (from rumors to meta-analyses and scientific consensus), backed the scientific consensus on vaccine benefits and GM food safety with scientific reports and studies, and answered the public's questions. The discussions started on a non-controversial topic — Earth's sphericity — and ended when the three topics — the other two being vaccines and GM foods — had been discussed, and all participants' questions had been answered. In Study 1, we measured participants' opinions on the Earth's sphericity, the benefits of vaccination, and the health effects of GM food, before and after the intervention. Participants answered on Likert scales and used an anonymous voting system with a ballot box. Study 2 is a replication of Study 1 with additional measures, including participants' trust in the scientific community and participants' degree of confidence in their responses. Data, materials, questionnaires, and pictures of the intervention's setting can be found here: <https://osf.io/9gbst/>.

Since our experimental design does not allow us to isolate the causal factors that contributed to change people's minds, we will not speculate on the role that might have played the exposition to the scientific consensus (Gateway Belief Model) or argumentation. But from our data we will be able to infer: (i) whether participants changed their minds, and (ii) if, on the contrary, cases of backfire were common. Based on the literature reviewed above, we predict that our intervention will change people's minds in the direction of the scientific consensus ( $H_1$ ) and that cases of backfire will be rare ( $H_2$ ).

## Study 1

The first study was designed as a proof of concept to measure whether our intervention would change people's minds on the heated topics that are, in France, GM food and vaccination. We hypothesized that our intervention would change people's minds in the direction of the scientific consensus ( $H_1$ ).

### *Participants*

In October 2018, at Strasbourg University, as part of a French Science Festival, we discussed with 103 participants who volunteered (without compensation) to take part in the workshop: "The wall of fake news: what is a scientific proof." When coming to our workshop, volunteers did not know that they were going to discuss vaccination and GM food. Everyone was welcome and no one have been excluded from the workshop. The median age bracket was 15 to 18 years old, as many high school students came to the workshop. The youngest participant was 13 while the oldest was 80 years old. We excluded children under 13 because they attended the workshop with their parents or teacher, and thus did not respond independently.

### *Design and procedure*

Before and after our intervention, we asked participants to answer questions in French about Earth's sphericity, the benefits of vaccination, and GM food safety on seven-points Likert scales. The first question was: "What do you think of the Earth sphericity?". The scale ranged from "I am absolutely certain that the Earth is FLAT" (1) to "I am absolutely certain that the Earth is SPHERICAL" (7). The second question was: "What do you think of vaccines?". The scale ranged from "I am absolutely certain that vaccines are DANGEROUS for human health" (1) to "I am absolutely certain that vaccines are BENEFICIAL for human health" (7). The third question was: "What do you think about GM (Genetically Modified) food?". The scale ranged from "I am absolutely certain that GM food is DANGEROUS for health" (1) to "I am absolutely certain that GM food is HARMLESS for health" (7). After answering the questions and selecting their age bracket, they were asked to put the piece of paper in a ballot box anonymously.

Discussions took place in groups of one to six volunteers and lasted between 10 to 30 minutes. Two group leaders (the authors) lead the discussions. Each group leader was in charge of one group, so the maximum number of parallel groups was two. We, as group leaders, started the discussions by asking participants what they thought about the Earth's sphericity. All participants believed the Earth to be spherical because of the abundant scientific evidence. To challenge their belief, we handed them a book entitled: "200 Proofs Earth is Not a Spinning Ball." Even though participants were unable to debunk the numerous arguments present in the book, they maintained their initial position because of the stronger scientific evidence. This allowed us to bring to their attention the origin of their belief in the Earth sphericity: trust in science. At this early stage we also explained to them what scientific evidence is and introduced the notion of *scientific consensus* (with the help of the pyramid of proof document that can be found in appendix B). After this short introduction on the Earth's sphericity accompanied by some notions of epistemology, we engaged the discussion on vaccination and GM food, arguing that there are few reasons to distrust scientists on these topics.

We asked participants' opinion on each topic, made them guess the amount of evidence gathered by scientists, informed them of the scientific consensus, and answered their questions. The majority of the discussion time was devoted to GM food, as participants had little knowledge on the topic, and asked many questions. A session ended when the three topics had been discussed and all of the participants' questions had been answered. We used the brief report of the Committee to Review Adverse Effects of Vaccines [2012] and the brief report of the National Academies of Sciences & Medicine [2016] to present the scientific consensus on GM food safety and vaccine benefits. We emphasized the fact that genetic engineering is first and foremost a technology [Blancke, Grunewald and De Jaeger, 2017; Landrum and Hallman, 2017]. As ecology was a recurrent topic of interest, we also argued that genetic engineering could contribute to a sustainable agriculture — in the fight against global warming it is an ally rather than an enemy [Ronald, 2011].

Participants were provided with scientific studies and misinformation coming from blogs, journal articles, books or tweets (the list of materials used during the intervention can be found in appendix A). We also read some scientific studies with participants, debunked the misinformation articles, and highlighted the discrepancy between the scientific facts and the way GM food and vaccines are sometimes portrayed in the news media. The materials were used to support our arguments and answer participants' questions. Therefore not all participants were exposed to the same material. But all participants were presented with the two reports of the National Academies of Sciences & Medicine on GM food safety and vaccine benefits, were familiarized with the pyramid of proof, had to guess how much evidence is available today on GM food safety and vaccines benefits, and were told that there is a scientific consensus on these topics.

We presented ourselves as non-experts allocating their trust in the scientific community because of the rigorous epistemic norms in place. Participants were asked not to trust us on our words, but to check the facts online. We urged them to use Google Scholar or Wikipedia, thanks to its accessibility and reliability [J. Giles, 2005].

## Results and discussion

All statistical analyses in this paper were conducted in R [v.3.6.0 R core team, 2017], using R Studio [v.1.1.419 RStudio team, 2015].

Since pre- and post-intervention responses were anonymous and could not be matched, we used a non-parametric test (permutation with "lmPerm" package [Wheeler and Torchiano, 2016]) to compare pre- and post-intervention ratings. The permutation test generated all the possible pairings between the pre- and post-intervention ratings of our data set and re-computed the test statistic for the rearranged variables [for a detailed explanation see D. Giles, 2019].

Our intervention had no significant effect on the Earth's sphericity ratings  $F(1, 204) = 0.70, p = 0.49$  (number of iterations = 103), as before our intervention participants already believed the Earth to be spherical (before:  $M = 6.83, SD = 0.53$ ; after:  $M = 6.94; SD = 0.27$ ). We found a small effect of our intervention on opinion about vaccination  $F(1, 204) = 12.64, p = .02$  (number of iterations = 4609), with participants rating vaccines as more beneficial and less harmful after our intervention ( $M = 6.13$ ;

$SD = 1.34$ ) than before ( $M = 5.61$ ;  $SD = 1.53$ ). Our intervention had a very strong effect on opinion about GM food  $F(1, 204) = 155.54, p < .001$  (number of iterations = 5000), with participants rating GM food as being less harmful to human health after our intervention ( $M = 5.29$ ;  $SD = 1.74$ ) than before ( $M = 3.55$ ;  $SD = 1.80$ ).

Our intervention shifted participants' opinions in the direction of the scientific consensus, offering support for our first hypothesis.

## Study 2

Study 2 is a replication of Study 1 with additional measures, including participants' trust in the scientific community and participants' degree of confidence in their responses. Participants were also assigned a participant number, allowing us to compare each participant's pre- and post-intervention responses, and thus measure the magnitude of the backfire effect. Based on the literature reviewed in the Introduction, we hypothesized that cases of backfire would be rare ( $H_2$ ).

### *Participants*

In May 2019, at the Cité des Sciences et de l'Industrie in Paris, as a part of the Forum of Cognitive Science, we discussed with 72 participants ( $M_{Age} = 26.06, SD = 10.19$ ; three participants failed to provide their age) who volunteered without compensation to take part in our workshop. Again, everyone was welcome, and no one was excluded from the discussion groups.

### *Design and procedure*

First, participants wrote their age and their participant number on the questionnaire. Second, we measured participants' trust in the scientific community with the following question: "To what extent do you trust the scientific community?", the scale ranged from "0%" (1) to "100%" (6), each point of the scale was associated with a percentage (the second point corresponded to "20%", the third point "40%", etc.). Third, we asked participants to answer three questions about the Earth sphericity, vaccine benefits and GM food safety, together with their degree of confidence on a six-points Likert scale before and after the intervention. The three scales were shifted from seven to six points Likert scales to

prevent participants from ticking the middle point of the scale to express uncertainty. But participants now had the opportunity to express their uncertainty via the confidence scales.

The first question was: "What do you think of the Earth sphericity?". The scale ranged from "The Earth is FLAT" (1) to "The Earth is SPHERICAL" (6). The second question was: "What do you think of vaccines?". The scale ranged from "In general, vaccines are DANGEROUS for human health" (1) to "In general, vaccines are BENEFICIAL for human health" (6). Contrary to Study 1, we specified "in general" because of the complaints expressed by some participants in the Study 1. The third question was: "What do you think about the impact of Genetically Modified (GM) food on human health?". The scale ranged from "GM food is DANGEROUS for health" (1) to "GM food is HARMLESS for health" (6). Each

question was accompanied with a second question assessing participants confidence that went as follow: "How confident are you in your answer?". Participants answered on a six-point Likert scale ranging from "I am 0% sure" (1) to "I am 100% sure" (6), each point of the scale was associated with a percentage (the second point corresponded to "20%", the third point "40%", etc.). The rest of the design and procedure are the same as in Study 1, except that during the afternoon one of the group leader present in Study 1 was replaced by another group leader whom we trained in the morning. We used the exact same materials and followed the same procedure as in Study 1.

## Results

### *Main results*

Since our experimental design allowed us to match pre- and post-intervention ratings, we conducted a one-way repeated measures analyses of variance (ANOVA) to compare the pre- and post-intervention ratings on each topic. The intervention had no significant effect on the Earth's sphericity ratings ( $p = 0.10$ ), as before our intervention participants already believed the Earth to be spherical (before:  $M = 5.71$ ,  $SD = 0.52$ ; after:  $M = 5.76$ ;  $SD = 0.43$ ). The intervention had a medium effect on opinions about vaccination  $F(1, 71) = 8.63$ ,  $p < .01$ ,  $\eta^2 = 0.11$ , with participants rating vaccines as more beneficial and less harmful after the intervention ( $M = 5.31$ ,  $SD = 0.85$ ) than before ( $M = 5.10$ ,  $SD = 0.98$ ). The intervention had a very strong effect on opinions about GM food  $F(1, 71) = 58.97$ ,  $p < .001$ ,  $\eta^2 = 0.45$ , with participants rating GM food as being less harmful to human health after the intervention ( $M = 4.63$ ,  $SD = 1.35$ ) than before ( $M = 3.26$ ,  $SD = 1.54$ ).

### *Did the intervention increase participants' trust in science?*

One-way repeated ANOVA revealed that our intervention had no effect on participants' trust in science ( $p = 0.10$ ; *Mean* before = 4.91, *Mean* after = 4.99, corresponding to "80%" on the scale). And that initial trust in the scientific community had no effect on participants' propensity to change their minds on the Earth sphericity ( $p = 0.06$ ), vaccine benefits ( $p = 0.90$ ), nor GM food safety ( $p = 0.91$ ).

### *What is the effect of confidence on attitude change?*

In the analysis below, three participants who failed to provide their age were excluded ( $N = 69$ ,  $M_{Age} = 26.13$ ,  $SD = 10.64$ ). A linear regression was conducted to evaluate the effect of participants' initial confidence on the extent to which they changed their minds (measured as the difference between pre- and post-interventions ratings). We found that initial confidence had no effect on the propensity of participants to change their minds on the Earth sphericity ( $p = 0.96$ ), vaccine benefits ( $p = 0.10$ ), nor GM food safety ( $p = 0.81$ ).

### *How common were backfire cases?*

After our intervention, out of 72 participants, six participants changed their minds (in the direction of the scientific consensus or not) on the Earth sphericity, 19 on vaccination and 49 on GM food. Cases of backfire effects (i.e. change in the opposite direction of the scientific consensus) were rare: one for the Earth sphericity, five for vaccination, and three for GM food.



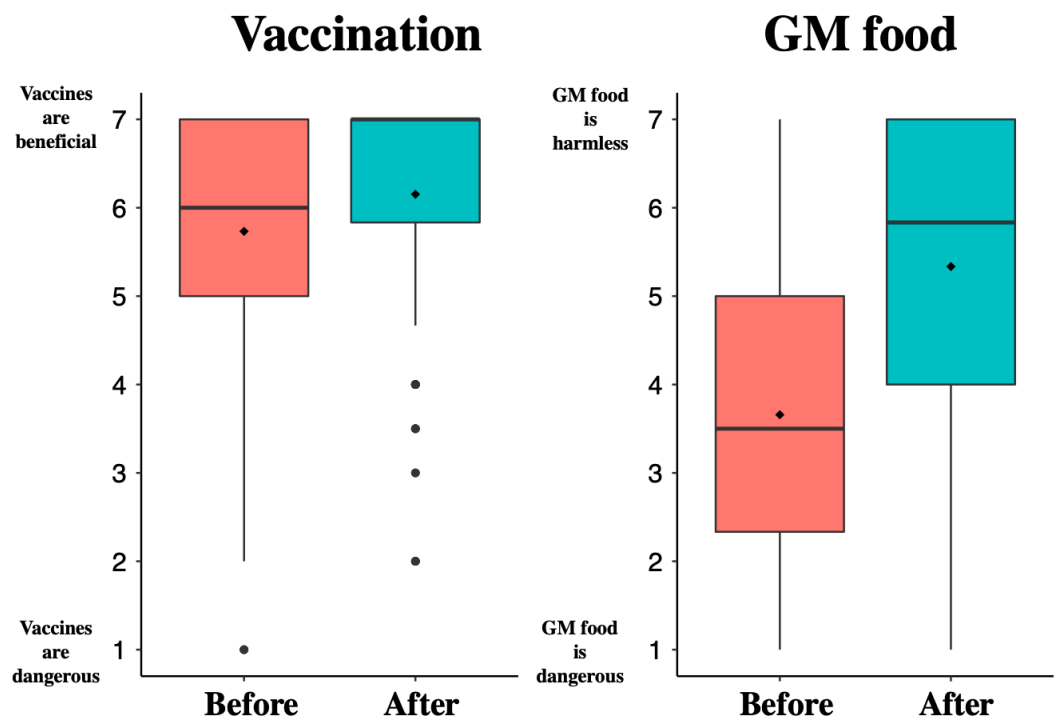
## Discussion

We successfully replicated the results of our first intervention, suggesting that the effect is robust to the different phrasing of the questions, and providing further evidence in favor of the positive influence of discussing heated topics at science festivals ( $H_1$ ). We also found support for the hypothesis that cases of backfire are rare ( $H_2$ ).

### Internal meta-analysis

We ran fixed-effects meta-analysis model implemented in the 'metafor' R package [Viechtbauer, 2010] to compare the results of Study 1 and Study 2. This statistical test allowed us to calculate the overall effect of the intervention by averaging the effect sizes of Study 1 and Study 2. The test modulated the weight given to each study depending on their precision, i.e. effect sizes with smaller standard errors were given more weight [for a detailed explanation see Harrer et al., 2019].

Across the two studies, after the intervention participants considered vaccines to be more beneficial ( $\beta = 0.33 \pm 0.07, z = 5.44, p < .001, CI [0.21, 0.45]$ ) and GM food to be less dangerous than before the intervention ( $\beta = 0.75 \pm 0.06, z = 12.33, p < .001, CI [0.63, 0.87]$ ). For a visual representation of the results see Figure 1.



**Figure 1.** Boxplot of the vaccination and GM food ratings before and after our two interventions ( $N = 175$ ). The six-points Likert scale of the second study was transformed into a seven-points Likert scale. The diamonds represent the means, and the circles represent the outliers ( $1.5 \times$  interquartile range or more below the first quartile).

## General discussion

The present studies show that it is possible to change people's minds at science festivals, even on heated topics, and in relatively little time. Moreover, the risks of backfire effects seem very limited, suggesting that counter-argumentation on

heated topics is probably safer than expected [Ecker and Ang, 2019; Kahan, 2013; Nyhan and Reifler, 2010] and that the worries of the Cultural Cognition Thesis may be overblown [Kahan, 2017; Kahan, Peters et al., 2012].

Overall, the high trust that participants had in science did not exempt them from holding false beliefs on vaccination and GM food (e.g. GMOs were often confused with pesticides). The mere fact of explaining what a GMO is and how they are used in agriculture and medicine helped reduce fears. Most participants were very surprised by the scientific consensus and the number of studies published on this subject. But they also spontaneously produced counterarguments to challenge the consensus, pointing out for example the existence of conflicts of interest. These common counterarguments were easily addressed in the course of the discussion. But this spontaneous generation of counterarguments could hinder the effectiveness of the Gateway Belief Model, since the consensus is typically conveyed in a one-way message format, in which participants' counterarguments are left unanswered, potentially leading to rejection of the consensus or even to the well-known backfire effect [see Altay, Schwartz et al., 2020].

The Deficit Model of Communication [Sturgis and Allum, 2004], which assumes that conflicting attitudes toward science are a product of lay people's ignorance, may be relevant for opinions on GM food since most participants lacked information on the subject — as polls and studies on GM food understanding have already shown [Fernbach et al., 2019; McFadden and Lusk, 2016; McPhetres et al., 2019]. Participants, deprived of strong arguments to defend their stance, nonetheless had the intuition that GMOs were harmful, suggesting that some cognitive obstacles might prevent GMOs' acceptance [Blancke, Van Breusegem et al., 2015; Swiney, Bates and Coley, 2018]. But as these initial intuitions relied on weak arguments (such as "GMOs are not natural"), they were easy to dispel through argumentation.

Not all participants were equally sensitive to our arguments. The Cultural Cognition Thesis [Kahan, Jenkins-Smith and Braman, 2011] may help explain some of the inter-subject variability. For example, the participants who reacted most negatively to the consensus on GM food safety were environmental activists. In France the ecological party is well known for its strong stance against GMOs, thus the consensus may have been perceived as a significant threat to environmentalists' core values.

In the case of vaccination and the Earth's sphericity, high positive prior attitudes can account for the small and medium effect sizes observed as the progress margin was extremely small (particularly for the Earth's sphericity where the ceiling effect was obvious). No participants challenged the consensus on the Earth's sphericity and all of them were aware of it before the intervention. Similarly, most participants knew about the scientific consensus on vaccines and agreed that overall, vaccines are beneficial. But many participants had concerns about particular vaccines, such as the ones against papillomavirus, hepatitis B, and the flu. Corroborating studies showing that vaccine refusal is mainly targeted at specific vaccines and not at vaccination in general [Ward, 2016].

Lastly, as we found that most participants did not know what a scientific consensus is, providing laypeople with some basic notions of epistemology before applying

the Gateway Belief Model could be an easy way to increase their deference to scientific consensus.

### *Limitations*

Since our experimental design does not allow us to isolate the causal factors that contributed to attitude change (knowledge of the scientific consensus, argumentation, or simply being provided with information), causal factors should be investigated in future studies by adding control groups where participants are not exposed to the scientific consensus, are provided with arguments in a non-interactive context or are not taught basic epistemology.

It would also be relevant to vary the context of the intervention, as evidence suggest that scientists' intervention on Genetic Engineering in classrooms can increase students' knowledge on the topic [Weitkamp and Arnold, 2016]. Furthermore, the long-lasting effects of the intervention should be investigated by measuring attitudes weeks, or even months after the intervention, as McPhetres and colleagues did in a learning experiment on GM food [McPhetres et al., 2019].

Finally, our participants' increased knowledge about the scientific consensus on GM food and vaccination could have motivated them to discuss it with their peers. It has been shown that the more people know about the scientific consensus on global warming, the more likely they are to discuss it with their peers, leading to a "proclimate social feedback loop" [Goldberg et al., 2019, p. 1; see also Sloane and Wiles, 2020]. Even though the present study did not measure participants' sharing behaviors after the experiment, we strongly encourage future research to do so as it is an important — alas neglected — dimension of science communication.

### **Conclusion**

The two studies reported in this article show that during science festivals people can change their minds on heated topics if scientists take the time to discuss with them. The results were particularly striking for GM food since most participants with negative opinions on GM food left the workshop thinking that it was harmless to human health. The replication of our intervention indicates that the effect is robust, and that cases of backfire are rare. People coming to science festivals are probably more inclined to accept scientific arguments, and yet we show that not all of them have been exposed to scientific evidence on heated topics such as GM food. This population is a good target for science communication policies, as it is possible to leverage their trust and interest in science to spread scientific arguments outside the scope of the festivals through interpersonal communication [Goldberg et al., 2019]. Our results should encourage scientists to engage more often with the public during science festivals, even on heated topics [see also Schmid and Betsch, 2019].

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**Appendix A. Materials**

**Table 1.** List of the materials used during our interventions sorted by topic.

Earth Sphericity	Vaccination	GM food
Cover of the book: «Mensonge global: la plus grande dissimulation de tous les temps» (Leo Pacchi, 2016)	Institute of Medicine (U.S.). Committee to Review Adverse Effects of Vaccines, Stratton, K. R., & Clayton, E. W. (2012). Adverse effects of vaccines: evidence and causality. Washington, DC: National Academies Press.	National Academies of Sciences, Engineering, and Medicine. (2016). Genetically engineered crops: experiences and prospects. National Academies Press. (Brief report)
200 Proofs Earth is Not a Spinning Ball (Eric Dubay, 2018)	Wakefield, A. J., Murch, S. H., Anthony, A., Linnell, J., Casson, D. M., Malik, M., ... & Valentine, A. (1998). RETRACTED: Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children.	Séralini, G. E., Clair, E., Mesnage, R., Gress, S., Defarge, N., Malatesta, M., ... & De Vendômois, J. S. (2012). RETRACTED: Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize.
Pictures of the Earth from space	Donald Trump tweet: "Healthy young child goes to doctor, gets pumped with massive shot of many vaccines, doesn't feel good and changes — AUTISM. Many such cases!"	Cover of the french journal "Le nouvel Observateur" entitled "Oui, les OGM sont des poisons!"
Article from the french journal "Fredzone" entitled: «7 PREUVES QUE LA TERRE N'EST PAS PLATE»	Cover of the book: Habakus, L. K., & Holland, M. (Eds.). (2011). Vaccine epidemic: How corporate greed, biased science, and coercive government threaten our human rights, our health, and our children. Simon and Schuster.	Nicolia, A., Manzo, A., Veronesi, F., & Rosellini, D. (2014). An overview of the last 10 years of genetically engineered crop safety research. Critical reviews in biotechnology, 34(1), 77-88.
	Taylor, L. E., Swerdfeger, A. L., & Eslick, G. D. (2014). Vaccines are not associated with autism: an evidence-based meta-analysis of case-control and cohort studies. Vaccine, 32(29), 3623-3629.	Snell, C., Bernheim, A., Bergé, J. B., Kuntz, M., Pascal, G., Paris, A., & Ricroch, A. E. (2012). Assessment of the health impact of GM plant diets in long-term and multigenerational animal feeding trials: a literature review. Food and chemical toxicology, 50(3-4), 1134-1148.
	Article from the french journal "Le Monde" entitled: «Isabelle Adjani, nouvelle icône des "antivax"»	Cover of the book "Tous Cobayes!", (Gilles-Éric Séralini, 2012)

Appendix B.  
Pyramid of the  
hierarchy of proof

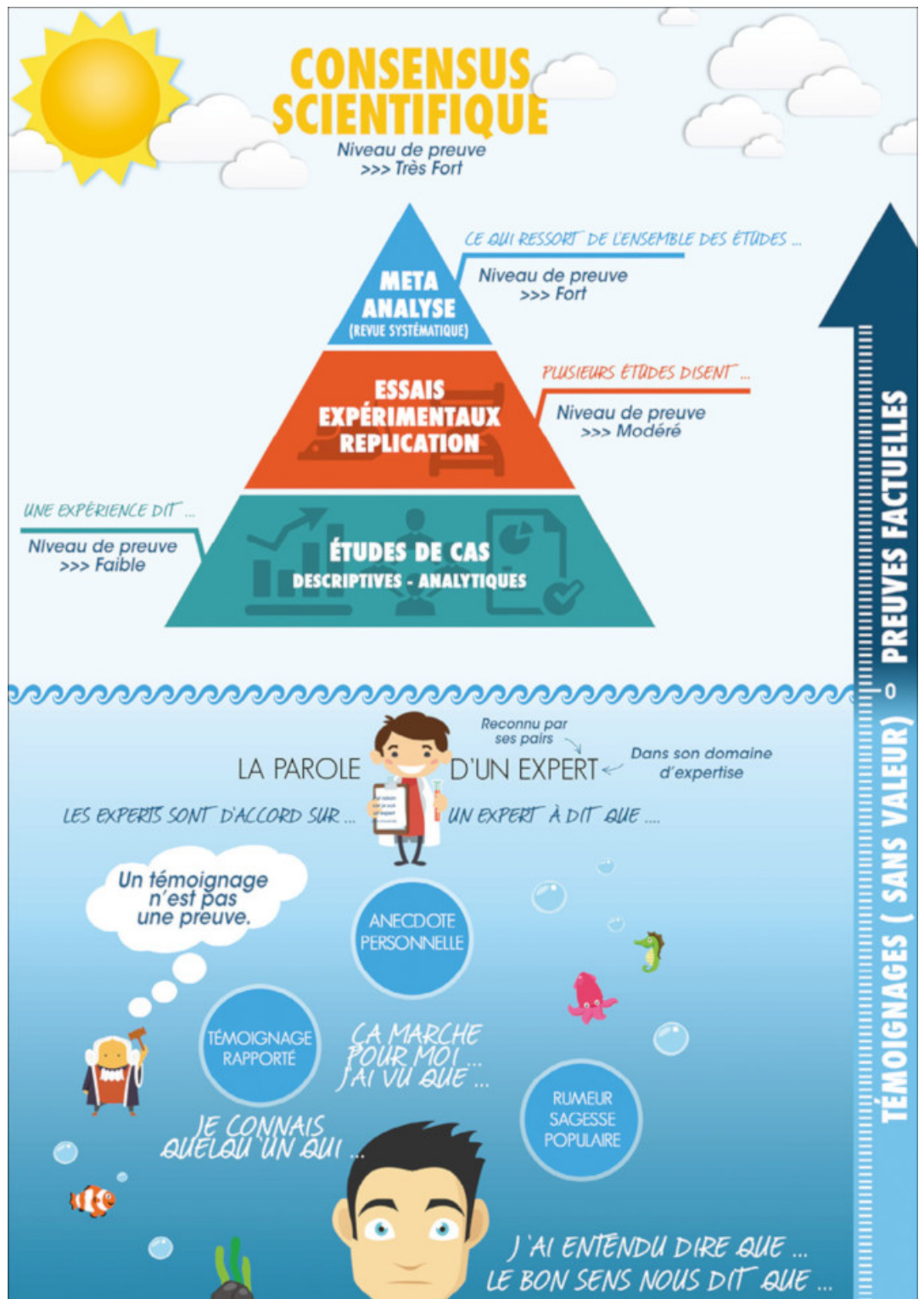


Figure 2. Pyramid of the hierarchy of proof.

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