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Bad News Has Wings: Dread Risk Mediates Social Amplification in Risk Communication

Robert D. Jagiello,[1] Thomas T. Hills[2]

Social diffusion of information amplifies risk through processes of birth, death, and distortion of message content [(1)]. Dread risk—involving uncontrollable, fatal, involuntary, and catastrophic outcomes (e.g., terrorist attacks and nuclear accidents)—may be particularly susceptible to amplification because of the psychological biases inherent in dread risk avoidance. To test this, initially balanced information about high or low dread topics was given to a set of individuals who then communicated this information through diffusion chains, each person passing a message to the next. A subset of these chains were also re-exposed to the original information. We measured prior knowledge, perceived risk before and after transmission and, at each link, number of positive and negative statements. Results showed that the more a message was transmitted the more negative statements it contained. This was highest for the high dread topic. Increased perceived risk and production of negative messages was closely related to the amount of negative information that was received, with domain knowledge mitigating this effect. Re-exposure to the initial information was ineffectual in reducing bias, demonstrating the enhanced danger of socially transmitted information.

KEY WORDS: risk perception, social risk amplification, social influence, public opinion, nuclear power, food additives

1. INTRODUCTION

The development of effective risk communication methods that minimize public anxiety relies on understanding how risk information propagates through social communication channels [(1)]. This is notoriously difficult to predict because public opinion on topics such as climate change, nuclear energy, disease risks, and immigration rapidly become polarized [(2)] and at variance with scientific evidence [(3,4,5)]. For instance, following the first Ebola case diagnosed in the United States, Twitter posts mentioning Ebola jumped from 100 per minute to 6000 per minute and quickly incorporated inaccurate claims that it could be transmitted through the air, water, and food [(6)]. This apparent unpredictability is common to socially propagated risk information, which is often communicated via friends, family, online forums, blogs, and other forms of social media. Though numerous factors influence risk perception [(7,8,9)], substantial work has shown the influence of social contagion on behaviour and attitudes [(2,10,11,12)], with specific factors including interpersonal proximity through social networks [(13,14)] and group size [(15,16,17,18)]. Many of these studies suggest that when scaled to populations, information dynamics may exhibit nonlinear amplification patterns leading to rapid changes in attitudes and behavior. A recent study by Moussaid, Brighton and Gaissmaier [(1)] examined this directly by quantifying information evolution around a controversial topic as a message passed along a chain of people. This evolution led to

[1]Department of Psychology, University of Warwick, University Road, Coventry, CV4 7AL, United Kingdom, R.D.Jagiello@gmail.com
[2]Department of Psychology, University of Warwick, University Road, Coventry, CV4 7AL, United Kingdom, T.T.Hills@warwick.ac.uk

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social risk amplification [19,20,21,22] in the form of communication bias towards negative statements.

A significant challenge remains in understanding how social propagation of information responds to different kinds of risks. One form of risk capable of inducing substantial fear is dread risk. According to a psychological analysis of the taxonomy of hazards [3,4,23,24], high dread risks (such as nuclear accidents, plane crashes, and terrorism) are characterized as uncontrollable, fatal, involuntary, and catastrophic to human life. Low dread risks (such as food additives, chlorinated water, and low levels of pollution) are seen as controllable, non-fatal, and voluntary. High dread leads to stricter calls for governmental regulations (e.g. nuclear plants) and higher levels of risk avoidance than low dread risks associated with the same death toll [23,25]. This asymmetry in hazard perception is highly relevant to risk judgment considering that elevated dread induces the use of an affect heuristic [26], or 'risk as feelings' [27]. Specifically, within the framework of dual processing theories [28,29], the affect heuristic is an automatic process that prioritizes emotional information over facts [30]. This leads to the overestimation of the probability of devastating outcomes [31,32,33]. The public outrage following disasters associated with dread risks is closely tied to a disproportionate perception of lethality and unfairness [34,35].

A second major challenge in opinion formation is understanding how social risk diffusion responds to the reintroduction of balanced information, which is often the hallmark of expert opinion [36]. Various psychological biases influence memory and social message transmission, such as enhanced retrieval for personal information and anecdotes, and selection for more easily communicated information [37,38,39], all of which may limit the ability of balanced accounts to correct social risk amplification. Higher anxiety promotes selective processing and is therefore associated with less risk attenuation in response to balanced information [40,41]. For example, neutral accounts heighten public panic in relation to epidemic outbreaks [5] and perpetuate fears whenever fears are already disproportionately high [4]. Might the reintroduction of balanced information have a limited effect after social risk amplification has taken place? Moreover, might it's efficiency be reduced further by dread risks? Slovic [3] states that high dread risks 'are resistant to change because they influence the way that subsequent information is processed', which is in line with the previously described affect heuristic [30]. High dread topics may therefore be potent enough that they cause the reintroduced information to be viewed through the tint of 'risk goggles'. This would render a neutral account not only ineffective in terms of inducing bias extinction but would potentially even be counteractive, by providing the subject with a new source of negative information [40].

In this article, we examine the social transmission of information about high and low dread risks (nuclear energy and food additives) and further examine how this information responds to the reintroduction of the initial account. Our approach involves treating message content as subject to the evolutionary processes of birth, death, and mutation, and tracking the change in information over repeated transmissions in human diffusion chains. In addition, we also focus on the sentiment of the message, asking how dread risk and the reintroduction of the initial information influences the dynamics of transmitted negativity. How is social contagion of risk mediated by these factors and what, if anything, does trying to provide balanced information accomplish?

2. METHOD

2.1 Participants

The study was advertised in social media groups and in public environments affiliated with the University of Warwick and the University of Luxembourg. A total of 154 participants (82 male and 72 female; $M_{age} = 23.23$; $SD = 3.56$ and $M_{age} = 22.16$; $SD = 1.95$ respectively) took part in exchange for the opportunity to win a £20 Amazon voucher.

2.2 Design

The study consisted of 14 chains of 8 participants each. Participants in the first position in the chain ($N = 14$) read a set of articles and then wrote a message for the next person in the chain. Participants in positions 2-5 ($N = 4 * 14 = 56$) read the message from the previous position in their chain and then wrote their own message. Positions 6-8 ($N = 3 * 14 * 2 = 84$) were exposed to a 'fork design' which was employed to determine the effect of reintroducing information into the chain. We split positions 6-8 into two branches, an 'informed' and 'uninformed' branch (Figure 1). For the 'informed' branch, position 6 received the same information as

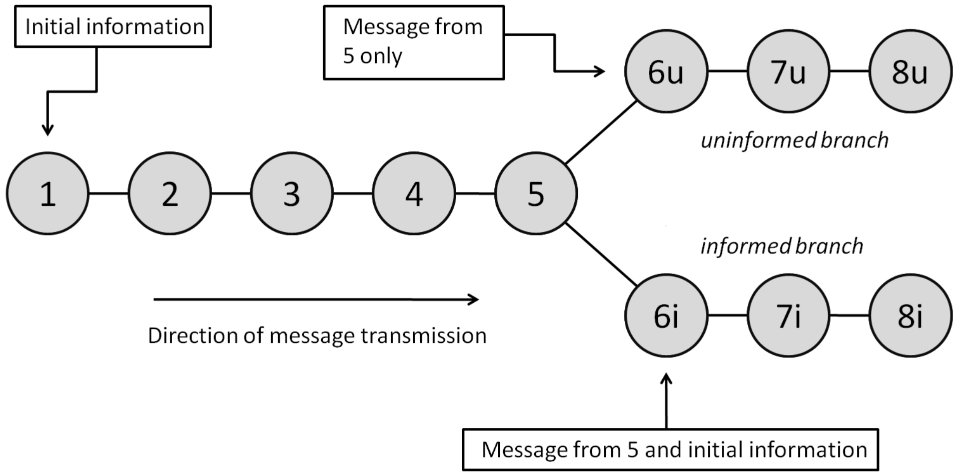

Fig. 1. Fork chain, split at the 6th node into an 'informed branch' and 'uninformed branch'.

position 1, in addition to the message from position 5. For the 'uninformed' branch, position 6 received only the message from position 5. Dread taxonomy consisted of two levels: the 'high dread' condition (N = 77; 7 chains) with participants reading and writing about 'nuclear energy' and the 'low dread' condition (N = 77; 7 chains) with participants reading and writing about 'food additives'.

All 154 messages were coded for negative and positive statements (see Appendix A - Coding Criteria). All messages were coded twice, once by the experimenter who was aware of the hypothesis and an additional time by the combined efforts of five confederates who were blind to the rationale of the study. Cronbach's Alpha indicates high inter-rater agreement for both negative (α = .961) and positive statements (α = .974) between the two resulting sets. Messages were also compared with the previous message to detect new, distorted, and omitted statements. Prior knowledge as well as risk and dread estimates were recorded using scales from 0 to 100 (for the questions used see Appendix B).

2.3 Materials and Stimuli

The first participant in each chain read four documents discussing the dangers and advantages of the topic. These documents were taken from various sources, such as the BBC, Dailymail, Telegraph, and National Geographic. Pictures were removed from the articles and the texts were balanced across the two dread conditions, controlling for the amount of words (Nuclear: 1521; Food: 1507), reading time (piloted; N = 5; Nuclear: 8:36 min.; Food: 8:42 min.) and density of positive and negative statements (21 statements each). The documents were presented online on a white background with instructions and text in font size 11.

2.4 Procedure

A survey was created for each chain position using Qualtrics. Participants in the first session were allocated to the first position of each of the 14 chains. This was repeated until all first chain positions were completed. Then the first session was closed and session 2 (containing the messages from session 1) began. Participants who opened one of the session links read and agreed to the informed consent document and, following random assignment to either nuclear energy (high dread condition) or food additives (low dread condition), were asked to fill out a short questionnaire evaluating their knowledge of the topic as well as their perceived risk.

Participants starting the chain (position 1) as well as those who were re-informed (position 6 informed) were exposed to the initial four balanced documents. The order of the text documents was randomized across chains. Subsequently, subjects were asked to compose a message for the next participant and then to judge the amount of perceived risk they associated with the topic. Sessions 2-5, 6 'uninformed', and 7-8 were exposed only to the message constructed by the previous participant in their chain. Session 6 'informed' saw both the previously constructed messages and the original articles.

3. RESULTS

We first establish that there were differences in dread risk between the two conditions and that message content changed over repeated transmissions. Participants had higher concerns (dread questionnaire; see 2.2) for nuclear energy ($M = 0.48$; $SD = 0.2$) as compared to food additives ($M = 0.36$; $SD = 0.19$), $t(152) = 4.007, p < .001$, demonstrating that nuclear power was more dreaded than food additives (Figure 2). Message content also changed substantially over repeated transmissions (Figure 3). Based on Moussaid et al. [(1)], we computed the probability that a statement was created (pBirth), vanished (pDeath), or was distorted (pDistort) during transmission. For the High Dread condition, pBirth was 45%, pDeath was 37%, and pDistortion was 43%; for the Low Dread condition, pBirth was 37%, pDeath was 35%, and pDistortion was 46%. These did not differ in relation to high or low dread (pBirth, $p = .115$; pDeath, $p = .807$, pDistortion, $p = .561$). However, upon re-information the rate for pBirth at chain position 6 was 78% in the informed branch, compared with 41% in the uninformed branch. The informed condition also saw a decrease in message distortion compared with the uninformed branch: 20% and 61%, respectively, $t(26) = 3.341, p = .003$. No effect of information manipulation was found for pDeath ($p = .598$). These results suggest that socially transmitted information is under constant flux, with the death, birth, and distortation rates of information continuously shaping message content over the period of our study. The findings also indicate that re-information reduces transmission inaccuracy.

3.1 Chain Analysis

Did messages become more negative over time? The proportions of negative (ω_p^-) and positive statements (ω_p^+) at each chain position were calculated as follows:

$$\omega_p^- = \frac{n_p^-}{(n_p^- + n_p^+)} \qquad \omega_p^+ = \frac{n_p^+}{(n_p^- + n_p^+)}$$

where n_p^- and n_p^+ represent the number of negative and positive statements, respectively. Figure 4 shows a heatmap illustrating the increasing prevalence of negative content over time. Chain position was a strong predictor of the proportion of negative statements ω_p^-, $F(10, 143) = 5.283, p < .001$.

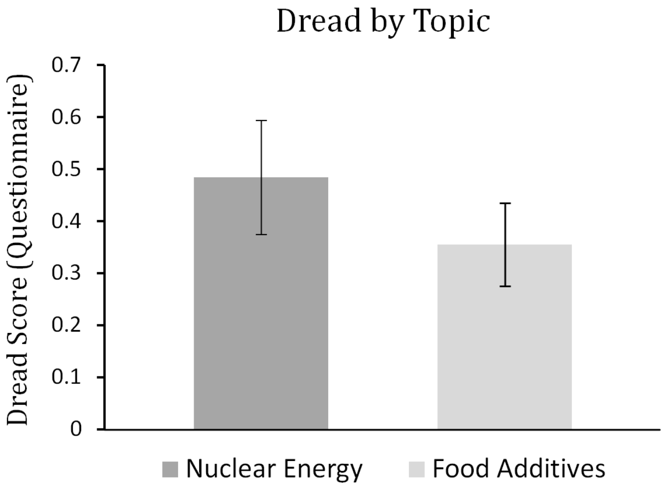

Fig. 2. Average scores of dread questionnaire across all chains, with error bars representing standard error. Nuclear energy caused significantly greater concern than food additives.

Post-hoc tests reveal that ω_p^- was significantly greater in the later positions (5, 6-8 informed and uninformed) than in the earlier positions (1-4) ($p = .038$). Hence, the proportional amount of negative statements made by subjects increased as messages were transmitted from node to node.

3.1.1 *Dread Risk*

High dread was associated with the accumulation of an overall higher proportion of negative information (comparing high (74%) vs. low (65%) dread chains, $t(152) = 2.927, p = .001$). A 2x11 Factorial ANOVA with dread taxonomy (high/low) and chain position (1-5; 6-8 informed; 6-8 uninformed) as independent factors and ω_p^- as dependent variable revealed a main effect for taxonomy, $F(1, 153) = 10.893, p = .002$, and for chain position, $F(10, 154) = 5.506, p = .001$, while the interaction was not significant, $F(10, 48) = 0.616, p = .622$. This effect is also found in informed and uninformed high dread conditions, where the proportions of negative statements increased as messages were communicated along the chain ('High Dread Informed', $F(7, 48) = 8.847, p = .001$, and 'High Dread Uninformed', $F(7, 48) = 8.271, p = .001$). However, the low dread conditions were not significantly affected by chain position in either information condition (informed, $F(7, 48) = 1.386, p = .233$, or uninformed, $F(7, 48) = 1.426, p = .217$) (Figure 5).

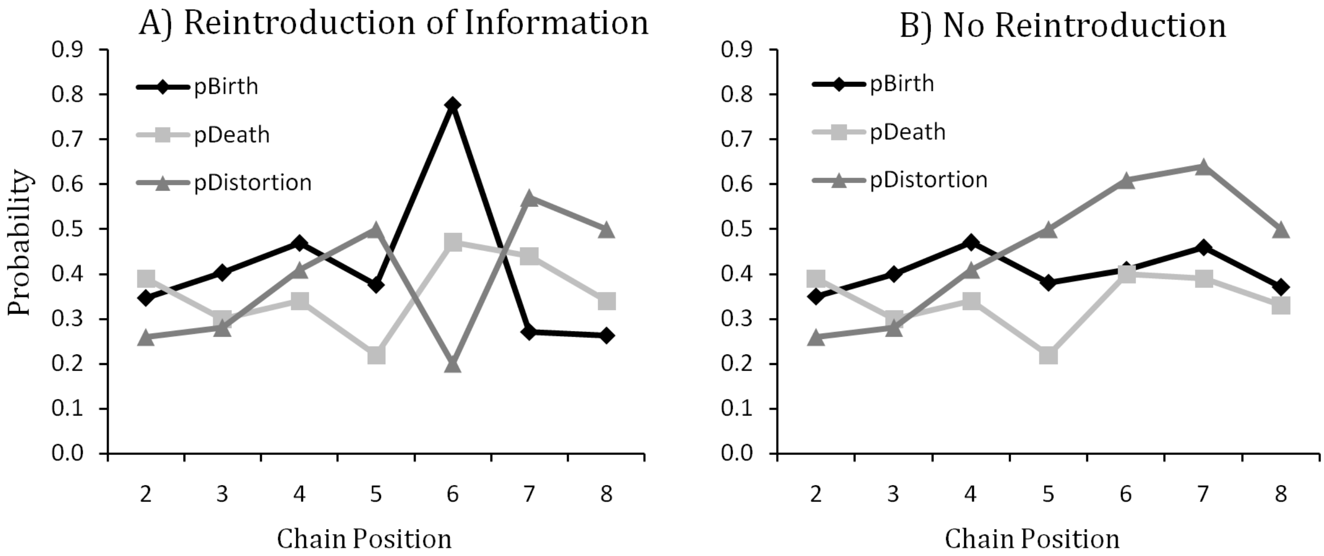

Fig. 3. Probability that a new statement was created (pBirth), an old statement vanished (pDeath), and that a statement was distorted (pDistortion). Positions 1 - 5 are the same in both figures, with the information manipulation taking place at the 6th node. The comparison of A) and B) graphically illustrates that the reintroduction of information causes a marked increase in pBirth, as well as a significant alleviation in pDistortion at the 6th position, with fluctuations in pDeath not reaching significance.

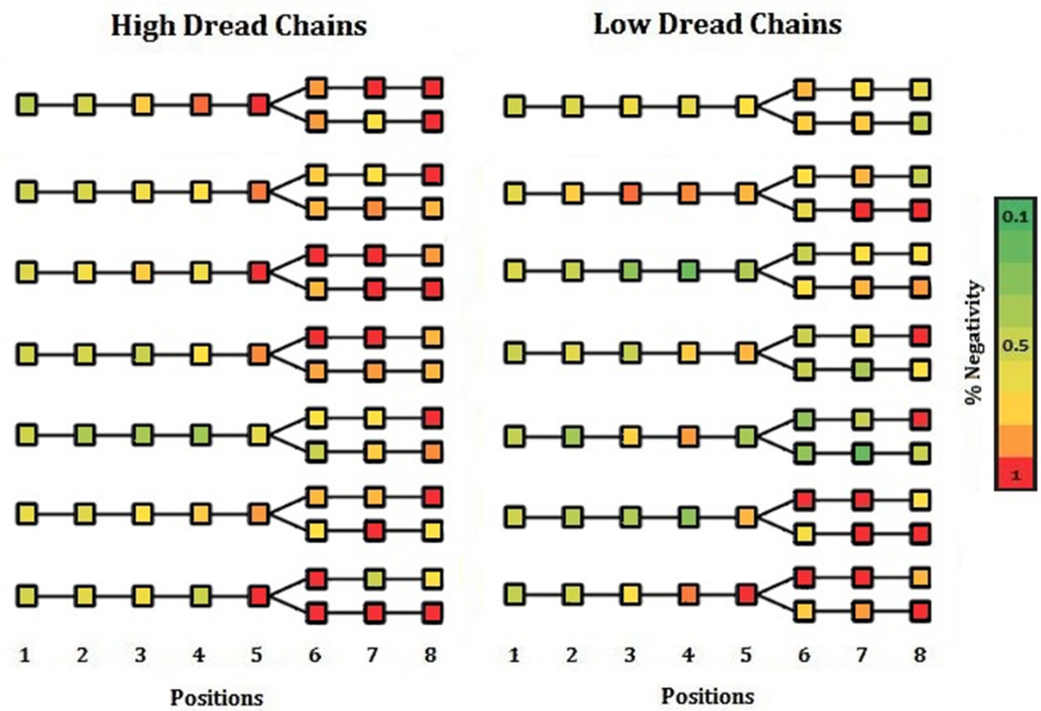

Fig. 4. Proportional negativity plotted for each node. Upper branches are 'informed' and lower branches are 'uninformed'. Colors indicate changes in the level of negativity.

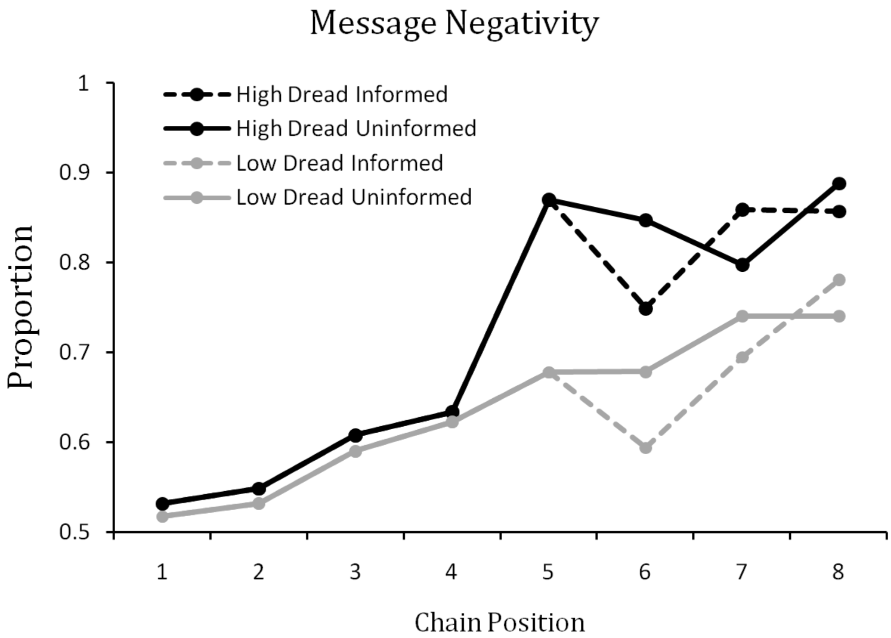

Fig. 5. Proportions of negative statements for each node and condition: High Dread (black), Low Dread (grey), Uninformed (line), Informed (dashed).

3.1.2 *Reintroduction of balanced information*

How did risk information in the diffusion chains respond to the reintroduction of balanced information? To test this, we compared position 1 with position 6 (informed and uninformed). A one-way ANOVA comparing the proportions of negativity found a significant difference, $F(2, 18) = 11.818, p = .001$. Further exploration showed that position 6-informed and 6-uninformed both had higher levels of negativity than position 1 ($p = .004$ and $p = .0001$ respectively), but failed to differ from each other ($p = .157$). This suggests that the reintroduction of balanced information was ineffective in the high dread condition as it did not restore negativity to its level in position 1. In the low dread condition, there was no difference between position 1, 6-informed, and 6-uninformed, $F(2, 18) = 1.594, p = .230$. This was expected given the lower overall negativity within low dread chains. In general, these findings suggest that despite the fact that re-information yielded mutational effects (pBirth and pDistort), it did not influence the amount of negativity transmitted from one person to the next.

3.2 **Individual Change**

What makes individuals resistant to social risk amplification? We measured this in two ways. First we examined the influences on (1) negative output, which is the amount of risk-focused information the individual passes on to the next participant, followed by an analysis of (2) opinion change, which reflects the propensity towards increasing one's risk perception.

3.2.1 *Predictors and Moderators of Negative Output*

A linear multiple regression analysis was used to investigate the predictive power of (1) received negativity (ω^-_{p-1}) (2) initial risk perception (IR) and (3) prior knowledge (kn_p) in regard to the message negativity ω^-_p that the individual transmitted. Including both high and low dread conditions and chain positions 1-8, a significant regression equation including the aforementioned predictors was found $F(3, 136) = 39.09, p < .0001$ with an R^2 of .463. Table I summarizes these results. Accordingly, transmitted negativity (output) increased with elevated received negativity as well as high initial risk assessment, while being dampened by prior knowledge (Figure 6). In the high dread condition, only increases in received negativity were predictive of heightened output negativity, $F(1, 68) = 30.78, p < .0001$ with an R^2 of .312. In the low dread condition, both received negativity and knowledge were significant predictors, $F(2, 67) =$

Table I . Beta coefficients and p-values of predictors of negative output, with standard error in brackets, in high and low dread conditions as well as overall

	Constant (β_0, p)	Received Negativity (β_1, p)	Initial Risk (β_2, p)	Prior Knowledge (β_3, p)
High Dread	**0.373, p = .0001** (SE = .094)	**0.547, p = .0001** (SE = .097)	0.154, p = .087 (SE = .088)	-0.221, p = .099 (SE = .132)
Low Dread	**0.430, p = .0001** (SE = .092)	**0.541, p = .0001** (SE = .095)	0.143, p = .109 (SE = .108)	**-0.480, p = .0001** (SE = .130)
Overall	**0.381, p = .0001** (SE = .063)	**0.565, p = .0001** (SE = .065)	**0.188, p = .005** (SE = .066)	**-0.362, p = .0001** (SE = .091)

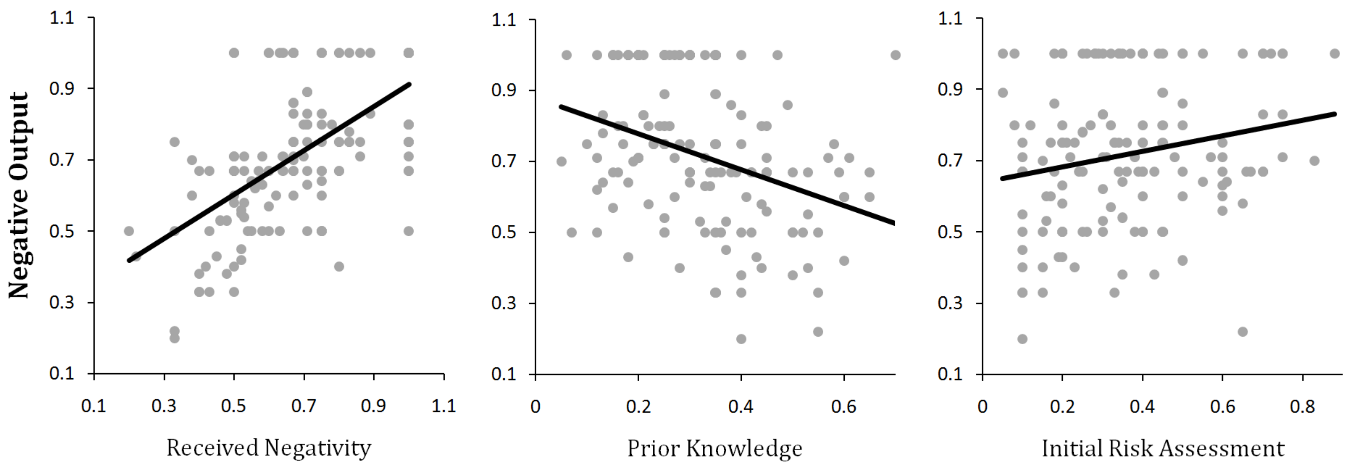

Fig. 6. Scatterplots depicting correlations between the negativity an individual passed on and (1) the negativity of the message they received, (2) their prior knowledge regarding the topic, and (3) their initial risk perception. Transmitted negativity increases whenever the individual has an initially hazardous view and is confronted with negative messages. It decreases, on the other hand, in relation to elevated expertise.

$30.24, p < .001$ with an R^2 of .474. Interactions between knowledge and received negativity were not significant ($p = .09$), suggesting that the mitigating force of knowledge is limited when it comes to the detrimental effects of received negativity.

3.2.2 *Opinion Change*

Did message content change perceived risk? Change in perceived risk, Δ_R, is the difference between pre- (IR) and post-risk (SR) assessments for a given topic ($\Delta_R = SR - IR$). The mean of the perceived risk change across all participants was 0.13 ($SD = 0.15$). We observed an increase in perceived risk in high and low dread conditions, $t(69) = 8.281, p = .001$ (high dread), and $t(69) = 6.269, p = .001$ (low dread) with no difference between conditions ($p = .806$) (Figure 7).

Change in perceived risk should be a function of the content individuals receive. Additionally expertise (prior knowledge) may inhibit attitude change. To address these assumptions, a multiple regression analysis was performed with attitude change Δ_R as dependent variable. Again, (1) received negativity ω_p^-, (2) initial risk perception (IR) and (3) prior knowledge (kn_p) served as predictors. Changes in risk perception for positions 1-8 were predicted by the aforementioned variables across conditions $F(3, 136) = 46.506, p < .0001$ with an $R^2 of .273$, as well as for high dread, $F(2, 67) = 26.365, p < .0001$ with an $R^2 of .545$, and low dread, $F(2, 67) = 23.507, p < .001$ with an $R^2 of .517$, separately. Opinion change varied positively with the amount

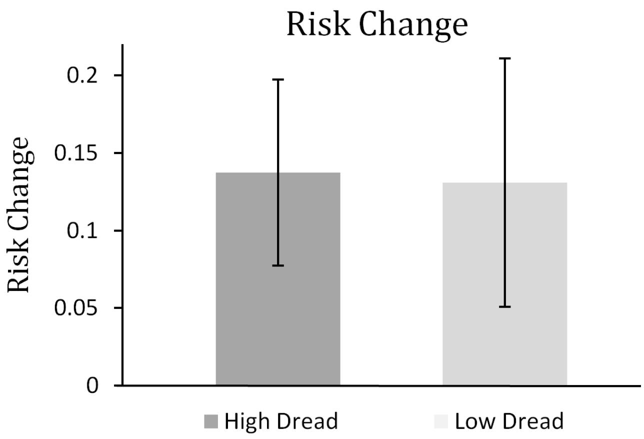

Fig. 7. Averages of risk change in both dread conditions (sig. different from nil).

of negative information received and negatively with the amount of prior knowledge. Additionally, high initial risk perceptions are linked to less severe opinion changes, most likely reflecting a ceiling effect. Results are summarized in Table II .

We also found an interaction between received negativity and prior knowledge ($\omega_{p-1}^{-} * kn_p$) across both conditions ($\beta = -0.818, SE = .406, p = .046$), indicating that high received negativity is linked to elevated changes in perceived risk especially if prior knowledge is sufficiently low. This suggests a resilience effect of knowledge that dampens an individual's susceptibility to changing their opinion. To visualize this effect, the data were broken down into tertiles, forming knowledge categories (Figure 8). In the third tertile where knowledge scores were highest (ranging from 0.39 - 0.71) the correlation between received negativity and opinion change was weaker ($r(47) = .343, p = .021$) than in the other two tertiles ($r(46) = .405, p = .004; r(47) = .541, p = .0001$).

4. DISCUSSION

Socially transmitted information is how humans learn about potential hazards they have not yet experienced. This provides the foundation for opinion formation about topics that often have long-term consequences, such as climate change, alternative energy sources, and health risks. Experimental research on social transmission is only beginning to take form, but its study is critical to addressing problems associated with public hysteria, opinion polarization, and the reduction of public anxiety. To our knowledge, the present work is the first to experimentally investigate (i) the impact of dread on social amplification of risk and (ii) to examine the effect of re-exposure to balanced information in the ongoing process of social diffusion. In this regard, the present article makes five contributions. First, we demonstrate social risk amplification in a new domain. Moussaid et al. [(1)] found social amplification of risk in relation to an antibacterial agent. In the present work we observe a similar effect in relation to nuclear energy, for which messages tended to become more negative over time. Second, we demonstrate that social amplification of risk is sensitive to dread, with high dread topics suffering a more rapid increase in negativity than low dread. Third, participants increased their risk attitudes the most when reading messages that displayed an elevated proportion of risk information. Fourth, greater personal knowledge of an area prior to receiving risk information did not counter the amplification of transmitted information, but resulted in less change in risk perception. Finally, the reintroduction of information from the initial set of articles was insufficient to reinstate the negativity levels of chain position 1. Even though re-information led to a drop in factual distortion and an increased amount of message content, this did not reduce the amount of transmitted negativity, which is especially relevant in the high dread case.

The resilience of the message content to the reintroduction of balanced information highlights an important element of human diffusion: socially transmitted information may evolve to become more learnable, as it experiences selection for content that is more easily understood and later reproduced [(39,42)]. Bartlett's [(43)] studies of human memory demonstrate this at the level of individuals, by showing that people tend to recall stories in patterns that are consistent with their own prior expectations. By reintroducing balanced accounts into chains, the present results demonstrate a similar process of message adaptation across individuals and further show that this makes the message content more resilient than the information on which it was initially based. Additionally, messages from peers are likely to have more weight and hence greater influence in regard to selective re-transmission of information. It is therefore likely that negative peer interpretations induced a selective bias, which led participants at the re-informed 6th position to disregard the positive side of the balanced information in favour of a confirmation of the negatively focused facts. Past research has demonstrated mechanisms of

Table II . Beta coefficients and p-values of predictors of opinion change, with standard error in brackets, in high and low dread conditions as well as overall.

	Constant (β_0, p)	Received Negativity (β_1, p)	Initial Risk (β_2, p)	Prior Knowledge (β_3, p)
High Dread	**0.201, p = .002** (SE = .094)	**0.306, p = .0001** (SE = .097)	**-0.580, p = .0001** (SE = .088)	**-0.216, p = .012** (SE = .132)
Low Dread	0.050, p = .499 (SE = .092)	**0.528, p = .0001** (SE = .095)	**-0.452, p = .0001** (SE = .108)	**-0.180, p = .046** (SE = .130)
Overall	**0.109, p = .021** (SE = .063)	**0.450, p = .0001** (SE = .065)	**-0.505, p = .0001** (SE = .066)	**-0.203, p = .001** (SE = .091)

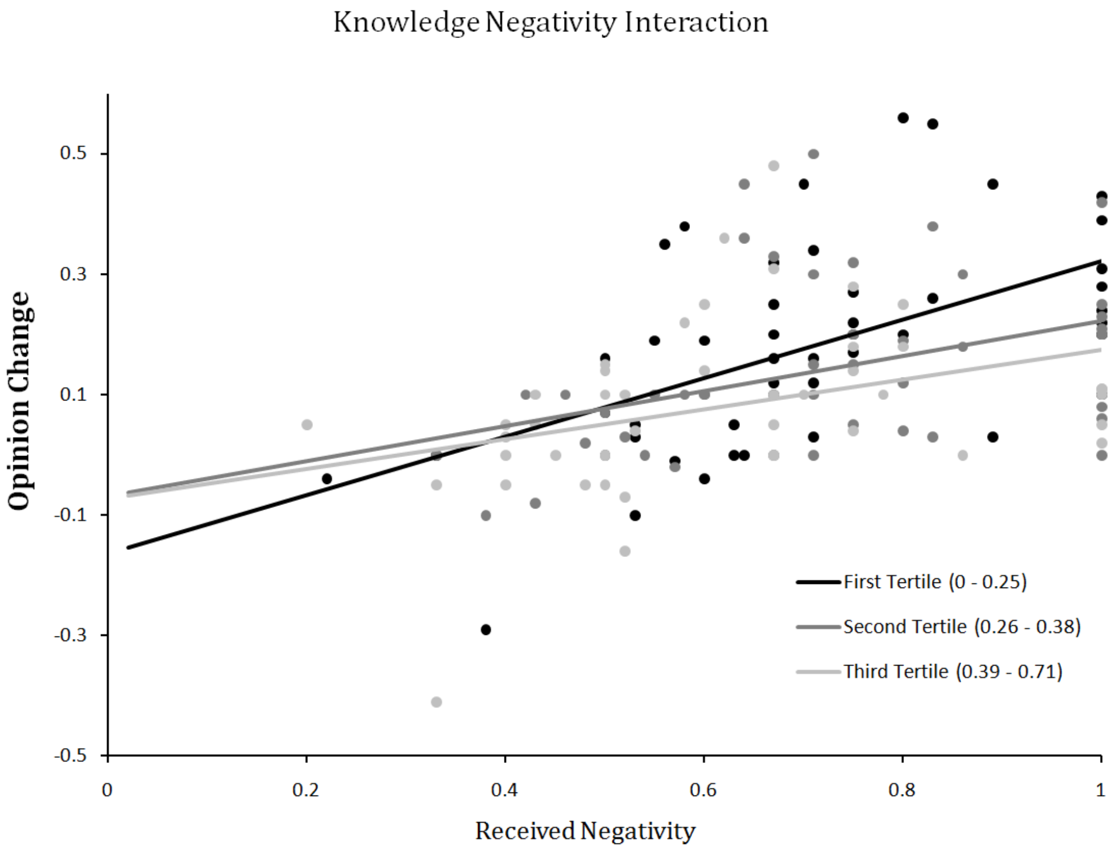

Fig. 8. In order to visualize the impact of knowledge on the relationship between received negativity and opinion change, participants' knowledge scores were categorized into thirds of the subject pool (N = 47). As can be seen, the relation between received negativity and opinion change is strongest in the first tertile and weakest in the third (where knowledge scores are highest), hence suggesting a mitigation effect of expertise.

social proof and group-think that show the capacity of inducing such biases[44,45].

Our results further indicate that higher levels of prior knowledge were associated with lower transmission negativity. Further, individual's with higher content relevant knowledge were more resilient to the detrimental effects that receiving a high risk message had on one's risk perception. This is in line with past research that has shown that the integration of balanced information may be facilitated through a process of inoculation, whereby individuals are prepared for biased information through pre-exposure to more balanced arguments[46,47,48,49]. Hence the findings suggest that inoculation may also work in social diffusion chains by demonstrating that individuals with higher knowledge are less prone to increase their perceived risk in response to propagation of negative content. In regard to the actual content amplification in transmitted messages, no interaction could be found and therefore expertise may not offer the same level of resilience as it does for attitudes. Future research should therefore aim to address how certain factors may affect opinions differently than their written manifestations and how this discrepancy influences the diffusion of risk information.

Limitations of the present design can further serve to pave the way for future directions of inquiry. Firstly, in regard to the questionnaire that was used, the concept of psychological distance and the role it plays in risk perception need to be considered. Risk perceptions are generally higher in response to threats that are in closer proximity as opposed to geographically distant hazard sources[50]. The questions that were used to measure risk perceptions of nuclear energy ('Imagine now that near to where you live a new nuclear power plant is in construction [...]') could have been interpreted by participants as a more proximate threat than in the food additives condition ('Imagine reading an article about how the general amount of food additives in the country you live in has been increased [...]'). On the other hand, it could be argued that food is interpreted as more proximate due to its ubiquitous day-to-day presence. Both topics are inherently different—an issue that is unavoidable given that phenomena that lie on different ends of Slovic's dread axis differ along numerous dimensions. Furthermore, it needs to be noted that the topics used in the present design are well known, widely discussed phenomena that are likely to have been subject to social diffusion prior to this experimental induction. Future replication attempts of the observed effects may include artificially made-up risks that respect the dread characteristics of Slovic's taxonomy, in order to limit the magnitude of effects that may have already occurred outside of the lab. This could provide a powerful approach to understanding the factors that lead benign risk topics to incite public hysteria.

To conclude, following the work of Moussaid et al.[1], we demonstrate that processes of opinion formation and social amplification of risk can be investigated in an experimental setting that tracks sentiment and content over time. The present work extends this investigation by further demonstrating the ability to elucidate the role of risk types and the influence of interventions that attempt to restore balanced attitudes. Because dread risk is unique in its ability to pose socially contagious public health problems[3,30], documenting its enhanced sensitivity to social amplification of risk is a first step towards reducing hazardous responses in the future.

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5. APPENDIX A - CODING CRITERIA

The coding criteria are adapted from Moussaid et al.[(1)]. Criteria for negative statements in nuclear energy chains are the following:

1. Any mention of a negative aspect of nuclear energy, such as

   a. detrimental consequences of its use
   b. anecdotal evidence of danger
   c. indicators of risk avoidance

   Examples:

   a. 'The production of nuclear energy causes radioactive waste, harming the environment.'
   b. 'Remember Chernobyl?'
   c. 'Germany is decreasing their nuclear energy production over the next years.'

2. Any personal judgment that is suggestive of the dangers of nuclear energy, such as 'I feel like a world without nuclear power would definitely be a bit safer!'

The criteria for positive statements are the following:

1. Any mention of
   a. positive aspects of nuclear energy
   b. any form of risk mitigation
   c. any type of anecdotal endorsement

   Examples:

   a. 'Nuclear power plants drive the economy.'
   b. 'Disposal of radioactive waste is regulated by the government.'
   c. 'My cousin works at a power plant. It's super safe.'
2. Personal judgments such as 'I don't think power plants are that dangerous.'

The criteria for food additives have been established in an analogous manner.

6. APPENDIX B - QUESTIONNAIRE

The questions that were used in the course of participation in this study can be seen below, (1) nuclear energy and (2) food additives. All questions were answered via the use of a slider (3). The question regarding the general risk perception (1.3. and 2.3.) was administered twice, once before message transmission and once after.

1.1 How familiar are you with nuclear energy, its production, risks, and benefits?
   - 0% No knowledge
   - 1% - 20% Minimal amount of knowledge (I have read 1 article/seen 1 news report)
   - 20% - 40% Some knowledge (I followed the news coverage)
   - 40% - 60% Moderate knowledge (I read more than 5 articles/1 book)
   - 60% - 100% Advanced knowledge (I study physics or another science related to the topic and I am regularly following up on the newest findings)

1.2. Imagine now that near to where you live a new nuclear power plant is in construction. How concerned would you be about that?

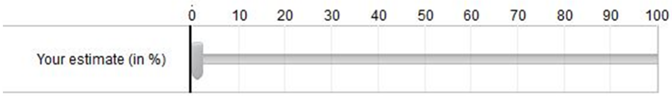
1.3. Please indicate how dangerous you perceive nuclear energy production to be.

2.1. How familiar are you with food additives, their risks, and benefits?
   - 0% No knowledge
   - 1% - 20% Minimal amount of knowledge (I have read 1 article/seen 1 news report)
   - 20% - 40% Some knowledge (I followed the news coverage)
   - 40% - 60% Moderate knowledge (I read more than 5 articles/1 book)
   - 60% - 100% Advanced knowledge (I study nutrition or another science related to the topic and I am regularly following up on the newest findings)

2.2. Imagine reading an article about how the general amount of food additives in the country you live in has been increased. How concerned would you be about that?

2.3. Please indicate how dangerous you perceive food additives to be.

3. Slider



7. APPENDIX C - MATERIALS

1. Nuclear Energy

Doc 1. Nuclear energy is the energy in the nucleus, or core, of an atom. Energy is what holds the nucleus together. There is a huge amount of power in an atoms dense nucleus. In fact, the power that holds the nucleus together is officially called the 'strong force'. Nuclear energy can be used to create electricity, but it must first be released from the atom. In nuclear fission, atoms are split to release the energy. A nuclear reactor, or power plant, consists of a series of machines that can control nuclear fission to produce electricity. The fuel that nuclear reactors use to produce nuclear fission comes from pellets of the element uranium. Uranium is the fuel most widely used because its atoms split apart relatively easily. In a nuclear reactor, atoms of uranium are forced to break apart. As they split, the atoms release tiny particles called fission products. Fission products cause other uranium atoms to split, starting a chain reaction. The energy released from this chain reaction creates heat.

Nuclear energy produces electricity that can be used to power homes, schools, businesses, and hospitals. Power plants produce renewable, clean energy, as they do not pollute the air or produce greenhouse gases. They can be built in urban or rural areas, and do not radically alter the environment around them. The steam which is powering the turbines and generators is ultimately recycled: It is cooled down in a separate structure called a cooling tower. The steam turns back into water and can be used again to produce more electricity. Excess steam is simply recycled into the atmosphere, where it does no harm as clean water vapor. About 15 percent of the worlds electricity is generated by nuclear power plants. The United States has more than 100 reactors, although it creates most of its electricity from fossil fuels and hydroelectric energy. Nations such as Lithuania, France, and Slovakia create almost all of their electricity from nuclear power plants. However, the byproduct of nuclear energy is radioactive material, which is a collection of unstable atomic nuclei. These nuclei lose their energy and can affect many materials around them, including organisms and the environment, causing burns and increasing the risk for cancers, blood diseases, and bone decay. Radioactive waste is what is left over from the operation of a nuclear reactor, mostly protective clothing worn by workers, tools, and cloths that have been in contact with radioactive dust. Radioactive waste is long-lasting and tools can stay radioactive for thousands of years. The government regulates how these materials are disposed of so they don't contaminate anything else.

Used fuel and rods must be stored in special containers that look like large swimming pools. Water cools the fuel and insulates the outside from contact with the radioactivity. Some nuclear plants store their used fuel in dry storage tanks above ground. Critics of nuclear energy worry that the storage facilities for radioactive waste will leak, crack, or erode. Radioactive material could then contaminate the soil and groundwater near the facility. This could lead to serious health problems for the people and organisms in the area. This is what happened in Chernobyl, Ukraine, in 1986. A steam explosion at one of the power plant's four nuclear reactors caused a fire, called a plume. This plume was highly radioactive, creating a cloud of radioactive particles that fell to the ground, called fallout. The fallout spread over the Chernobyl facility, as well as the surrounding area. The fallout drifted with the wind, and the particles entered the water cycle as rain. The environmental impact of the Chernobyl disaster was immediate. For kilometers around the facility, the pine forest dried up and died. The red color of the dead pines earned this area the nickname the Red Forest. Fish from the nearby Pripyat River had so much radioactivity that people could no longer eat them.

More than 100,000 people were relocated after the disaster, but the number of human victims of Chernobyl is difficult to determine. The effects of radiation poisoning only appear after many years. Cancers and other diseases can be very difficult to trace to a single source.

Doc 2. Nuclear energy presents itself with economic benefits. Each year, the average nuclear plant generates approximately \$470 million in economic output or value, which includes more than \$40 million in total labor income. These figures include both direct output and secondary effects. The direct output reflects the plants annual electricity salesapproximately \$453 million. The secondary effects at the local levelapproximately \$17 millioninclude subsequent spending by firms attributable to the presence of the plant and its employees as plant expenditures filter through the local economy. There are also secondary effects outside the local area, at the state and national level. For a nominal 1,000-megawatt nuclear plant, these secondary effects are \$80 million and $393 million, respectively. Analysis shows that every dollar spent by the average nuclear plant results in the creation of $1.04 in the local community, $1.18 in the state economy and $1.87 in the U.S. economy. The average nuclear plant pays about $16 million in state and local taxes annually. These tax dollars benefit schools, roads, and other state and local infrastructure. The average nuclear plant also pays federal taxes of $67 million annually.

Doc 3. The Sixth Report of Fukushima Prefecture Health Management Survey, released in April, included examinations of 38,114 children, of whom 35.3 percent - some 13,460 children - were found to have cysts or nodules of up to 5 mm (0.197 inches) on their thyroids. "Yes, 35.8 percent of children in the study have lumps or cysts, but this is not the same as cancer," said Naomi Takagi, an associate professor at Fukushima University Medical School Hospital, which administered the tests. "We do not know that cause of this, but it is hard to believe that is due to the effects of radiation," she said. "This is an early test and we will only see the effects of radiation exposure after four or five years." The local authority is carrying out long-term testing of children who were under the age of 18 on March 11 last year, the day on which the magnitude-9 Great East Japan struck off the coast of north-east Japan, triggering the massive tsunami that crippled the Fukushima nuclear plant. Thyroid examinations were first conducted in October last year and will be carried out every two years up to the age of 20 and every five years for the rest of the children's lives. A second report has been issued by Japan's Institute of Radiological Sciences in which it found that some children living close to the plant were exposed to "lifetime" doses of radiation to their thyroid glands.

Doc 4. The World Health Organization (WHO) released a report that estimates an increase in risk for specific cancers for certain subsets of the population inside the Fukushima Prefecture. A 2013 WHO report predicts that for populations living in the most affected areas there is a 70% higher risk of developing thyroid cancer for girls exposed as infants (the risk has risen from a lifetime risk of 0.75% to 1.25%), a 7% higher risk of leukemia in males exposed as infants, a 6% higher risk of breast cancer in females exposed as infants and a 4% higher risk, overall, of developing solid cancers for females. Preliminary dose-estimation reports by WHO and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) indicate that, outside the geographical areas most affected by radiation, even in locations within Fukushima prefecture, the predicted risks remain low and no observable increases in cancer above natural variation in baseline rates are anticipated. In comparison, after the Chernobyl accident, only 0.1% of the 110,000 cleanup workers surveyed have so far developed leukemia, although not all cases resulted from the accident. Estimated effective doses from the accident outside of Japan are considered to be below (or far below) the dose levels regarded as very small by the international radiological protection community. The United Nations Scientific Committee on the Effects of Atomic Radiation is expected to release a final report on the effects of radiation exposure from the accident by the end of 2013. A June 2012 Stanford University study estimated, using a linear no-threshold model, that the radioactivity release from the Fukushima Daiichi nuclear plant could cause 130 deaths from cancer globally (the lower bound for the estimate being 15 and the upper bound 1100) and 199 cancer cases in total (the lower bound being 24 and the upper bound 1800), most of which are estimated to occur in Japan. Radiation exposure to workers at the plant was projected to result in 2 to 12 deaths. However, a December 2012 UNSCEAR statement to the Fukushima Ministerial Conference on Nuclear Safety advised that because of the great uncertainties in risk estimates at very low doses, UNSCEAR does not recommend multiplying very low doses by large numbers of individuals to estimate numbers of radiation-induced health effects within a population exposed to incremental doses at levels equivalent to or lower than natural background levels."

2. Food Additives

Doc 1. Many substances are added to foods to prolong shelf and storage life and to enhance color, flavor, and texture. The possible role of food additives in cancer risk is an area of great public interest. New food additives must be cleared by the US Food and Drug Administration (FDA) before being allowed into the food supply, and thorough testing is done in lab animals to determine any effects on cancer as part of this process. Additives are usually present in very small quantities in food, and some are nutrients that may have beneficial effects (for example, vitamins C and E are sometimes added to food products as a preservative). Other compounds find their way into the food supply through agricultural use, animal farming, or food processing, even if their use is not directly intended for human consumption. Examples include growth hormones or antibiotics used in animal farming, small amounts of pesticides and herbicides in plant-based foods, and compounds such as bisphenol A (BPA) or phthalates that enter food from packaging. Some of these compounds are not known to directly cause cancer, but they may influence cancer risk in other ways for example, by acting as hormone-like substances in the body. Unintended contamination of food may also result in exposure to chemicals that are a cause of concern and may be related to cancer risk. Examples include heavy metals such as cadmium or mercury. These metals may enter the food supply if they build up the food chain, such as from fish, or they may enter through contamination or their natural presence in soil or water. For many other compounds for which the effects on cancer risk are not clear, there may be other good reasons to limit exposure. But at the levels that these are found in the food supply, lowering cancer risk is unlikely to be a major reason to justify this. Food processing may also alter foods in ways that might affect cancer risk. An example is the refining of grains, which greatly lowers the amount of fiber and other compounds that may reduce cancer risk. The processing of meat, by adding preservatives such as salt or sodium nitrite to prevent the growth of germs, or smoking the meat to preserve or enhance color and flavor, may add compounds that might increase the potential of these foods to cause cancer. Studies have linked eating large amounts of processed meats with an increased risk of colorectal cancer. Some food processing, such as freezing and canning vegetables and fruits, can preserve vitamins and other components that may decrease cancer risk. Cooking or heat-treating (such as when canning) vegetables breaks down the plant cell walls and may allow the helpful compounds in these foods to be more easily digested.

Doc 2. Well, let's start with a short explanation of what E numbers are. E stands for Europe, and the E number code relates to a set of EU rules about which foods can contain them and how much you should be able to consume in a day. For instance E284 boric acid can only be used in caviar, and E252 potassium nitrate (used in bacon and salami) has an acceptable level of daily intake (ADI) of 0-3.7% mg/Kg body weight. Many E numbers are very familiar and important to good food and nutrition: for instance E300 is vitamin C, E101 is vitamin B2, E948 is oxygen and E160c is paprika.

The rules were developed to regulate additives (rather than encourage their use), so that dangerous substances like toxic lead tetroxide could be banned from use in children's sweets, for instance. In the past, food adulteration was a deadly problem.

But what about the bad E numbers? E621 monosodium glutamate is anecdotally blamed for an extraordinary range of symptoms, but in fact if you grate parmesan on your pasta you are likely to be adding more glutamate to your meal than you'd ever find in an MSG-laden ready meal. There's a group of food colours called the 'Southampton Six' that have a small but proven association with hyperactivity in children, and which you might want to avoid. Sulphur dioxide (E220) can exacerbate asthma, although without it wine usually tastes foul and in any case it's been used in pretty much every bottle of wine produced since Roman times.

But the leading causes of food allergies and intolerances are entirely natural: milk, wheat, eggs, nuts, fish, soya, celery... And of course every single food or drink on the planet, whether it contains E numbers or not, is toxic at some level - apples contain cyanide, people have died from water intoxication, cabbage contains goitrogens, potatoes contain toxic solanine and broccoli contains carcinogens. But, as with E numbers, the amounts of these toxic substances are minute, and the benefits of consuming these foods and drinks invariably far outweigh the risks. The difference with E numbers is that they have been extensively tested and analysed to ascertain safe levels.

The reality is that all foods are a combination of chemicals, whether added by man or not, and just because a food is organic doesn't necessarily make it better for you. The worst nutritional problems are caused by substances that come in purely organic form: salt, fat and sugar, none of which are E numbers.

The argument in favour of Es is that they make food healthier, safer, cheaper, better tasting and more attractive. Of course, many horrible and unhealthy foods also contain E numbers, but invariably it's not the Es that make them unhealthy - it's the salt, fat and sugar.

Doc 3. Artificial food additives and preservatives could be causing children to be disruptive, a growing bank of evidence is proving. These chemicals - or E-numbers as they are known - are added to enhance the flavour and colour of food, and to prolong its shelf life. Gordon Walker, the headmaster of a primary school in Cornwall, noticed how his own son's behaviour improved after he stopped eating food containing E-numbers. As a result, he conducted an experiment at his school to see how other children were affected by the additives. His concerns are backed up by scientific evidence. Dr Neil Ward, a senior lecturer in analytical chemistry at the University of Surrey, has carried out four independent studies evaluating the impact of food additives on hyperactive children, in particular the colourings E102, E110, E123. 'All of our studies have confirmed that additives do have a detrimental effect on the behaviour of hyperactive children,' says Dr Ward. 'We have also found that a lot of so called "ordinary children are very sensitive to additives and artificial chemical in their diet, so it's a very widespread problem. 'And we have discovered links between additives and an increased incidence of eczema, asthma and allergies in selected groups of children who consume high levels of additives and artificial chemicals in their diet.' Food preservatives have been used by mankind for centuries. Salt, sugar and vinegar, for example, were among the first, and were used to preserve foods for longer periods. However in the past 30 years, with the advent of processed foods, there has been a massive explosion in the chemical corruption of foods using additives to completely change natural flavours and colours to make them last longer. Under today's law on European food standards, every additive or preservative put into food must be identified and given a number, which is its E-number. All E-numbers present in UK food and drinks are regulated by the Food Standards Agency. There are hundreds of registered E-numbers, but as new ones are added, discontinued or even banned in some countries every week, it is impossible to put an exact figure on how many there are at any one time. However, it is estimated there are 270 in use, numbered between E100 and E1520.

Doc 4.E621 monosodium glutamate, otherwise known as MSG, Monosodium Glutamate, E621 is a flavour enhancer thats commonly used to pep up food products and make them taste better. Unfortunately, it is known to cause problems for some people and certain people seem to more sensitive to its effects than others. Amongst the known side effects, MSG can cause symptoms such as headaches, nausea, dizziness, muscle pain, palpitations and even pain.

Aspartame, E951 is an artificial sweetener thats commonly used as a sweetening ingredient. In particular, its often found in products aimed at dieters or diabetics, such as desserts, low-fat foods, low sugar drinks, snacks and sweets. Its well known to be linked to problems in people who suffer from the condition PKU, and they are well advised to avoid it completely. But aspartame has become a concern to other people too and side effects, such as headaches, have often been reported. E211, sodium benzoate, is an E number thats used as a preservative and is found in products such as margarine, salad dressing, soy sauce, sweets and soft drinks. Studies have found that its linked to hyperactivity in children, plus it may cause reactions in people have allergic conditions or asthma.