Identifying and Debunking Environmentally-Related False News Stories – An Experimental Investigation

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Abstract

Most research on false information is currently beeing conducted in the realm of politics and Covid-19. This study addresses environmentally-related news stories. With the help of two experiments, I explore determinants that can explain who is good at distinguishing between accurate (i.e., factually correct) and false information, and compare several intervention scenarios to debunk false information. In experiment one, subjects had to rate environmentally-related news stories as accurate or false. Afterward, subjects received systematically varied information about the correctness of the news stories depending on the experimental condition they had been randomly assigned to. After a period of three weeks, the subjects were asked to evaluate the news stories again (experiment two). In experiment one, I find that the perceived familiarity with news stories increased the propensity to accept them as true. Moreover, actively open-minded thinking helped to distinguish between accurate and false information. But the willingness to think deliberately did not seem to be important. In experiment two, it can be found that by repeating false news stories, subjects were more likely to adequately identify them later (i.e., no evidence for a familiarity backfire effect). However, it decreased the likelihood to adequately identify accurate news stories. A somewhat reverse, but weaker effect occurred when factually correct news stories were repeated: the correct identification of accurate news stories was more successful, but the opposite holds for the identification of false news stories.

Keywords

false news information; narratives; cognitive reflection test; actively open-minded thinking; environmental economics

1 Introduction

BRETSCHGER and PITTEL (2020) describe in their literature review twenty challenges in environmental and resource economics. For example, they acknowledge urbanization as a key for environmental devel-opment that leads – most notably in low and middle income countries (UN, 2018) – to challenges regarding energy supply, transport, and provision of infrastructure. Climate change, which poses another challenge, is likely to give rise to extreme weather events, puts a large number of species at risk of extinction, and increases the prices of basic foodstuffs. Simulations project a temperature increase from 1.5-5°C by the end of the 21st century (TOLLEFSON, 2020). Relatedly, migration can be motivated by, for example, droughts, rising sea levels or hurricanes. Environmental migration is a rather complex, multicausal issue (ADGER et al., 2014) that can lead to a more and more pressing challenge according to forecasts (IONESCO et al., 2017). While representing urging issues that require fast and substantial action on various levels of governance, adequate assessment and handling of these challenges might be endangered by false information[1]. The magnitude of environmentally-related false information can be illustrated by climate change. There is overwhelming scientific consensus that climate change is man-made (e.g. COOK, 2019, 2020). However, there are people who are prone to climate myths (e.g. "climate has changed before" or "it is the sun") and, as a consequence, are more likely to reject proposed policy measures to combat climate change. Even the 45th President of the United States, Donald Trump, was very skeptical about climate change. As a consequence, the U.S. withdrew from the 2015 Paris Agreement on climate change mitigation – with consequences to the whole world (since climate change is

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[1] The term "fake news" is quite topical nowadays. LAZER et al. (2018: 1094) define fake news as "[…] fabricated information that mimics news media content in form but not in organizational process or intent. Fake news outlets, in turn, lack the news media's editorial norms and processes for ensuring the accuracy and credibility of information." In line with several other scholars (e.g. WARDLE and DERAKHSHAN, 2017; VOSOUGHI et al., 2018), I avoid the ambiguous term "fake news" because it has not only been used to denote false information but also by some politicians to describe content that is not in line with one's own opinion. Instead, I opt for "false information" or "false news stories" throughout this paper.

not a local phenomenon). False information may also matter due to the link between public discourse and policy making. For example, CAPLAN and STRINGHAM (2005: 80) argue that even the economists Ludwig von Mises and Frederic Bastiat were "*sharply* [...] *pessimistic about public opinion. In modern terms, they believe that the general public suffers from systematically biased beliefs about economics*". In the realm of environmental economics, this might be relevant if intuitively appealing but wrong measures are the result of widespread narratives based on wrong facts. For example, many economists criticize the degrowth movement as an inadequate measure to combat climate change (cf., PIES, 2011).[2]

There are several reasons for actively creating false information. These include economic interests (more clicks on websites means more money through advertising) as well as deliberate manipulations of public opinion and the pursuit of political interests (ALLCOTT and GENTZKOW, 2017; NAPOLI, 2018). According to ALLCOTT and GENTZKOW (2017: 227), it is "both privately and socially valuable when people can infer the true state of the world." For example, false news stories may undermine trust in traditional media. Another problem with false claims is that they spread fast. Analyzing Twitter tweets from 2006 to 2017, VOSOUGHI et al. (2018) found that false information spreads faster than correct information. They argue that this is due to the degree of novelty (false information is more novel) and emotional reactions of the recipients (e.g. false information inspires feelings of suspense and fear). Current research on false information is predominantly carried out in the realm of the two contexts politics and Covid-19. Reinforced by the 2016 U.S. election, psychologists and economists have increasingly been interested in false information – predominantly based on topics related to U.S. politics (e.g. ALLCOTT and GENTZKOW, 2017; GUESS et al., 2019). Besides politics, Covid-19-related false information (sometimes referred to as "infodemics"; e.g. GRÜNER and KRÜGER, 2021) have received public attention (e.g. PENNYCOOK et al., 2020; ROOZENBEEK et al., 2020).

In their experimental studies, PENNYCOOK and RAND (2019a: 48) find that "people fall for fake news because they *fail* to think." What does this mean? The starting point of their analysis is the dual-process theory (cf., STANOVICH and WEST, 2000), which distinguishes between autonomous, intuitive processes (system 1) and deliberate, analytic processes (system 2). To measure differences between intuitive and analytical thinking, PENNYCOOK and RAND (2019a) apply the cognitive reflection test (CRT), which has been introduced by FREDERICK (2005). This test uses questions, which have an intuitive but wrong answer; the correct answer often requires a second look at the task. PENNYCOOK and RAND'S (2019a) central insight is that people who perform well in CRT are good at discerning between true and false news (with the exception of very complex scientific issues, where no effect was identified) when it comes to analyzing news headlines (incl. a picture and a short text of 1-2 sentences). To put it differently, being relatively successful in CRT does not make individuals more inclined to justify their prior beliefs, but instead leads to a better identification of false news (PENNYCOOK and RAND, 2019b). Furthermore, there are some studies that describe actively open-minded thinking (AOT; HARAN et al., 2013; BARON et al., 2015) as a protective factor against the belief in false news stories (e.g. BRONSTEIN et al., 2019). AOT captures the individuals' willingness to revise beliefs and the search for alternative explanations. Similar to CRT, a high score on the AOT scale is positively associated with the individuals' capability discern false from correct news stories. Another finding is that those people who overclaim their knowledge tend to fall for false news stories (PENNYCOOK and RAND, 2019c). Furthermore, people seem to be relatively uncritical with news stories (i.e., more likely to believe them) that are in line with their political attitudes and other beliefs (MORAVEC et al., 2019; PENNYCOOK and RAND, 2019c). The latter can be explained with confirmation bias, broadly speaking, the tendency of people to hear only things that they want to hear (LORD et al., 1979). In line with that, LAZER et al. (2018) argue that people tend not to question the credibility of information (in contrast, they tend to accept information uncritically) unless it violates preconceived ideas or they face incentives to do so. Furthermore, the so-called illusory truth effect seems to be important. PENNYCOOK et al. (2018) found that prior exposure to a statement increases the probability that it will be evaluated as correct. Even reading a fabricated news headline once increases the chance of being identified as correct after seeing it again. The background for this is that the processing fluency is increased through repetition and, thus, accuracy is derived.

As indicated above, debunking false news stories is a challenge. Correcting false news touches on the topic of how people update their prior beliefs. For

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2   The degrowth movement argument has been adopted from one anonymous reviewer.

example, repetition may make a false news story appear more familiar and thus more likely to be perceived as true. In contrast, correction mechanisms that include the repetition of false news may even help the false news story to work stronger. The literature describes various constellations where corrections are ineffective or lead individuals to believe even more strongly in the false news stories. Non-intended effects as a result of a correction (i.e., increased adherence to the false news) are sometimes referred to as "backfire effect". Among the more important backfire effects in the realm of false news stories are the familiarity backfire effect, overkill backfire effect, and the worldview backfire effect (COOK and LEWANDOWSKY, 2011; LEWANDOWSKY et al., 2012). The familiarity backfire effect addresses adverse effects that can occur when the false information is repeated in the course of its correction. Repetition increases familiarity with the false news item. This is problematic because there is a positive relationship between familiarity and accepting a story as true. However, recent studies raised some doubts about the robustness and importance of the familiarity backfire effect. For example, PENNYCOOK et al. (2018) discuss studies in which familiarity due to corrections have had positive effects in distinguishing between true and false news stories. Correcting false news stories is not necessarily more successful the more counterarguments are brought forward (overkill backfire effect). It can even lead to an increased acceptance of the false news. More counterarguments require people to be willing and able to use more cognitive effort. Given that information is occasionally flooded in everyday life, it is not surprising if an increase in the supply of information is rejected (i.e., ignored). The worldview backfire effect describes situations in which the correction of false news stories generates contradictions to peoples' beliefs or cultural identity. As a consequence, people may stick even more strongly to their "worldview".

This paper adds value to the literature by extending the thematic spectrum of false information by addressing the following two research questions in the realm of agricultural and environmental economics:

(1) What are the drivers of (not) falling prey to false narratives?

(2) What intervention scenarios are effective to debunk false information (i.e., limit falling prey to false narratives) and are there side effects (e.g. backfire effects)?

To analyze these questions, I carry out two experiments. In experiment 1, subjects are asked to evaluate environmentally-related news stories taken from the media. At the end of experiment 1, subjects are randomly assigned to one of several scenarios that provide information about the correctness of the stories. Some weeks after finishing experiment 1, the subjects are contacted to evaluate the same news stories again.

The remainder of this paper is structured as follows: the study design is explained in Section 2. After describing the approach to data analysis (Section 3), the experimental findings are discussed in Section 4. Section 5 concludes.

2 Design of the Study

The overall study design comprises two experiments (henceforth referred to as experiment 1 and experiment 2; cf., Table 1). In experiment 1, the subjects were shown 12 news stories from the environmental sector in the length of a small paragraph. The subjects` most important task was to rate them as accurate (i.e., factually correct) or false (i.e., containing any kind of false information). To better understand their evaluation, I collected data on several economic and psychological variables (e.g. risk attitude, manner of thinking, willingness to search for alternative explanations, attitudes and opinions). At the end of experiment 1, subjects received information on whether the news stories were accurate or false. The amount of

Table 1.   Overall study design at glance

Experiment 1	Experiment 2 (Follow-up session 3 weeks later)
News stories on the environment and related questions ▪ 12 news stories from the environmental sector ▪ Topics of the stories: assessment of risk and subjective knowledge ▪ General environmental-related questions **Psychological tests and sociodemographic variables** ▪ Cognitive reflection test (CRT) ▪ Actively open-minded thinking (AOT) ▪ Individual risk attitude ▪ Big 5 ▪ Sociodemographic and socioeconomic determinants **Treatment conditions** ▪ Information about the correctness of the stories	▪ 12 news stories from the environmental sector

Source: own presentation

information as well as the manner of communication was determined by the treatment condition the subjects were assigned to. After a period of 3 weeks, the subjects were contacted again with the plea to join a much shorter second experiment. Before that, they did not receive any information about a second experiment. In experiment 2, subjects were asked to evaluate the same 12 news stories from the environmental sector again. Three weeks were used because it allowed to recruit subjects (students) within one semester and the second experiment did not fall into the examination period of this semester. This convenient choice helped to recruit as many subjects in the second experiment as possible.

Subjects received €5 for their participation in experiment 1. In addition, two randomly selected subjects received a payment of €50. Furthermore, three randomly selected subjects earned money depending on their decisions in the risk elicitation procedure. An additional show-up fee of €3 was paid to subjects who also joined experiment 2. The evaluation of the news stories was not financially incentivized. It was not intended to encourage subjects to look them up on the Internet.

2.1 Experiment 1

(1) 12 news stories from the environmental sector

The chosen topics of the news stories were inspired by a survey by the statistics portal "statista" to find out which environmental problems are considered to be most important by Germans.[3] After the topics were selected, I was looking for corresponding news stories. In total, 12 news stories have been examined. Half of them are accurate, the other half contain false information. To create false news stories, I searched for accurate news items and injected wrong facts into them. Table 2 gives an overview of the news stories, a brief description, and information on whether manipulations have been carried out (a translation of the stories can be found in Appendix II).

Story [1] describes various consequences of climate change. Deviating from the original source of the European Commission, a conjunction fallacy has been implemented. It asserts that it is more likely that climate change will lead to both consequences x_1 and x_2 than only to x1. Story [2] is about the amount of microplastics released into the environment. It was

communicated to the subjects without changes to the original source. In story [3], the relevance of the honey bee is illustrated by an incorrect quotation, according to which human beings would disappear from the earth within a couple of years without bees. The quote is often mistakenly attributed to Albert Einstein. Here, I attributed it to an actual bee researcher (which is wrong as well). Story [4] tackles the consequences for the environment due to food waste. No manipulations to the original source have been made. Causes of bird deaths are the subject of story [5]. The relevance (i.e., number of deaths) of different causes (x_i) are described: it is argued that x_1 causes more victims than x_2, x_2 causes more victims than x_3, and, therefore, x_3 causes more victims than x_1. In other words, it violates the transitivity assumption. Story [6] deals with the consequences of the reactor catastrophe of Chernobyl. With the help of mushrooms as an example, it is illustrated that even today radiation exposure can be measured in Germany. No manipulations to the original source have been made. Negative externalities due to air pollution are the topic of story [7]. It deals with deaths caused by nitrogen dioxide and ozone. No manipulations to the original source have been made. Story [8] discusses ways to feed the world population. Contrary to the authors' key statement that organic farming cannot feed the world population entirely, the fabricated story claims exactly the opposite. In story [9], the challenge of disposable cups for coffee to go is addressed. It reports evidence for Germany in 2016 without conducting any manipulations. Story [10] is about the use of airplanes. On the one hand, politicians recommend not to use airplanes. On the other hand, they predominantly travel by airplanes themselves. Compared to the original source, the numbers of the use of airplanes by politicians have been considerably exaggerated. Story [11] describes the problem of waste being exported from Germany to other countries by referring to current studies. No manipulations to the original source have been made. The last news item [story 12] deals with smoking: in stark contrast to the authors of the original study, the manipulated news story claims that the authors call for a complete ban on cigarettes sold without filters.

(2) Topics of the stories: assessment of risk and subjective knowledge

Further details regarding the essential parts of the news stories (indicated by the labels of the respective stories; cf., Table 2) were collected. More specifically, I asked the subjects to evaluate the risks and dangers

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[3] https://de.statista.com/statistik/daten/studie/4630/umfrage/wichtigste-umweltprobleme-in-deutschland/

Table 2.   Description of the news stories

Nr.	Label	Short description	Adopted without manipulation? ("adequate story")	Type of manipulation (if applicable)	Source (of the non-manipulated story)[a]
1	Consequences of climate change	Negative implications of climate change	No	Conjunction fallacy	European Commission
2	Microplastics	Amount of M. released into the environment	Yes	-	Spiegel Online
3	Importance of the honey bee	Relevance of the bee: no humans without bees	No	Exaggeration [Quotation: No humans without bees]	(Various)
4	Food waste	Consequences of food waste for the environment	Yes	-	German Environment Agency
5	Causes of bird deaths	Several reasons for birth deaths: wind turbines are pronounced	No	Violation of transitivity	NABU (Nature And Biodiversity Conservation Union)
6	Mushrooms and consequences of Chernobyl	Relationship of Chernobyl and radiation exposure (example: mushrooms in Germany)	Yes	-	Consumer Advice Centre (North Rhine-Westphalia)
7	Air quality	Negative consequences due to nitrogen dioxide and ozone	Yes	-	Deutsches Ärzteblatt
8	Nutrition of the world population	Chances of organic farming to maintain current standards	No	Opposite sign of the relevant effect	Spiegel Online
9	Use of coffee paper cups	Coffee to go and the corresponding disposable cups	Yes	-	Sueddeutsche Zeitung
10	Use of airplane for passenger transport	Trade-off: politicians recommend not to use airplanes but use it themselves considerably	No	Exaggeration (more extreme representation)	BR Online
11	Waste exports	Evidence on waste export from Germany into over countries	Yes	-	Handelsblatt Online
12	Smoking	Discussion of cigarettes with(out) filters	No	Opposite sign of the relevant effect	Deutsches Ärzteblatt

[a] The full reference of the news stories (i.e., link to websites) can be found in Appendix II.
Source: own presentation

for the environment/society as well as to rate their knowledge within the various contexts.

(3) General environmentally-related questions

The experimental subjects were asked to assess their expertise in environmental issues in general. They should also indicate whether they think they are better or worse informed about such issues than the average student of the Martin Luther University Halle-Wittenberg. In addition, subjects gave answers on how often they talk with friends about environmental challenges, and how they describe the public discourse on environmental issues (either value-based or an open exchange of perspectives).

(4) Cognitive reflection test (CRT)

FREDERICK (2005) introduced a psychological test to classify people as more intuitive or more deliberate thinkers (cognitive reflection test; CRT). The items of the test follow a common pattern: a quick answer is intuitively plausible but mathematically wrong. Delib-

erate thinking usually leads to the identification of the correct answer. The higher the score on the CRT scale, the more the people are classified as deliberate thinkers. Frederick's scale has been used extensively in experimental studies and it is therefore conceivable that the subjects are familiar with it. Therefore, I rely on modified items from different sources (FREDERICK, 2005: 27; BARON et al., 2015: 266; THOMSON and OPPENHEIMER, 2016: 101). To give an example: "Soup and salad cost €5.50 in total. The soup costs a dollar more than the salad. How much does the salad cost?" (BARON et al., 2015: 266). The intuitive, but wrong answer is €2.50; the correct one is €2.25.

(5) Actively open-minded thinking (AOT)

AOT measures the extent to which individuals actively seek for alternative explanations and whether they use evidence to adjust their beliefs. I adopt the 7-item scale from HARAN et al. (2013). The subjects had to rate themselves on a scale ranging from 1 (completely disagree) to 7 (completely agree). For example, item 1

Table 3. **Eliciting the individual's risk-attitude (Eckel-Grossman gamble choices)[a]**

Choice (50/50 gamble)	Low payoff	High payoff	Expected payoff	Standard deviation	Implied CRRA range
Gamble 1	28	28	28	0	3.46 < r
Gamble 2	24	36	30	6	1.16 < r < 3.46
Gamble 3	20	44	32	12	0.71 < r < 1.16
Gamble 4	16	52	34	18	0.50 < r < 0.71
Gamble 5	12	60	36	24	0 < r < 0.50
Gamble 6	2	70	36	34	r < 0

(a) The last three columns were not shown to the subjects.
Source: own presentation

reads as follows: "Allowing oneself to be convinced by an opposing argument is a sign of good character." (HARAN et al., 2013: 201).

(6) Individual risk attitude

To elicit the individual's risk attitude, I use the procedure according to ECKEL and GROSSMAN (ECKEL and GROSSMAN, 2002; DAVE et al., 2010; cf., Table 3). The subjects have to pick one out of 6 gambles. In each gamble, there is a 50% probability of a (relatively) low payoff and a 50% probability of a (relatively) high payoff. The gambles systematically vary in the expected payoff and standard deviation: an increase in the expected payoff goes along with an increase in the standard deviation. Subjects are classified as risk-averse if they select one of the gambles 1-4, risk-neutral if they pick gamble 5, and risk-seeking if they opt for gamble 6.

(7) Big 5

The Big 5 were measured on a 10-item short scale (BFI-10, cf., RAMMSTEDT et al., 2012). They read as follows: extraversion (energetic, enjoys meeting new people vs. reserved, prefers solitude), agreeableness (empathic, friendly vs. uninterested in others, challenging), conscientiousness (organized, finishes important things instantly vs. careless, procrastinates important things), neuroticism / emotional stability (anxious, easily upset vs. relaxed, emotionally stable), and openness to experience (open for new things, creative vs. dislike change, limited imaginative).

(8) Sociodemographic and socioeconomic determinants

A number of sociodemographic and socioeconomic variables were collected (e.g. gender, age, political attitude, activity in social networks, trust in mass me-

dia, and membership of a religious community; cf., Appendix IV).

(9) Information about the correctness of the stories

At the end of experiment 1, subjects were randomly assigned to one of five scenarios. Randomization helps to make the scenarios comparable with respect to its behavioral differences (more technically spoken, randomization balances known and unknown confounders in expectation; DUNNING, 2012). In the scenarios, information is provided about whether the stories were accurate or contain false information. They differ in the manner of communication as well as in the amount of information provided to the subjects:

- Scenario 1: No information provided
- Scenario 2: Subjects were shown only the false news stories again ("The following news stories contain any kind of false news information.")
- Scenario 3: Subjects were shown only the accurate news stories again ("The following news stories are accurate.").
- Scenario 4: Subjects were communicated details about the false news stories (i.e., what was wrong & reasons for its dissemination; see Appendix III for further details).
 For example, news story 1, consequences of climate change: "For logical reasons it is not possible that the probability of two events x1 and x2 together is greater than the probability of a single event x2. [...] It is not possible that two consequences of climate change together are more likely than just one consequence."
- Scenario 5: Subjects were shown all stories again and provided with information on whether the stories are accurate or contain any kind of false news information *and* (as a consequence) whether the answers of the subjects are correct or not ("This news story is accurate / not accurate. Your answer was correct / wrong.")

2.2 Experiment 2 (Follow-Up Session 3 Weeks Later)

Three weeks after the first experiment, the subjects were invited to join a second experiment. The only task in experiment 2 was to rate the correctness of the identical 12 news stories again (i.e., as accurate or false). Note that in experiment 1 a total of 300 sub-

jects were recruited. This means that N = 60 subjects were randomly assigned to each of the scenarios. Since the subjects' willingness to attend the second experiment was unclear ex-ante, I hoped that at least 50% of the subjects would also participate in the second experiment, which would result in a somewhat acceptable sample size of N=30 per scenario.

3 Approach to Data Analysis

The experimental subjects were recruited via the learning platform of the Martin Luther University Halle-Wittenberg (StudIP). In StudIP, people were advertised on the bulletin board and in various bachelor courses (with different degree programs). Experiment 1 lasted from 2019-12-17 to 2019-12-23. Each subject was contacted again 3 weeks later. Experiment 2 began on 2020-01-07 and data collection was closed on 2020-01-20.

(i) Experimental design

The basic design of both experiments is fundamentally different. In experiment 1, only correlations can be interpreted because all subjects have the same tasks (within-subject design).[4] In contrast, with the help of between-subject design, causal interpretations are feasible in experiment 2. However, as a consequence, experiment 2 suffers from a lower per group sample size.

(ii) Primary outcome variable

The target variable of experiment 1 is the number of adequately identified news stories. Adequate identification means that accurate news stories are declared as correct and false news stories are declared as wrong. Three regressions are provided: (1) adequate identification of all news (N = 0, …, 12), (2) adequate identification of correct news (N = 0, …, 6), and (3) adequate identification of false news (N = 0, …, 6). Experiment 2 explores the efficiency of five scenarios. The analysis is conducted on the most aggregate level (i.e., adequate identification of all news) due to constraints in the sample size.

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[4] Causal interpretations would also have been possible in experiment 1 if subjects were randomly assigned to different groups (e.g. each story could have three versions: (i) original, unaltered version, (ii) version with wrong facts injected an illogical way, and (iii) version with wrong facts injected).

(iii) Methods

In experiment 1, simple OLS regressions are estimated since the dependent variables can approximately be treated as continuous. Moreover, I provide standardized beta coefficients to compare theoretical constructs that are measured with a different number of items/questions. In experiment 2, the subjects are shown the same news stories as in experiment 1. To deal with repeated measurements, I use the Wilcoxon matched-pairs signed-ranks test to test for equality of matched pairs of observations. The null hypothesis of the non-parametric test is that both distributions are the same.

(iv) Study type

With regard to the variables CRT and AOT, it was ex-ante assumed that both are positively associated with the success in distinguishing between true and false news. However, due to the lack of prior studies, the bulk of the study is exploratory, i.e., the aim is to uncover patterns in the data. These can be analyzed in follow-up studies with new data in a so-called confirmatory analysis. For example, personality traits have rarely been addressed in the realm of false information. Maybe they have some potential to explain (not) falling prey to false narratives (e.g. openness to experience might be a driver of how individuals evaluate news stories). Therefore, it might be worth a look at it.

(v) Data manipulation

The question "Have you seen or heard about this story before?" could either be answered with "Yes", "Unsure" or "No". To make data analysis simpler, I combined the answers "Unsure" and "No". Combining response options serves the goal to simplify data analysis (e.g. PENNYCOOK et al., 2018). Moreover, subjects who identified their gender as "other" were dropped out of the sample due to their low sample size (N = 2). No further data cleaning was carried out.

4 Experimental Findings

A total of 300 subjects were recruited in experiment 1 and 240 of them also joined experiment 2. I want to mention only a couple of characteristics. Details are not required to understand the rest of the paper (e.g. the concrete values of the Big 5 are not important for the purpose of this paper) but are for the sake of completeness summarized in Appendix I. In both experiments, the majority of subjects were female (slightly less than 60%). The subjects are on average 22.5 years

old. Almost 70% of the subjects argue that the public discourse on environmental issues is value-loaded (i.e., no free exchange of perspectives). Subjects were asked to state their subjective competence with environmental issues on a scale from very poor (1) to very good (5). On average, the subjects rate their competence slightly higher than average (≈3.3).

In the following, I present the results of the two experiments. The findings are enriched by interpretations and comparisons of earlier research in case of surprising results.

4.1 Experiment 1

On average, the subjects correctly identified slightly more than half of the news stories (M = 6.69, SD = 1.56) in experiment 1. What determinants can explain the extent to which subjects adequately distinguish between accurate and false news stories (cf., Table 5)? The results of regression I indicate that the perceived familiarity with the stories is crucial for the success of subjects' evaluation. The perceived familiarity with a news story that is in fact false (Story seen_false news) is negatively associated with the

Table 5.   OLS-Regressions to explain adequate identification of news stories (N = 300)[a,b]

	I Adequate identification of all news		II Adequate identification of correct news		III Adequate identification of false news	
	Beta [95% CI]	P-value	Beta [95% CI]	P-value	Beta [95% CI]	P-value
Story seen_false news[c]	-0.321 [-0.499; -0.223]	0.000			-0.374 [-0.414; -0.233]	0.000
Story seen_correct news[d]	0.235 [0.099; 0.365]	0.001	0.263 [0.108; 0.265]	0.000		
AOT	0.124 [0.011; 0.488]	0.040	0.155 [0.058; 0.393]	0.008	0.019 [-0.131; 0.190]	0.718
CRT	-0.050 [-0.190; 0.080]	0.423	-0.009 [-0.097; 0.082]	0.869	-0.058 [-0.138; 0.040]	0.280
Female (=1)	-0.074 [-0.643; 0.168]	0.251	-0.046 [-0.395; 0.183]	0.471	-0.053 [-0.456; 0.195]	0.430
Conscientiousness	0.012 [-0.198; 0.244]	0.840	0.007 [-0.153; 0.173]	0.901	0.010 [-0.138; 0.168]	0.849
Agreeableness	-0.098 [-0.417; 0.031]	0.091	-0.032 [-0.207; 0.116]	0.581	-0.095 [-0.304; 0.017]	0.080
Openness	-0.008 [-0.207; 0.181]	0.896	0.003 [-0.139; 0.147]	0.957	-0.013 [-0.153; 0.121]	0.822
Extraversion	0.033 [-0.133; 0.236]	0.581	-0.145 [-0.291; -0.033]	0.014	0.173 [0.069; 0.344]	0.003
Neuroticism	-0.023 [-0.238; 0.161]	0.707	-0.077 [-0.231; 0.049]	0.203	0.039 [-0.097; 0.196]	0.511
Religion	0.037 [-0.279; 0.535]	0.537	0.023 [-0.226; 0.344]	0.686	0.035 [-0.210; 0.399]	0.543
Trust mass media	0.021 [-0.164; 0.243]	0.704	0.028 [-0.107; 0.181]	0.616	0.001 [-0.162; 0.165]	0.986
Social networks	-0.101 [-0.339; 0.015]	0.074	-0.081 [-0.227; 0.039]	0.166	-0.055 [-0.217; 0.081]	0.370
Politics (right)	-0.079 [-0.174; 0.038]	0.212	-0.099 [-0.132; 0.010]	0.094	-0.009 [-0.095; 0.082]	0.885
Age	0.093 [-0.008; 0.092]	0.100	0.061 [-0.018; 0.057]	0.302	0.072 [-0.011; 0.061]	0.177
Discourse (value-loaded)	0.021 [-0.320; 0.462]	0.722	0.029 [-0.209; 0.350]	0.619	0.003 [-0.273; 0.293]	0.943
Challenges environment (friends)	0.028 [-0.172; 0.269]	0.668	0.118 [-0.014; 0.304]	0.074	-0.076 [-0.258; 0.059]	0.218
Overconfidence environment	0.019 [-0.271; 0.359]	0.783	-0.043 [-0.291; 0.153]	0.542	0.068 [-0.111; 0.344]	0.317
Competence environment	0.068 [-0.164; 0.473]	0.341	0.101 [-0.074; 0.406]	0.175	-0.002 [-0.253; 0.245]	0.973
Risk attitude	0.013 [-0.104; 0.130]	0.823	-0.071 [-0.136; 0.034]	0.245	0.083 [-0.025; 0.153]	0.163
Prob > F	0.0000		0.0000		0.0000	
	$F_{(21, 278)}$ = 3.41		$F_{(19, 279)}$ = 3.90		$F_{(20, 279)}$ = 18.76	
R-squared	0.1845		0.1927		0.2038	

(a) Since there is no random process of data generation in experiment 1, statistical inference (i.e., interpreting CIs and p-values) is only valid if a superpopulation is assumed (cf., LAVRAKAS, 2008; HIRSCHAUER et al., 2020). I do not assume that in this paper. As a consequence, the analysis of experiment 1 focuses on the *effect size* in terms of standardized beta-coefficients.
(b) Details on the variables can be found in Appendix IV.
(c) Perceived familiarity with a news story that is in fact false
(d) Perceived familiarity with a news story that is in fact accurate
Source: own presentation

adequate identification of the news stories, whereas the perceived familiarity with a news story that is in fact accurate (Story seen_correct news) is positively associated with adequate identification of the news stories. In other words, familiarity considerably increases the subjects' propensity to accept stories as accurate. In line with earlier studies, there is a positive association between AOT and adequately identifying the news stories. However, CRT does not seem to help in this realm. This is somewhat surprising because it contradicts earlier findings. Moreover, both agreeableness as well as activity on social network are negatively correlated with adequately distinguishing between false and true.

Now, I would like to elaborate whether there are differences between the adequate identification of correct news stories (regression II) on the one hand and false news stories (regression III) on the other one. The majority of accurate news stories are identified as such (M = 4.58, SD = 1.13). The subjects performed much worse in correctly identifying false news (M = 2.11, SD = 1.20). As indicated above, perceived familiarity with the stories is crucial: it helps to more adequately identify correct news stories but erodes the correct identification of false news. This can be explained by subject's tendency to trust news stories they (believe to) have seen before. AOT seems to matter in regression II but appears to be negligible in regression III. As indicated in regression I, CRT does not play an important role. It is negligible to explain adequate identification of both accurate and false news stories. Extraversion seems to mitigate the familiarity effect, i.e., it is negatively correlated with the capability to adequately identify correct news stories but positively correlated with correctly detecting false news stories. Moreover, it should be mentioned that being more politically oriented to the right is negatively associated and discussing environmental challenges with friends is positively associated with adequately identifying correct news stories; there does not seem such associations with the adequate identification of false news information in regression III.

In the following, story-specific similarities and differences are briefly addressed. The proportions of news stories that have been adequately identified by the subjects are depicted in Table 6. It ranges from very low values (e.g. story #10: 13.33% or story #1: 15.00%) to very high values (e.g. story #9: 91.33 or story #4: 94.00%). How can such big differences arise? Story 1 describes consequences of climate change with the help of a conjunction fallacy. According to this, two consequences together are more likely to happen in the course of climate change than just one of the consequences. From a logical point of view this is impossible. But it is representative: before the Covid-19 pandemic, there were many Fridays for Future demonstrations in Germany, and the local university, where this study has been carried out, is also actively involved. Therefore, it is not surprising that people perform poorly here. Subjects probably thought about the likely consequences of climate change. As SHILLER (2019) points out people often do not think in equations, they have a story (narrative) in their mind. Widely distributed narratives may also play an important role is news story 10. The reputation of politicians is impaired since examples seem to be easily available (i.e., representativeness heuristic) where politicians broke rules or renege on promises. Since subjects are caught in a venue of narratives, making things more extreme does not violate the picture in their heads (i.e., the story itself), and, in turn, will be accepted relatively uncritically. Subjects' performance in story 10 is poor because they think the stories are typical for reality. Relatedly, the stories 4 and 9 tackle other narratives. Subjects seem to be quite aware that food waste is a serious threat to society as well as paper cups are.

Table 6. Story-by-story identification (N = 300)[a]

#	Label of stories	Accurate or false	Adequate identification (in %)
1	Consequences of climate change	False	15.00
2	Microplastics	Accurate	65.67
3	Importance of the honey bee	False	29.00
4	Food waste	Accurate	94.00
5	Causes of bird deaths	False	75.33
6	Mushrooms and consequences of Chernobyl	Accurate	71.33
7	Air quality	Accurate	57.00
8	Nutrition of the world population	False	29.00
9	Use of coffee paper cups	Accurate	91.33
10	Use of airplane for passenger transport	False	13.33
11	Waste exports	Accurate	79.00
12	Smoking	False	49.67

(a) For adequate news stories applies: percentage of subjects believing that the story is correct = adequate identification; for false news stories (i.e., news stories that contain false information) the percentage of adequate identification is 100% minus the percentage of the fraction of subjects believing that the story is adequate.
Source: own presentation

Table 7.   Efficacy of the scenarios (N = 240)

Scenarios	∑1-5	1	2	3	4	5
		No information	False news stories shown	Correct news stories shown	Details on false news stories	Story-by-Story identification
I Adequate identification overall						
Mean Experiment 1	6.775	6.895	7.042	6.468	6.844	6.641
Mean Experiment 2	6.937	6.687	6.914	6.957	7.488	6.698
Difference	+0.162	-0.208	-0.127	+0.489	+0.644	+0.056
P-value	0.1153	0.1989	0.4877	0.0258	0.0187	0.7297
II Adequate identification of false news stories						
Mean Experiment 1	2.150	2.145	2.234	2.212	2.044	2.113
Mean Experiment 2	2.700	1.937	3.446	2.085	3.444	2.641
Difference	+0.550	-0.208	+1.212	-0.127	+1.400	+0.528
P-value	0.0000	0.1452	0.0000	0.5414	0.0000	0.0400
III Adequate identification of correct news stories						
Mean Experiment 1	4.625	4.750	4.808	4.255	4.800	4.528
Mean Experiment 2	4.237	4.750	3.468	4.872	4.044	4.056
Difference	-0.387	+/- 0	-1.340	+0.617	-0.755	-0.471
P-value	0.0003	0.9182	0.0000	0.0013	0.0005	0.0213

Source: own presentation

So, the only difference to other news stories, such as #10 or #1, is that no manipulation was implemented. Making things more extreme would result in a false news story, but would probably not be correctly identified by the subjects.

4.2 Experiment 2 (3-Week Interval)

At the end of experiment 1, subjects were given information about the correctness of the stories. The five scenarios are: scenario 1 (no information), scenario 2 (communication of the stories that contain false new information), scenario 3 (communication of the stories that are correct), scenario 4 (communication of details), and scenario 5 (story-by-story identification). Three weeks after experiment 1, the subjects were invited to attend experiment 2. In experiment 2, they were solely shown the news stories again. Of the 300 subjects in experiment 1, a total of 240 subjects also joined experiment 2.[5] The findings are depicted in Table 7.

Overall, the scenarios led to a small increase in the capability to distinguish between accurate and false news information (+0.162). However, the differ-

ence is not statistically significant at the 5% level (p-value = 0.1153). There are considerable differences between the scenarios. The scenarios 1 (i.e., no information) and 2 (i.e., false news stories shown again) performed worst. Both scenarios have a detrimental effect (-0.208 and -0.127, respectively) on the correct differentiation between accurate and false news stories (but neither of them is statistically significant; p-values: 0.1989 and 0.4877, respectively). Scenario 5 (i.e., story-by-story identification) produced a small positive (+0.056), but not statistically significant effect (p-value = 0.7297). The scenarios 3 (i.e., correct news stories shown again) and 4 (i.e., details on false news stories) positively affected the capability to distinguish between accurate and false news stories. Besides notable effect magnitudes (+0.489 and +0.644, respectively), the effects are statistically significant at the 5% level (p-value = 0.0258 and 0.0187, respectively). To put it differently, repeating the correct stories or providing subjects with details and explanations regarding false news content seems to be beneficial.

By repeating false news stories, subjects are more likely to adequately identify them later (+1.212; p-value = 0.0000). Thus, there is no evidence for a familiarity backfire effect. However, repeating false news stories results in a decreased capability to identify adequate news stories (-1.340; p-value = 0.0000). A somewhat reverse, but weaker effect seems to occur when adequate stories are repeated: identification of adequate news stories is more successful (+0.617,

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5   The number of subjects in experiment 2 is distributed among the scenarios as follows: scenario 1 (N = 48), scenario 2 (N = 47), scenario 3 (N = 47), scenario 4 (N = 45), and scenario 5 (N = 53). The reduced sample size can at least in part be explained by the fact that subjects provided email addresses with typos or, as one subject pointed out later, the invitation to the second experiment has landed in their spam order.

p-value = 0.0013), but the opposite holds for the identification of false news stories (-0.127, p-value = 0.5414). This indicates that subjects remember the information that have been highlighted in the correction but negative side-effects are possible. Detailed explanations why the false stories contain false content (scenario 4) increases the adequate identification of false news stories (+1.400, p-value = 0.0000), but the effect on the identification of adequate news stories is detrimental (-0.755, p-value = 0.0005). In scenario 5, where each story is uncovered and the participants are explicitly told whether they were right or wrong, results are ambiguous: subjects perform better in adequately identifying false stories (+0.528; p-value = 0.0400), but perform worse in identifying adequate messages (-0.471, p-value = 0.0213).

5 Conclusion

The purpose of this paper was twofold: first, to identify drivers of (not) falling prey to false narratives, and second, to compare several intervention scenarios to debunk false news stories. For this purpose, an experimental study was carried out in which subjects had to evaluate environmentally-related news stories (i.e., related narratives) as adequate (factually correct) or false. A key result of this study is related to the familiarity with the stories. While PENNYCOOK et al. (2018) use the headline "Prior Exposure Increases Perceived Accuracy of Fake News" in their paper, I provide evidence that even the *perceived* familiarity with the stories is crucial for the subjects' propensity to accept a story as adequate. Many subjects stated familiarity with the stories, even if it contained fabricated news. It is conceivable that familiarity is perceived when news stories are in line with one's own beliefs (confirmation bias) or narratives. It is of economic relevance that people need help to escape their own filter bubble. Former studies in the area of false news found that AOT as well as CRT are positively associated with the capability to distinguish between false and true. This study does not find supporting evidence of CRT. But AOT is in line with existing experimental findings. If the latter is robust, human capacity building might help to strengthen subjects' capability to stronger revise beliefs and the search for alternative explanations. Relatedly, closing the gap between narratives and scientific knowledge with the help of education has the potential to reduce the influence of false information.

In line with previous studies, I found that debunking false news stories poses a challenge. This study indicates that repeating false news stories makes subjects more likely to adequately identify them later. Thus, there is no evidence for a familiarity backfire effect. However, repeating false news stories also decreased the capability to adequately identify adequate messages. A somewhat reverse, but weaker effect seems to occur when adequate stories are repeated: the correct identification of adequate news stories is more successful, but the opposite holds for the identification of false news stories. Detailed explanations of why the false stories contain false content increases the correct identification of false news stories, but the effect on the correct identification of correct news stories is detrimental. To put it differently, there is some evidence indicates that fact-checking is barely enough to combat false news stories. As a consequence, fact-checking should be enriched by other measures, such as regulation to reduce incentives to spread false information or machine learning approaches to detect false information.

This study suffers from some limitations which may serve as a starting point for further research: First of all, it is a small, ad hoc sample of students who have self-selected themselves into the study. Therefore, I cannot claim any representativeness of the findings neither for students nor for the population in Germany. Further studies should address the general population (e.g. quota-representative study of a population). It should also be examined whether the time gap between the two experiments matter. Moreover, decisions were explicitly requested in the study. Thus, the subjects were forced to actively think about the news stories. In everyday life (e.g. in leisure time) people may be less critical. Especially in a study environment, subjects may want to present themselves as critical-thinking individuals and, in case of doubt, might tend to indicate that a news story contains false information. Furthermore, the paper cannot capture the complexity of social networks. This includes comments from relevant others or activities of friends. From a more general perspective, research in the realm of false information should further extend the spectrum of topics and its associated narratives.

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Appendix

I. Experimental Subjects

Table A1. Description of the subjects

Variable		Experiment 1 (N = 300)		Experiment 2 (N = 240)	
		Mean	SD	Mean	SD
Gender	Male	0.4166 (i.e. N=125)	-	0.4125 (i.e. N=99)	-
	Female	0.5766 (i.e. N=173)	-	0.5833 (i.e. N=140)	-
	Other	0.0066 (i.e. N=2)	-	0.0041 (i.e. N=1)	-
Age [18-…]		22.4633	3.473	22.4958	3.414
AOT [1, …, 7]		5.4938	0.779	5.4886	0.761
CRT [0, …, 7]		5.7900	1.432	5.8208	1.386
Risk attitude [1, …, 6]		2.9666	1.587	3.0250	1.615
Conscientiousness [1, …, 5]		3.4983	0.849	3.5437	0.846
Agreeableness [1, …, 5]		2.9833	0.799	2.9770	0.812
Openness [1, …, 5]		3.5016	0.997	3.5125	0.995
Extraversion [1, …, 5]		3.1316	1.009	3.0812	0.985
Neuroticism [1, …, 5]		3.0450	0.958	3.0520	0.959
Politics (right) [0, …, 10]		3.5366	1.834	3.4708	1.817
Religion [0; 1]		0.2966	-	0.3083	-
Trust mass media [1, …, 5]		3.0500	0.866	3.0583	0.861
Social networks [1, …, 4]		3.0933	0.983	3.0875	0.970
Discourse (value-loaded) [1; 0]		0.6800	-	0.6916	-
Challenges environment (friends) [1, …, 6]		3.1333	0.922	3.1333	0.918
Competence environment [1, …, 6]		3.2833	0.691	3.2791	0.691
Overconfidence environment [1, …, 6]		3.1966	0.706	3.2208	0.688

Source: own presentation

II. Translation of the News Stories (Original Language: German)

The following news items have been used in the study. For each story the source is provided where the story has been taken from. For fabricated news items, I provide some details about the false content.

1. Consequences of Climate Change

Climate change has consequences for all regions of the world. The ice of the polar caps is melting and sea levels are rising. In some regions, extreme weather events and increasing precipitation are becoming more frequent, while elsewhere extreme heat waves and droughts are intensifying. Water expands when it warms. At the same time, the polar ice caps and glaciers are melting as a result of global warming. *These changes are more likely to cause both sea-level rise and erosion in coastal areas than sea-level rise alone.*

Source of the news item (not shown to the subjects): https://ec.europa.eu/clima/change/consequences_de
Part in italics is fabricated content and not part of the original story (Subjects were shown the sentences but not highlighted in italics)

2. Microplastics

A study found that around 330,000 tons of so-called microplastics are released into the environment in Germany every year. The Fraunhofer Institute for Environmental, Safety and Energy Technology in Oberhausen has calculated the quantities that are released by 51 sources. Pedestrians also release microplastics into the environment via the soles of their shoes. It is estimated that around one hundred grams are released per capita and year in Germany. That puts footwear in the seventh place on the list of the largest microplastic sources in the study. With 19 grams, shampoos and co. are in 17th place on the negative list.

Source of the news item (not shown to the subjects): https://www.spiegel.de/wissenschaft/mensch/mikroplastik-der-groesste-verursacher-sind-autoreifen-a-1226400.html

3. Importance of the Honey Bee

The honey bee plays a major role in the conservation of biodiversity and the fruit yield of many vegetable, fruit, and arable crops. Professor Thomas D. Seeley, author of "The Lives of Bees: The Untold Story of the Honey Bee in the Wild" and Horace White Professor at Cornell University, described the importance of the bee as follows: "Once the bee disappears from the earth, mankind has only four years to live. No more bees, no more pollination, no more plants, no more animals, no more humans."

Source of the news item (not shown to the subjects): Various sources, for example, https://www.salonkolumnisten.com/mythenjagd-10-bienensterben/ (quotation wrongly attributed to Albert Einstein) falschzitate.blogspot.com/2017/05/wenn-die-biene-einmal-von-der-erde.html
The very beginning is true (relevance of the honey bee), the person really exists (and yes, it is a famous researcher within the field of honey bees), but neither Albert Einstein nor Thomas Seeley have ever pointed out this quotation.

4. Food Waste

Each year, about one third of the world's food gets lost on its way from the field to the plate, while at the same time about 800 million people suffer from hunger. What's more, waste is a burden on the environment. More than 38 million tons of greenhouse gases are produced annually, about 43,000 square kilometers of agricultural land are used, and 216 million cubic meters of water are consumed. Moreover, for every foodstuff we eat, energy is consumed in production and transport, and we also use pesticides, mineral and agricultural fertilizers that pollute the environment.

Source of the news item (not shown to the subjects): https://www.umweltbundesamt.de/themen/wider-die-verschwendung

5. Causes of Bird Deaths

Our birds fortunately belong to the best-studied groups of living organisms, and the data on their population and trends in population are excellent - compared to other groups of animals such as insects. Birds are therefore particularly suitable as indicators of the overall condition of nature. *What are the threats to the domestic bird population? Wind turbines cost some birds their lives. The animals get caught in the rotor blades or fly against masts. The German Nature and Biodiversity Conservation Union (Naturschutzbund Deutschland) estimates the number of bird deaths to be higher for power lines than for hunting. Furthermore, it states that hunting causes more victims than wind turbines. It is therefore not surprising that experts see the cause of bird deaths primarily in wind turbines rather than in power lines.*

Source of the news item (not shown to the subjects): https://www.nabu.de/tiere-und-pflanzen/voegel/gefaehrdungen/24661.html
Part in italics is fabricated content and not part of the original story (Subjects were shown the sentences but not in italics)

6. Mushrooms and Consequences of Chernobyl

More than 30 years ago, the reactor in Chernobyl exploded. However, the consequences are still being felt not only there but also here in Germany. Some foodstuffs are still contaminated radioactively today. The radioactive cloud that swept across Europe in April and May 1986 contaminated large parts of Germany. The regions of Bavaria, southern Thuringia, and areas in Baden-Württemberg were particularly affected at the time. Even today, the soils in many regions, especially in southern Germany, and some foodstuffs are still contaminated with caesium-137 and, to a lesser extent, strontium-90. Some mushroom species, such as bread stubble fungi, chestnut boletuses, black-headed milkworts, trumpet chanterelles, and sweet-smelling snailblades, still exhibit a strongly increased radioactivity to some extent.

Source of the news item (not shown to the subjects): https://www.verbraucherzentrale.de/wissen/lebensmittel/lebensmittelproduktion/tschernobyl-und-die-folgen-lebensmittel-immer-noch-belastet-12683

7. Air Quality

Despite improvements in air quality in Europe, persistent air pollution continues to cause hundreds of thousands of premature deaths on the continent each year. As the European Environment Agency (EEA) announced in Copenhagen, around 400,000 people died prematurely in 2016 in the EU because they were exposed to particulate matter. Nitrogen dioxide (NO2) and ozone also led to premature deaths. Nearly all Europeans living in cities are exposed to air pollution that exceeds the recommended levels of the World Health Organization (WHO), the agency said in its annual report on air quality in Europe published today.

Source of the news item (not shown to the subjects): https://www.aerzteblatt.de/nachrichten/106726/Umweltagentur-400-000-Todesfaelle-wegen-Luftverschmutzung-in-Europa

8. Nutrition of the World Population

An international research team under the supervision of Pete Smith, from the University of Aberdeen, published groundbreaking results on the nutrition of the world population in the renowned journal "Nature". The authors discuss various strategies. They take a critical view of conventional agriculture: through the use of nitrogen fertilizers beyond what agricultural crops can absorb, groundwater is polluted and insects die due to chemical synthetic pesticides. *In contrast, the authors see opportunities in the complete conversion to organic farming in order to maintain today's standards.*

Source of the news item (not shown to the subjects): https://www.spiegel.de/wissenschaft/mensch/kann-oekologische-landwirtschaft-die-menschheit-ernaehren-a-1177968.html
Part in italics is fabricated content (the authors said the opposite) and not part of the original story (Subjects were shown the sentences but not in italics)

9. Use of Coffee Paper Cups

On the way to work, during the lunch break, on the track: coffee to go is omnipresent - and with it the corresponding disposable cups. The German Environment Agency (UBA) calls the paper cups "cups in the hot drinks segment for out-of-home consumption" somewhat brittle, which are increasingly becoming a problem in cities. On Tuesday, the agency published a new study on the to-go cups. The result: the total volume of coffee cups in Germany in 2016 was about 2.8 billion; that corresponds to 34 cups per inhabitant. According to the study, six out of ten cups are plastic-coated paper cups, the remaining pure plastic cups. But that is not all: there are also 1.3 billion plastic lids. While the paper cups are sold by bakeries or cafés - usually with lids - the lidless, pure plastic cups usually come from vending machines in companies, for example.

Source of the news item (not shown to the subjects): https://www.sueddeutsche.de/wirtschaft/to-go-becher-einweg-umwelt-nachhaltigkeit-1.4455834

10. Use of Airplane for Passenger Transport

117 million passengers departed from German airports in 2018 - a record. The government is now discussing measures to curb the popularity of flying. The only embarrassing thing is that politicians and government officials prefer to fly themselves. Politicians in the federal government and their civil servants do not have to pay for their official flights and trips. Yet they do not set a good example. The Federal Ministry of the Interior confirmed to the ARD magazine "Hart aber fair" not the exact numbers, but nevertheless the politicians' preference for flying. *According to the magazine, government officials boarded an airplane more than forty times as often as they took the train: 2,661 train rides are offset by 109,422 flights.*

Source of the news item (not shown to the subjects): https://www.br.de/nachrichten/deutschland-welt/thema-politikerfluege-zugfahren-predigen-ins-flugzeug-steigen,RcJmHo8
Part in italics is fabricated content and not part of the original story (Subjects were shown the sentences but not in italics)

11. Waste Exports

Germany's consumers are spending an extra one billion euros on complex packaging disposal - year after year. Used glass, paper, textiles or batteries are carefully separated from ordinary household waste, and discarded televisions or toasters often take miles to reach the municipal building yard. Now, however, a study by the University of Würzburg-Schweinfurt is questioning the image of the environmentally friendly waste separation nation: Calculated in tons, Germany exported significantly more waste abroad in 2018 than products of the mechanical engineering industry, the Würzburg Logistics Institute found out together with the software company AEB. Up to 20 percent of the plastic waste produced went abroad.

Source of the news item (not shown to the subjects): https://www.handelsblatt.com/unternehmen/handel-konsumgueter/abfall-deutschland-exportiert-mehr-muell-als-maschinen/25078510.html?ticket%E2%80%A6&ticket=ST-1902132-ZXMyusoaESjvpsvxWRxO-ap6

12. Smoking

It is a growing trend among adolescents to refrain from using tobacco filters to be able to enjoy smoking for longer. Scientists from London and San Diego therefore call in the British Medical Journal for a *complete ban on cigarettes sold without filters. They argue that cigarettes with filters absorb part of the tar and thus allow "healthier" smoking. "Our studies provide clear evidence that this safety argument should be followed to mitigate the already harmful effects of smoking,"* write Thomas Novotny of San Diego State University and his colleagues from the London School of Hygiene & Tropical Medicine in their article.

Source of the news item (not shown to the subjects): https://www.aerzteblatt.de/nachrichten/106976/Forscher-fordern-Verbot-von-Filterzigaretten
Part in italics is fabricated content (authors claim the opposite) and not part of the original story (Subjects were shown the sentences but not in italics)

III. Translation of the Details Provided to the Subjects in Scenario 4

▪ **Consequences of Climate Change**

For logical reasons it is not possible that the probability of two events x1 and x2 together is greater than the probability of a single event x2. In psychological treatises, this is sometimes referred to as conjunction fallacy. For example, it is incorrect to say that, in the course of climate change, the consequences of rising sea levels and erosion in coastal areas are more likely than the mere rise in sea levels. It is logically not possible that two consequences of climate change together are more probable than just one consequence. Probability is often confused with rep-resentativeness. The two consequences may be typical of climate change, but they are not more likely.

▪ **Importance of the Honey Bee**

Occasionally the disappearance of the honeybee is mistakenly equated with the disappearance of humanity from planet Earth within a few years. Of course, bees have an important function as pollinators, but such a precise timing for the consequences of the failure of a single influencing factor in a complex system is hardly possible. Furthermore, there are other pollinators besides bees (e.g. beetles, butterflies). Furthermore, many important plants do not need to be visited by insects at all because the wind takes over pollination. These include wheat, corn, rice, rye, barley, oats, and millet. The first three alone provide more than half of all calories consumed by humans. The persistence of the spread of the erroneous statement is astonishing. It is often amplified in the form of a quotation by reference to authorities such as Albert Einstein or prominent bee researchers (e.g. David Seeley).

▪ **Causes of Bird Deaths**

The influence of wind turbines on the death of birds is relatively small. The Nature and Biodiversity Conservation Union of Germany (NABU) estimates the number of deaths caused by wind turbines at about 100,000 per year. A greater danger for birds is posed by hunting (e.g. ducks or geese) and power lines. Currently, about 1.2 million birds die in Germany every year due to legal hunting. Birds also collide with power lines regularly. A NABU study from 2017 estimates that 1.5 to 2.8 million birds die every year as a result of a collision with a power line. In particular by interest groups (e.g. opponents of wind power plants), the number of bird deaths caused by wind power plants may well be exaggerated.

▪ **Nutrition of the World Population**

Under current conditions, a 100% conversion to organic farming is not realistic in the long term. It can be expected that the world's population will continue to grow and that agriculture will have to produce considerably higher yields. Therefore, it can be expected that even under conventional conditions, areas under cultivation will have to be greatly expanded. Under organic conditions, this effect would be even stronger because the yields of organic farming are lower. In order to switch completely to organic farming by 2050, in the worst scenario – with large harvest losses and the most unfavorable conditions caused by climate change – 81 percent more land would have to be used for agriculture than today. Against the background of the current challenges, it is rather wishful thinking to switch completely to organic farming.

▪ **Use of Airplane for Passenger Transport**

Government officials boarded an airplane a good four times as often as they boarded a train: 26,661 train rides are opposed to 109,422 flights. Since the use of airplanes as well as the exemplary function of politicians is criticized by the public, false claims in which the use of the airplane is over-communicated can be spread relatively easily.

▪ **Smoking**

Scientists from London and San Diego demand in the British Medical Journal to completely ban the sale of filter cigarettes. They argue that the filters are a sham anyway: used to save tobacco and make people believe they make smoking less harmful. In fact, the invention of the filter cigarette in the 1950s was a reaction of the tobacco industry to studies proving that smoking causes lung cancer. Cigarettes with a filter, according to the advertising promise of that time, would absorb some of the tar and thus allow "healthier" smoking. "We now know that this safety argument was a fairy tale – one of many that the tobacco industry invented to sell cigarettes," write Thomas Novotny of San Diego State University and his colleagues from the London School of Hygiene & Tropical Medicine in their editorial. False claims about cigarettes are widespread. The cigarette industry in particular benefits when filters can save tobacco.

IV. Description of the Variables

Table A2.   Summary of variables and their measurement

Variable	Question / Statement / → Explanation	Values	Comment
Dependent variable			
Correct identification story	If the story is accurate: identical to "Identification story" If story is false: reverse to "Identification story" (i.e., 1-"Identification story")	1=yes; 0=no	
Identification story	What do you think of the content of this story? Is the claim made accurate?	1=yes; 0=no	After each story
- Identification story_false news - Identification story_correct news	Identical to "Identification story", but considering only false news stories (Identification story_false news) or only correct news stories (Identification story_correct news)	1=yes; 0=no	Subset of stories
Independent variables			
Age	How old are you?	#Years	
AOT	Please rate your agreement or disagreement with each statement. 1. Allowing oneself to be convinced by an opposing argument is a sign of good character. 2. People should take into consideration evidence that goes against their beliefs. 3. People should revise their beliefs in response to new information or evidence. 4. Changing your mind is a sign of weakness. 5. Intuition is the best guide in making decisions. 6. It is important to persevere in your beliefs even when evidence is brought to bear against them. 7. One should disregard evidence that conflicts with one's established beliefs.	1 = Completely Disagree, 7 = Completely Agree	Last 4 items reverse coded
Big 5	How well do the following statements describe your personality? I see myself as someone who…(1) …is reserved, (2) …is generally trusting, (3) …tends to be lazy, (4) …is relaxed, handles stress well, (5) …has few artistic interests, (6) …is outgoing, sociable, (7) …tends to find fault with others, (8) …does a thorough job, (9) …gets nervous easily, (10) …has an active imagination	(1) Disagree strongly, (5) Agree strongly [Items 1, 3, 4, 5, and 7 recoded (1=5) (2=4) (3=3) (4=2) (5=1)] Mean (3r,8) = Conscientiousness Mean (2,7r) = Agreeableness Mean (5r,10) = Openness Mean(1r,6) = Extraversion Mean (4r,9) = Neuroticism	
Challenges environment (friends)	I discuss environmental challenges with my friends...	Daily (6), several times a week(5), once a week (4), ..., less frequently (1)	
Competence (context)	Please assess yourself. How well are you informed about the following matters? 1. Consequences of climate change, 2. Microplastics, 3. Bee deaths, 4. Food waste, 5. Bird deaths, 6. Food contamination due to the consequences of Chernobyl, 7. Air pollution, 8. Nutrition of the world population, 9. Use of coffee paper cups, 10. Use of airplane for passenger transport, 11. Waste exports, 12. Smoking	Very poor (1), very well (5)	

Variable	Question / Statement / → Explanation	Values	Comment
Competence environment	How familiar are you with environmental issues?	Very poor (1), very good (5)	
CRT	1) If it takes 2 nurses 2 minutes to measure the blood pressure of 2 patients, how long would it take 200 nurses to measure the blood pressure of 200 patients? 2) Soup and salad cost €5.50 in total. The soup costs a euro more than the salad. How much does the salad cost? 3) In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? 4) If you're running a race and you pass the person in second place, what place are you in? 5) A farmer had 15 sheep and all but 8 died. How many are left? 6) Emily's father has three daughters. The first two are named April and May. What is the third daughter's name? 7) How many cubic feet of waste are there in an empty box that is 10 cm wide 20 cm deep 10 cm long?	CRT-Score = number of correct answers to the questions: 1) 2 2) 2.25 3) 47 4) 2 5) 8 6) Emily 7) 0	
Degree program	How would you categorize your field of study in terms of content? (Social Sciences, Law, Economics, Humanities and Cultural Studies, Art and Design, Medicine and Health Care, Agricultural and Forestry Sciences, Mathematics and Natural Sciences, Engineering, Other)		
Discourse (value-loaded)	How would you best describe the public discourse on environmental issues? Please choose an alternative.	Value-loaded, no free exchange of perspectives (=1); Objective discourse, open exchange of perspectives (=0)	
Female (=1)	What is your gender?	Female = 1, Male = 0 (Other=2)	"Other" dropped due to low sample size (N=2)
Overconfidence environment	My knowledge of environmental issues is [...] than that of an average student at the Martin Luther University Halle-Wittenberg.	Much worse (1), much better (5)	
Politics (right)	In politics people often talk about "left" and "right" to distinguish different attitudes. If you think about your own political views: Where would you place them?	0=entirely left, 10=entirely right	
Religion	Do you belong to a church or religious group?	1=yes; 0=no	
Risk attitude	→ Procedure according to ECKEL and GROSSMAN → Subjects had to pick one out of six gambles (which determines the individual risk attitude)	1-4=Risk averse 5=Risk neutral 6=Risk seeking	
Risk society (context)	How do you assess the risks/hazards to the environment and society of the following issues? 1. Consequences of climate change, 2. Microplastics, 3. Bee deaths, 4. Food waste, 5. Bird deaths, 6. Food contamination due to the consequences of Chernobyl, 7. Air pollution, 8. Nutrition of the world population, 9. Use of coffee paper cups, 10. Use of airplane for passenger transport, 11. Waste exports, 12. Smoking	Very small (1), very large (5)	
Social networks	Do you have an account on social networks such as Facebook or Twitter?	Yes, I actively use it (4), Yes, I use it occasionally (3), Yes, but I don't use it (2), No (1)	
Story seen	Have you seen or heard this news story before?	yes=1, no/unsure=0	After each story
-Story seen_false news -Story seen_correct news	Identical to "Story seen," but only considers false news stories (Story seen_false news) or only correct news stories (Story seen_correct news)	yes=1, no/unsure=0	Subset of stories
Trust mass media	In general, how much trust and confidence to you have in the mass media - such as newspapers, TV, and radio - when it comes to reporting the news fully, accurately, and fairly?	Very low (1), very high (5)	Source: GALLUP NEWS (2010)

V. Robustness Check: Zero-Order Correlations

Table A3.   Partial correlations between dependent variables and independent variables (N=300)

	I **Adequate identification of all news**	II **Adequate identification of correct news**	III **Adequate identification of false news**
Story seen_false news	-0.2022	-	-0.3595
Story seen_correct news	0.0932	0.2830	-
AOT	0.1701	0.2005	0.0328
CRT	0.0133	0.0531	-0.0327
Female (=1) vs Male (0)	-0.1882	-0.1410	-0.1124
Conscientiousness	-0.0205	-0.0303	0.0018
Agreeableness	-0.1256	-0.0336	-0.1318
Openness	-0.0061	0.0510	-0.0558
Extraversion	-0.0297	-0.1129	0.0674
Neuroticism	-0.0911	-0.0520	-0.0696
Religion	0.0653	0.0393	0.0480
Trust mass media	0.0507	0.0930	-0.0215
Social networks	-0.1248	-0.0971	-0.0710
Politics (right)	-0.0351	-0.1158	0.0632
Age	0.1471	0.0859	0.1105
Discourse (value-loaded)	0.0680	0.0632	0.0290
Challenges environment (friends)	0.0697	0.1655	-0.0648
Overconfidence environment	0.1024	0.1111	0.0287
Competence (context)	0.1105	0.1471	0.0055
Risk attitude	0.1116	0.0071	0.1383

Source: own presentation

VI. Robustness Check: Story by Story Regressions (AME After Logit)[a]

Story-by-story analyses are carried out by using binary logistic regression models. Since the coefficients of logistic regression models cannot be interpreted in a meaningful way, average marginal effects are reported.

Table A4. Marginal effects after logit to explain the ability to identify false news stories[a]

	(1) Consequences of climate change	(3) Importance of the honey bee	(5) Causes of bird deaths	(8) Nutrition of the world population	(10) Use of airplane for passenger transport	(12) Smoking
Story seen	-0.1246 (0.026)	-0.2335 (0.035)	-0.3276 (0.076)	-0.1897 (0.042)	-0.0860 (0.028)	-0.4166 (0.058)
AOT	0.0039 (0.026)	0.0370 (0.030)	0.0264 (0.032)	0.0153 (0.035)	-0.0468 (0.024)	0.0298 (0.037)
CRT	-0.0269 (0.012)	-0.0084 (0.015)	-0.0099 (0.017)	-0.0002 (0.019)	0.0010 (0.012)	-0.0016 (0.020)
Female (=1)	-0.0181 (0.042)	-0.0572 (0.045)	-0.0365 (0.063)	0.0143 (0.065)	0.0225 (0.049)	0.0103 (0.065)
Conscientiousness	0.0333 (0.024)	-0.0014 (0.026)	0.0337 (0.028)	0.0142 (0.032)	-0.0465 (0.023)	-0.0274 (0.033)
Agreeableness	-0.0392 (0.028)	0.0002 (0.029)	0.0113 (0.032)	-0.0324 (0.035)	-0.0517 (0.025)	-0.0292 (0.036)
Openness	-0.0286 (0.020)	-0.0290 (0.023)	0.0173 (0.024)	0.0173 (0.027)	-0.0077 (0.020)	0.0185 (0.028)
Extraversion	0.0313 (0.022)	0.0360 (0.025)	-0.0067 (0.025)	0.0410 (0.029)	0.0171 (0.021)	0.0641 (0.029)
Neuroticism	0.0392 (0.022)	0.0533 (0.024)	-0.0226 (0.026)	0.0251 (0.029)	-0.0199 (0.021)	-0.0568 (0.030)
Religion	0.0611 (0.050)	-0.0344 (0.046)	-0.0312 (0.055)	0.0446 (0.061)	-0.0203 (0.041)	0.0673 (0.062)
Trust mass media	-0.0478 (0.024)	0.0124 (0.026)	0.0436 (0.028)	-0.0180 (0.032)	-0.0240 (0.022)	0.0375 (0.032)
Social networks	-0.0193 (0.019)	-0.0232 (0.022)	-0.0391 (0.025)	-0.0103 (0.027)	0.0043 (0.019)	0.0312 (0.029)
Politics (right)	-0.0015 (0.012)	0.0082 (0.013)	-0.0026 (0.014)	0.0101 (0.016)	-0.0191 (0.011)	-0.0295 (0.016)
Age	0.0035 (0.005)	0.0164 (0.006)	0.0068 (0.007)	0.0008 (0.007)	0.0088 (0.005)	-0.0099 (0.008)
Discourse (value-loaded)	0.0011 (0.043)	-0.0547 (0.045)	0.1517 (0.041)	-0.0306 (0.055)	0.0348 (0.046)	-0.0806 (0.060)
Challenges environment (friends)	-0.0295 (0.023)	0.0262 (0.027)	-0.0214 (0.029)	-0.0137 (0.032)	0.0086 (0.024)	-0.0390 (0.034)
Overconfidence environment	0.0150 (0.036)	-0.0004 (0.039)	-0.0114 (0.040)	0.0335 (0.045)	0.0044 (0.032)	0.0356 (0.047)
Competence environment	0.0049 (0.036)	-0.0019 (0.041)	0.0372 (0.044)	0.0271 (0.048)	-0.0090 (0.033)	-0.0593 (0.049)
Risk attitude	-0.0026 (0.013)	7.39e-06 (0.014)	0.0149 (0.016)	0.0064 (0.018)	-0.0071 (0.012)	0.0238 (0.018)
Risk society (context)	-0.0322 (0.029)	-0.1695 (0.021)	0.0034 (0.029)	-0.0137 (0.029)	-0.0517 (0.020)	0.0312 (0.024)
Competence (context)	-0.0214 (0.033)	0.0204 (0.026)	-0.0347 (0.030)	0.0247 (0.028)	-0.0366 (0.020)	-0.0238 (0.025)
Prob > chi2 (after logit)	0.0008	0.0000	0.0002	0.5573	0.0177	0.0007
Pseudo R2 (after logit)	0.1885	0.3276	0.1561	0.0540	0.1566	0.1156

(a) Marginal effects, standard errors in brackets below
Source: own presentation

Table A5. Marginal effects after logit to explain the ability to identify correct news stories[a]

	(2) Microplastics	(4) Food waste	(6) Mushrooms and conse-quences of Chernobyl	(7) Air quality	(9) Use of coffee paper cups	(11) Waste exports
Story seen	0.4092	0.0981	0.2962	0.3409	0.1350	0.2264
	(0.036)	(0.019)	(0.029)	(0.045)	(0.025)	(0.023)
AOT	0.0265	-0.0212	0.0278	0.1030	0.0528	0.0308
	(0.034)	(0.019)	(0.031)	(0.034)	(0.019)	(0.0279)
CRT	0.0204	-0.0083	0.0164	-0.0264	0.0058	-0.0173
	(0.019)	(0.011)	(0.016)	(0.019)	(0.010)	(0.016)
Female (=1)	0.0234	-0.0206	-0.0291	-0.0247	-0.0367	-0.1252
	(0.061)	(0.045)	(0.060)	(0.063)	(0.047)	(0.065)
Conscientiousness	0.0319	-0.0070	-0.0262	-0.0645	0.0334	0.0347
	(0.031)	(0.016)	(0.029)	(0.031)	(0.018)	(0.025)
Agreeableness	-0.0310	-0.0095	0.0394	0.0049	-0.0112	-0.0505
	(0.035)	(0.018)	(0.033)	(0.034)	(0.019)	(0.028)
Openness	0.0165	0.0066	0.0199	-0.0151	0.0027	-0.0011
	(0.026)	(0.013)	(0.024)	(0.026)	(0.016)	(0.022)
Extraversion	-0.0217	-0.0264	-0.0448	-0.0326	-0.0273	-0.0504
	(0.028)	(0.015)	(0.026)	(0.028)	(0.016)	(0.024)
Neuroticism	-0.0103	-0.0321	-0.0234	-0.0594	0.0157	-0.0125
	(0.029)	(0.016)	(0.025)	(0.029)	(0.018)	(0.024)
Religion	0.0765	-0.0076	-0.0316	0.0100	-0.0410	0.0688
	(0.056)	(0.031)	(0.055)	(0.058)	(0.039)	(0.043)
Trust mass media	-0.0077	0.0100	0.0514	0.0280	-0.0237	-0.0214
	(0.032)	(0.017)	(0.028)	(0.031)	(0.019)	(0.026)
Social networks	-0.0019	-0.0251	-0.0181	-0.0503	0.0061	-0.0274
	(0.029)	(0.016)	(0.026)	(0.027)	(0.015)	(0.023)
Politics (right)	-0.0138	-0.0157	0.0253	-0.0306	0.0005	-0.0253
	(0.016)	(0.008)	(0.015)	(0.016)	(0.009)	(0.013)
Age	0.0031	-0.0015	0.0050	-0.0037	0.0080	0.0025
	(0.008)	(0.004)	(0.007)	(0.008)	(0.005)	(0.006)
Discourse (value-loaded)	0.0335	0.0874	0.0024	-0.0126	0.0306	-0.0719
	(0.056)	(0.019)	(0.050)	(0.056)	(0.030)	(0.051)
Challenges environment (friends)	0.0345	-0.0131	-0.0151	0.0238	0.0309	0.0368
	(0.032)	(0.017)	(0.028)	(0.031)	(0.019)	(0.024)
Overconfidence environment	-0.0426	-0.0198	0.0929	-0.0253	-0.0175	-0.0410
	(0.044)	(0.025)	(0.039)	(0.044)	(0.028)	(0.036)
Competence environment	0.0274	0.0204	-0.0306	0.0692	0.0043	0.0386
	(0.047)	(0.024)	(0.043)	(0.046)	(0.027)	(0.039)
Risk attitude	-0.0035	0.0110	0.0223	-0.0122	-0.0115	-0.0408
	(0.018)	(0.010)	(0.016)	(0.018)	(0.010)	(0.015)
Risk society (context)	0.0090	0.0383	-0.0081	0.0923	0.0227	0.0585
	(0.037)	(0.017)	(0.027)	(0.030)	(0.018)	(0.023)
Competence (context)	-0.0158	0.0324	0.0683	-0.0474	0.0068	0.0098
	(0.031)	(0.016)	(0.025)	(0.030)	(0.015)	(0.023)
Prob > chi2 (after logit)	0.0000	0.0033	0.0000	0.0000	0.0000	0.0000
Pseudo R2 (after logit)	0.1500	0.3154	0.2362	0.1861	0.3205	0.2302

(a) Marginal effects, standard errors in brackets below
Source: own presentation