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Understanding Moral Narratives as Drivers of Polarization about Genetically Engineered Crops

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Author Note

Data and materials are available at: Waldhof, G. (2023). Replication Data for: "Understanding Moral Narratives as Drivers of Polarization about Genetically Engineered Crops". *Harvard Dataverse, V1*. https://doi.org/10.7910/DVN/FEC7OL. Specifically, the file includes the survey materials (in German), participants' descriptions of the narratives and subjective images, the codings of the narratives according to moral foundations, all data for the regression, a codebook explaining all variables, the data for the correspondence analyses, and the code to reproduce the analyses. The questionnaire and methodology for this study was approved by the Ethics committee of the Leibniz Institute of Agricultural Development in Transition Economies (Certificate Reference Number: 03/2019).

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Abstract

Motivated by an increasing interest in narratives in economics, we investigated the relevance of moral concerns in narratives for policy preferences. Specifically, taking the German debate about genetic engineering of foods (GE) as an example, we conducted a representative online survey in Germany to identify common narratives, their moral content, and related subjective images about GE.

In line with previous research, we found that two-thirds of respondents choose to reject GE. Moreover, based on Moral Foundations Theory, we found that GE opponents much more frequently addressed the moral foundations Care and Sanctity in their stated narratives about GE. GE supporters most frequently addressed the moral foundation Loyalty in their stated narratives about GE.

Also, subjective images about GE were much more negative among opponents than among supporters. However, the subjective images of opponents and supporters were in striking accordance about GE being a deviation from what is considered normal. Both sides overwhelmingly described images related to the enhancement of plants, as something strange, supersized, or artificial.

In a linear regression model, we showed that the moral content of narratives about GE is indeed significantly related to the attitude towards this technology.

In total, the findings suggest that the moral content of narratives is highly relevant for policy preferences, and should thus be considered in science communication and policymaking.

Keywords: narratives, Moral Foundations Theory, genetic engineering, morality, polarization

Introduction

Scientific academies consider the genetic engineering of plants for human consumption (GE) to be a promising tool for tackling future challenges such as food security (National Academies of Sciences, Engineering, and Medicine, 2016; German National Academy of Sciences Leopoldina [Leopoldina] et al., 2019; Leopoldina et al., 2015). Contrary to that, non-governmental organizations (NGOs) such as Greenpeace or Testbiotech have long warned of potential uncontrollable risks of GE, and propose a ban of foods produced with this technology (see for example Greenpeace, 2015; Then & Bauer-Panskus, 2017).

Particularly in Germany, this discrepancy resulted in a long-lasting and heated debate (Inbar & Waldhof, 2022; Dürnberger, 2019; Blancke et al., 2015; Freitag, 2013; Zwick, 1998). Even more so, Pies et al. (2021) describe that GE supporters and opponents maintain their strongly polarized positions and have not been able to move towards consensus for long.

Within the public, the topic is polarizing as well, although skepticism is more frequent than acceptance, both internationally but in Germany in particular (Kennedy & Thigpen, 2020; Scott et al., 2016; BfR, 2022). For example, in a study by Inbar and Waldhof (2022), roughly two-thirds of respondents in Germany stated to be against GE foods. Similarly, Scott et al. (2019) found rejection rates as high as 73% among respondents in Germany. These findings suggest that those narratives about GE that are shared and represented by NGOs are more appealing to the majority of the German public than are those represented by the scientific academies.

In the present study, we inquire *why* this is the case. Specifically, we investigate the moral *narratives* that people rely on to inform their attitude towards GE.

A growing body of literature looks at the narratives that people hold in relation to their policy preferences (Eliaz & Spiegler, 2020; Spiegler, 2016; Andre et al., 2022). Shiller (2017) saw narratives as stories that guide people's expectations about current topics. Similarly, Eliaz and Spiegler (2020) proposed that narratives shape political beliefs. This was already formulated in 2009 by Akerlof and Shiller who related economic decisions to the belief in certain stories. Thus, narratives can be understood as heuristics that help develop preferences for policies, such as a ban of GE or an approval, respectively.

What makes narratives an interesting study object for economics is that they suggest and motivate economically relevant behavior (Roos & Reccius, 2021) and decisions, e.g. whether to vote in favor or against GE. Shiller (2019) also postulated that narratives can "drive major economic events" (p. iii). Similarly, Benabou et al. (2020) argued that moral

narratives have the power to change people's beliefs about social costs and benefits. With that, narratives coordinate collective behavior in an uncertain world (Roos & Reccius, 2021). They thus impact policy-making, consumer behavior, markets, and demands of certain goods, e.g. genetically engineered crops.

At the same time, importantly, this also means that "[d]ifferent narratives will typically generate different political beliefs because they manipulate correlations between different sets of variables" (Eliaz & Spiegler, 2020, p. 3788). With that, political disagreements may be explained by a "clash of narratives" Eliaz and Spiegler (2020, p. 3786). I.e., if people believe different narratives about GE to be most relevant, they may come to opposing views on whether or not to ban GE.

Previous research provided evidence that GE attitude is related to moral beliefs (Moon & Balasubramanian, 2003; Sjöberg, 2008; Tanaka, 2004). Even more so, Inbar and Waldhof (2022) and Scott et al. (2016) found that for many people, their position towards GE itself is a morally held belief. Other research has linked GE attitudes to moral foundations and moral values (Waldhof, 2022b; Siegrist, 1999).

Building on this previous research on GE attitudes and economic narratives, we propose in the present paper that people's moral belief systems are decisive for which narrative about GE they find most appealing. We thus assume here that the moral content of a narrative about GE guides GE attitude and respective policy preferences. This proposition is supported by research that has found that moral beliefs are particularly powerful in motivating behavior (Skitka et al., 2005; Chen, 2020), such as political engagement (Sktika & Baumann, 2008; Misch et al., 2021).

Thus, the question arises of what the moral contents of narratives about GE are, and how they differ between supporters of GE and opponents of GE. Narrative research in economics increasingly addresses the role of morality in narratives. For example, Akerlof and Shiller (2009) pointed out that moral concerns such as confidence and fairness are relevant for economic behavior. Similarly, Benabou et al. (2020) argued that moral or immoral behavior results in social costs or benefits. They described moral narratives as arguments behind these costs or benefits that thus guide behavior. For Benabou et al. (2020, p. 2), such moral narratives are even the "most important narratives". Shiller (2020) also postulated that narratives transport a moral interpretation of events.

Even more specifically, Benabou et al. (2020, p. 27) called for investigating the type of moral notions in narratives, requiring going beyond "fairness-harm conception[s]". In the present study, we extended our inquiry beyond such conceptions by applying Haidt's Moral

Foundations Theory (2012) to identify a likely spread of moral foundations addressed in narratives as well as potential conflicts between them.

Furthermore, we built our analysis on the idea formulated by Sloman et al. (2009) that the moral judgment of a narrative occurs through the evaluation of this narrative against a normative ideal. Similarly, Roos and Reccius (2021, p. 14) made the important suggestion that narratives are evaluated against representations about "how the world ought to be".

Following this suggestion, we propose here that narratives have a normative implication through addressing a specific moral foundation that is either catered to or violated. If the foundation is catered to, then the normative evaluation of the issue is "good", vice versa, if the foundation is violated then the normative evaluation of the issue is "bad". Depending on the evaluation, specific moral emotions are triggered that then motivate behavior (Haidt, 2003; Schwartz, 2007).

In the present paper, we point out this crucial aspect and make the argument that the evaluation of a narrative against a moral foundation drives the subsequent behavior and decision.

Relatedly, Benabou et al. (2020) point to the research domain of conflicting narratives. As mentioned above, some narratives in the official debate about GE are diametrically opposed, leading to diverging attitudes towards the technology. Similarly, Roos and Reccius (2021) pointed out that different people and groups focus on different moral values because they exhibit different value preferences. Tying in with this, we explored which narratives lead to a negative evaluation of GE, and which to a positive.

Using the GE debate in Germany as an example, the present study addressed the following questions:

1. Which moral evaluations – and conflicts between them – according to Haidt's Moral Foundations Theory lead to GE support, which lead to GE opposition?
2. Which narratives drive GE attitudes in Germany?
3. Do subjective images about GE differ between supporters and opponents?
4. What is the relative importance of moral narratives compared to other (socioeconomic) factors?

For this purpose, we conducted an online survey on GE attitudes in Germany, representative for the population according to age, gender, and region. In this survey, we used open text boxes for respondents to provide their reasoning behind their attitudes.

Furthermore, we asked participants to describe what they picture when thinking about GE (i.e., subjective images). We also collected data for other measures that have previously

been shown to be relevant for attitude formation, and GE attitudes in particular. These include for example, age, gender, emotionality, experience of emotions, or regulatory preferences.

We coded the provided narratives and subjective images according to prevalent contents, and according to addressed moral foundations. We conducted a correspondence analysis, as well as a linear regression.

We found that the majority (63%) chose to reject GE for food. The narratives that participants stated to justify their decision address the moral foundations Care, Loyalty, and Sanctity. In general, the analyses reveal a striking importance of Loyalty as driving GE attitude. In particular, opponents focused much more on concerns related to Sanctity, and also addressed the Care foundation more frequently than do supporters. Interestingly, supporters focused extensively on the Loyalty foundation, thus addressing potential benefits for others and society as a whole, rather than health issues that might be more relevant to them personally.

In their narratives, GE opponents focused heavily on potential health impairments and general risk perceptions. They also frequently addressed the narratives that GE would be unnatural, or an interference with nature; as well as the narrative that GE and related products would bring damage to the environment. Supporters strongly focused on narratives about food security, and contributions to general welfare. They also often stated environmental benefits through GE, and adaptive advantages of GE.

Moreover, we found that subjective images of GE differ between opponents and supporters in that those of opponents generally refer to more negative scenarios than those described by supporters. For example, while opponents often described somewhat post-apocalyptic images, supporters often described more neutral images related to laboratories, research and modern technology.

However, the subjective images of opponents and supporters were in striking accordance with another, about GE being a deviation from what is considered normal. Both sides overwhelmingly described images related to the enhancement of plants, something strange, supersized, or artificial.

In a linear regression model, we showed that the moral content of narratives about GE is indeed significantly related to the attitude towards this technology.

We contribute to the literature of narratives in economics (Ash et al., 2021; Macaulay & Song, 2022; Spiegler, 2016; Eliaz & Spiegler, 2020; Andre et al., 2022, Shiller, 2017, 2019, 2020). We identified people's (mis)perceptions of an economically highly relevant technology. These (mis)perceptions impact people's expectation formation, and with that

predict their voting behavior, purchasing behavior, and policy preferences in relation to GE. Rather than merely reporting on observed behavior, we provide evidence on what is going on in people's minds, i.e., which beliefs contribute to this behavior. With that, we also contribute to the literature on expectation formation (Bachmann et al. [Eds.], 2022; D'Acunto et al., 2021; Bachmann et al., 2020; Cookson et al., 2020). Particularly, we contribute to research that investigates the role of values, economic ideologies and beliefs in forecasting behavior (Carroll & Wang, 2022; Hudomiet et al., 2022; Mueller & Spinnewijn, 2022; Delavande, 2022; Döpke et al., 2019; Beckert, 2016; van Dalen, 2019). This research increasingly applies text analyses and text mining methods (Grimmer et al., 2022; Ash & Hansen, 2022; Gentzkow et al., 2019; Diaf et al., 2021; Fritsche & Puckelwald, 2018; Jelveh et al., 2018). Applying qualitative text analyses to research lay people's moral beliefs about GE specifically, we also contribute to this methodological development.

While normative beliefs are increasingly incorporated in economic analyses, there is not yet much research addressing the moral content of narratives specifically. We contribute to this emerging strand of literature in economics (Roos & Reccius, 2021; Benabou et al., 2020). Specifically, we illuminate moral concerns that feed into attitude and expectation formation. We also provide evidence on the relative importance of moral narratives compared to other (e.g. socioeconomic) factors. Thus, we provide novel insights into moral conflicts between narratives. With that, we contribute to explaining how diverging moral foundations lead to diverging expectations, policy preferences and economic behavior.

Through identifying conflicting moral foundations, we help explain conflicting attitudes, and thus also contribute to the literature on polarization, and polarized debates (Tosun & Schaub, 2017, Kubin et al., 2021; Graham et al., 2012; Waytz et al., 2019; Day et al., 2014; Voelkel & Feinberg, 2018; Graham et al., 2009). We also contribute to the literature in moral psychology on moral beliefs, moral conviction, moralization of attitudes, and moralization more general (Feinberg et al., 2019; Ellemers et al., 2017; Fernbach et al., 2019; Skitka et al., 2005; Graham et al., 2011; Skitka & Mullen, 2002; Tetlock et al., 2000; Tetlock, 2003; Rozin, 1999; Rozin, 2005, Haidt, 2012).

Moreover, we contribute to the literature on GE attitude, technology adoption, and related policy preferences (Connor & Siegrist, 2010; Dürnberger, 2019; Kajale et al., 2015 Siegrist et al., 2012; Siegrist, 2000; Siegrist, 1999; Kimenju et al., 2007; Lee et al., 2018). Because through analyzing people's narratives about GE with text analyses, we shed light on the underlying belief structure and motivations beneath GE attitudes.

Concluding, our key contribution is methodological. For the analysis of economic narratives and their impact on expectation formation and economic behavior, we illuminate the role of moral concerns by introducing a concept for identifying these in text. Particularly, we show how Moral Foundations Theory can serve as a lens for analyzing economic narratives.

We also provide some practical contributions: Understanding which narratives about GE people have on top of their heads is necessary to develop solutions for a more constructive debate about GE. Thus, the present research provides the ground for developing policy recommendations, as well as recommendations for science communication.

This paper is structured as follows. We first provide theoretical background on narratives in economics and propose to follow Roos and Reccius' (2021) definition of collective narratives in economics, particularly. We then provide theoretical background on Moral Foundations Theory (Haidt, 2012), and the representation of narratives as directed acyclic graphs (Spiegler, 2016). Subsequently, we describe the coding procedure of the narratives. We report on addressed moral foundations, addressed topics, and a correspondence analysis. We also briefly report on survey comments. Next, we report on the results of the analysis of mental models that people described. We then report on results of our linear regression model. Finally, we discuss our results and conclude with a brief outlook.

Theoretical Background on Narratives and their Moral Foundations

Narratives in Economics

A new strand in the economic literature investigates the role of narratives in explaining public phenomena and expectation formation. For example, Andre et al. (2022) explored the narratives people use to explain inflation surges. Similarly, Macaulay and Song (2022) investigated sentiment changes of Twitter users through engaging with a narrative portrayed in newspaper articles. Eliaz and Spiegler (2020) investigated why certain narratives spread while others do not and propose a model of competing narratives, in which people are drawn to hopeful narratives. Similarly, Benabou et al. (2020) attempted to explain the use of narratives as a means to justify one's own behavior against moral rules. Focusing even more on the role of actors in the spread of narratives, Eliaz et al. (2022) developed a model that shows how narratives can be used by political actors for political mobilization of the public. This conscious implementation of narratives has also been investigated by Antoci et al. (2020), who studied how influencers' self-interested strategic choice of narratives can impact public opinion. Ash et al. (2022) also contributed to this by developing an open-source

package, RELATIO, that helps mapping the relationships between actors involved in a narrative.

While scholarly interest in narratives in economics is increasing, definitions of the term are mostly broad. Based on a literature review on narratives in economics, Roos and Reccius (2021) concluded that there is still no common understanding in economics of what narratives are. Consequently, different concepts are used which are often described rather vaguely. For example, Robert Shiller (2017, 2019, 2020) who published his popular book "Narrative Economics" in 2019, described his understanding of narratives with illustrative anecdotes.

Many of current studies on narratives in economics appear to be based on the concept described by Shiller. For example, references to Shiller are made in Benabou et al. (2020), Ash et al. (2022), Andre et al. (2022), and Roos and Reccius (2021). Shiller (2020, p. 792) described narratives as "stories that offer interpretations of economic events, or morals, of hints of theories about the economy". As he did, narratives are often described as stories. For example, Benabou et al. (2020, p. 1) wrote "[n]arratives are stories people tell themselves, and each other, to make sense of human experience." Similarly, Roos and Reccius (2021, p. 13) also understood a narrative as a "sense-making story". Ash et al. (2022) understood narratives as stories that shape beliefs about social reality.

In his book, Shiller (2019) referred to the definition of a narrative provided by the Oxford English Dictionary (OED). The strategy to refer to the OED for a definition of "narrative" is also adopted by others, for example Andre et al. (2022), or Ash et al. (2022, p. 3), even though the exact wording appears to vary. For example, while Shiller (2019, p. XVII) cited the definition of a narrative by OED as "a story or representation used to give an explanatory or justificatory account of a society, period, etc.", Andre et al. (2022, p. 6) cited this as an "account of a series of events, facts, etc., given in order and with the establishing of connections between them."

Since so far, these descriptions are rather vague, as the term "story" is vague, there is still much room for the development of an understanding of a narrative in economics.

Spiegler (2016), Eliaz and Spiegler (2020), and Eliaz et al. (2022) proposed to understand narratives as a causal account for why certain public outcomes occur. Antoci et al. (2020) also understood narratives as some sort of account (between purely fictional or based on real facts) of an event. Spiegler (2016) and Eliaz and Spiegler (2020a,b) formalized this causal account as a probabilistic belief which can be represented as directed acyclic graphs (DAGs) based on the assumption of Bayesian networks. While Eliaz and Spiegler (2020)

proposed to understand a narrative as a causal relationship between a factor and an outcome, the relationship could be more precisely described as a probabilistic belief about this relationship based on a correlation between the variables. This is later explained in more detail. With that, the approach proposed by Spiegler (2016) and Eliaz and Spiegler (2020) focuses on the individual, formalizing narratives as a causal account that is needed for individual decision making.

The representation as DAGs proposed by Spiegler (2016) is also applied by other researchers investigating narratives in economics, e.g. Macauley and Song (2022), or Andre et al. (2022).

Collective Narratives in Economics according to Roos and Reccius (2021)

In 2021, Roos and Reccius developed a more comprehensive understanding of narratives in economics, and propose a definition for a "collective economic narrative" (2021, p. 13):

> "*A collective economic narrative is a sense-making story about some economically relevant topic that is shared by members of a group, emerges and proliferates in social interaction, and suggests actions."*

In their definition, Roos and Reccius (2021) emphasized the need of a narrative to be collective in order to be relevant for macroeconomic events. The authors stated that rather than private narratives that provide guidance for a specific person, collective narratives fulfill specific functions for an entire group.

At the core of this definition are five characteristics: narratives are stories that make sense of public phenomena, they are known and relevant to a group, they emerge from social interaction, and motivate action.

First, Roos and Reccius (2021) proposed to understand a narrative as a story. Their understanding is similar to those described above, but different from Eliaz and Spiegler's (2020) causal account. Roos and Reccius (2021, p. 15) described a narrative as "a partial articulation of a more complex underlying causal model". This means that the narrative itself does not necessarily convey an underlying causal relationship, but the narrative can be interpreted as a causal model, depending on the knowledge and assumptions of the interpreter.

Second, Roos and Reccius (2021) proposed that narratives help people to make sense of the world around them to guide and motivate their decision making and behavior. For such sense-making to work, it needs to connect to the belief system of the people holding a narrative (Roos & Reccius, 2021). And such a belief system consists of a set of "mental

models and normative, evaluative, affective and motivational elements" (Abelson, 1979, as cited in Roos & Reccius, 2021, p. 14).

Third, since Roos and Reccius (2021) defined collective narratives, they demanded that such are relevant and known to a group, as well as shared and understood by this group.

Such a narrative can thus also fulfill the purpose of binding a group together and differentiating this group from others. With this, collective narratives can be essential for group identity. Related to that, research on identity in economics provided evidence that the necessity to maintain and signal one's own identity can be a strong motivator for behavior and decision making (see for example Akerlof & Kranton, 2000, 2010; Shayo, 2010).

Fourth, Roos and Reccius (2021) proposed that collective narratives emerge from social interaction. Specifically, they pictured public discourses that address and develop certain narratives, and are spread through news media.

And fifth, narratives should suggest an action (Roos & Reccius 2021), such as the purchase of a product or voting behavior. The assumption that narratives motivate behavior is also central to the understanding provided by Eliaz et al. (2022) and Eliaz and Spiegler (2020). While narratives can still be important for group identity if they do not suggest an action, they only become a relevant object of investigation for economics if they motivate economic behavior and decision making (Roos & Reccius, 2021, pp. 6, 18; Eliaz et al., 2022).

Understanding of Narratives in the present Study according to Roos and Reccius (2021)

In the present study, we understand the analyzed narratives about GE as collective narratives according to Roos and Reccius (2021).

First and second, narratives about GE are likely sense-making stories. Specifically, we assume here that the narratives that people provide to justify their position towards GE are sense-making stories that put a complex new technology into context. This helps people to evaluate its relationship with their own belief system. Third and fourth, we assume that the analyzed narratives are collective, evolved through social interaction. Specifically, they are shared by large proportions of the German public and likely emerged and spread through the public debate about GE that started in the late 1980s, early 1990s. Fifth, we assume that the analyzed narratives about GE suggest actions with significant economic impact. Specifically, we assume that they lead people to diverging regulation preferences, i.e. supporting versus opposing GE. Moreover, the widespread GE opposition in Germany has an enormous economic impact, not only in Germany, but also in other countries that are politically or economically dependent on Germany, e.g. for export and import. While we are not aware of a

study investigating this for the German crop market specifically, Biden et al. (2018) estimated the opportunity cost due to the delay of the GE canola adoption in Australia between 2004 and 2014 to be over 300 million US Dollars. Similarly, van Eenennaam et al. (2021) estimated the opportunity costs of regulatory delay for GE livestock to amount to several billions of Dollars. Another example is provided by Qaim (2020) who argued GE techniques would be crucial for ensuring sufficiently high levels of food production that is both more diverse and environmentally friendly.

Because of the enormous impact of GE regulations on human welfare, the environment, and the economy, we wanted to better understand the sense-making stories people use to justify their regulation preferences towards GE. As mentioned earlier, moral beliefs are particularly stable. We therefore focused on the moral foundations that people's sense-making stories are based on, and how those of GE supporters differ from those of GE opponents.

Understanding the Narrative Selection about GE as Motivated by Personal Belief Systems

In accordance with Roos and Reccius (2021), we assumed here that people are attracted to those narratives that concur with their belief system. Similarly, Eliaz and Spiegler (2020) and Eliaz et al. (2022) also based their analyses on the idea that people's reasoning for following a certain narrative is motivated. For example, Eliaz and Spiegler (2020) focused on voting behavior, proposing that people select the narrative that "maximizes anticipatory utility" if it is credible (p. 3768). Similarly, Benabou et al. (2020, p. 36) theorized that motivated reasoning is a decisive factor for the attractiveness of certain moral narratives.

Based on the understandings of Roos and Reccius (2021), Eliaz and Spiegler (2020), and Eliaz et al. (2022), we also assumed that people's narrative selection is motivated. Specifically, following Roos and Reccius (2021) more closely, we assumed that people are drawn to *confirming* narratives, i.e. those that confirm intuitively held mental models and moral sentiments. We relate this assumption to the literature on confirmation bias, which provides evidence about a psychological mechanism in which people tend to interpret phenomena in ways that agree with their previously formed beliefs and expectations (see for example Nickerson, 1998). It is easier to make sense of the world if observed events concur with people's mental models about these events.

For example, someone who is very open towards new technological developments and believes that technological progress generally brings social development and wellbeing, will likely be more attracted to the narrative that GE brings technological progress and social

development. Chances are that this person will support GE. Similarly, someone who is generally distrusting of large corporations and perceptive of potential power abuse, will likely be more drawn to a narrative that points out potential power abuse and manipulation in relation to GE. Chances are that this person will oppose GE.

The idea that people are drawn to such narratives that confirm preexisting beliefs is also supported by the literature on motivated reasoning (see for example Druckman & McGrath, 2019; Epley & Gilovich, 2016; Kunda, 1990) and post hoc rationalization of quick and effortless judgments (see for example Kahneman, 2011; Pennycook & Rand, 2019). For example, Haidt proposed that moral intuitions can guide moral judgment, e.g. about a technology, and related reasoning then serves to justify this intuition (Haidt, 2001; Ditto et al., 2009).

Thus, following the understanding of confirmation bias and motivated reasoning in the literature, we assume that people are drawn to such narratives about GE that confirm what they already tend to believe.

Moreover, as mentioned above, because moral beliefs can be powerful drivers in polarization, we propose that new helpful insights can be generated when identifying the moral foundations of narratives about GE, as well as potential conflicts between them. Particularly, we propose to systematize the moral foundations that underlie narratives about GE according to Haidt's and colleagues' Moral Foundations Theory (Haidt, 2012; Graham, Haidt & Nosek, 2009; Graham, Nosek, Haidt, Iyer et al., 2011; Iyer et al., 2012). In the following, we provide an overview of this theory.

Moral Foundations Theory

For analyses of polarized topics, Moral Foundations Theory (MFT) has been widely applied in moral psychology and related fields. This theory, developed by Jonathan Haidt and his colleagues, aims to describe and explain why individuals and groups sometimes differ in what they perceive to be morally right or wrong (Koleva et al., 2017). MFT is built on extensive empirical findings across different cultures, suggesting that the human moral landscape consists of six moral foundations: Care, Fairness, Loyalty, Authority, Liberty, and Sanctity (Haidt, 2012; Graham, Haidt & Nosek, 2009; Graham, Nosek, Haidt, Iyer et al., 2011; Iyer et al., 2012; Haidt & Joseph, 2004).

Distinguishing a broader range of six moral foundations extends previous accounts of morality limited to concerns of harm and fairness (Iyer et al., 2017; Graham et al., 2011). Thus, MFT extends western philosophical traditions and better reflects empirical findings

across non-western cultures (Graham et al., 2018; Graham et al., 2009). For example, some emphasize the well-being of the group rather than the individual (Haidt, 2008; Haidt, 2007; Graham et al., 2009; Shweder et al., 1987; Shweder et al., 1997). With this broader picture of human morality, MFT has more explanatory power than assuming moral monism (see for example Graham et al., 2018).

MFT has proven robust for a variety of international data sets (Graham et al., 2011). It matches research on virtues in fields such as anthropology, psychology, evolutionary biology and philosophy across cultures (Haidt & Joseph, 2004). Examples can be found in research on collectivism (for example Triandis, 1995), or egalitarianism (Arts & Gelissen, 2001).

Moral Emotions related to Moral Foundations

The six moral foundations provide moral intuitions and emotions about perceived social activities and thus guide judgments about right or wrong (Graham et al., 2018; Iyer et al., 2012; Graham et al., 2009; Haidt, 2001; Haidt & Kesebir, 2010). This means that upon observing a socially relevant behavior or event, people intuitively feel a moral emotion that is related to one or more moral foundations. These emotions signal whether a moral foundation has been violated or catered to. Depending on this signal, a person is then motivated to a respective moral judgment or behavior. For example, a parent of small children could read in a newspaper article that GE foods are suspected to cause cancer. The parent might immediately experience fear and worry about their children's health. Here, the Care foundation would be addressed (see for example Waldhof, 2022a). The intuitive emotion of fear would signal to the parent that this foundation is violated. This might then motivate the parent to judge GE food as “not good” and vote for a ban of GE.

The role of moral emotions for narratives in economics has also been addressed by Roos and Reccius (2021) who argued, similar to MFT, that the feelings people experience in relation to a moral narrative serve as a signal of the evaluation of a set narrative, and consequently motivate action.

Brief Description of the Moral Foundations

According to MFT, the six foundations are activated when observing or experiencing socially relevant issues:

- Care is triggered by concerns of well-being, health and protection. Moral emotions related to Care are compassion, sympathy, or fear.

- Fairness is triggered by concerns of mutual beneficial cooperation, e.g. through following rules which involved parties voluntarily agreed on. Moral emotions related to Fairness are for example pleasure, liking, gratitude, anger, or contempt.
- Loyalty is triggered by concerns of uniformity, solidarity, and a voluntary subordination of each member below group cohesion. Moral emotions related to Loyalty are pride, trust, or distrust.
- Authority motivates voluntary subordination to an individual that is perceived as a legitimate leader. Moral emotions related to Authority are feelings of respect, admiration, or obedience.
- Liberty is concerned with detachment and individualism, and is triggered by strong emotional reactions to limits to personal freedom and autonomy.
- Sanctity motivates distance from pathogens, and motivates self-control with regards to norms, traditions, religions, or cultural norms. The typical moral emotion of Sanctity is disgust.

Moral Foundations Theory to identify conflicting Moral Narratives

MFT provides a systematic template for identifying moral structures and clashes of moral foundations. This is particularly useful for identifying moral sources of conflicts in polarized debates (see for example Enke, 2020; Haidt & Graham, 2007; Amin et al., 2017).

Consequently, applying MFT to narratives about GE promises to yield similarly insightful findings. Here, we built on the concept to qualitatively identify latent moral foundations in text, developed in Waldhof (2022a). This allowed us to determine the latent moral content in narratives about GE. We represent these moral narratives as directed acyclic graphs (DAGs), as explained in the following.

Representing Narratives and their Moral Foundation as Directed Acyclic Graphs

Recall that in the economics literature, narratives are generally described as a relationship between several factors. In most cases, this relationship is assumed to be causal. Spiegler (2016) and Eliaz and Spiegler (2020) proposed to represent this relationship as directed acyclic graphs (DAGs). This proposition is built on work about causal inference by Pearl (2009) and Sloman (2005). We largely adopt this strategy as described in the following.

Spiegler (2016) assumed a decision maker with a von Neumann-Morgenstern utility function. In the attempt to maximize their utility function, the decision maker consults the probabilities of a set of variables, as well as their relationships. However, since the decision

maker is non-rational and has imperfect information, their perceptions about the observations, their probabilities, and their relationships may be flawed. We thus only speak of *perceived* knowledge. Note that Spiegler (2016) thus interpreted these as subjective beliefs, possibly derived from a misspecification of facts. The decision maker relies on these beliefs to, for example, evaluate specific policy options (Eliaz & Spiegler, 2020, p. 3787), e.g. to prefer an adoption or ban of GE.

This subjectivity assumption is in line with Roos and Reccius (2021), who proposed that narratives need to connect to a decision maker's belief system in order to be adopted by them. Importantly, this also means that "[d]ifferent narratives will typically generate different political beliefs because they manipulate correlations between different sets of variables" (Eliaz & Spiegler, 2020, p. 3788).

According to Sloman et al. (2009) and Roos and Reccius (2021), this belief is then normatively evaluated against an ideal causal moral model. In our present study we assume that this ideal moral model consists of the moral foundations. If a decision maker holds a narrative that suggests that a moral foundation is violated, the decision maker will oppose GE. If, on the contrary, a decision maker holds a narrative that suggests that a moral foundation is catered to, the decision maker will support GE.

Spiegler proposed to characterize this perceived set of variables and their relationship as directed acyclic graphs (DAGs). According to Spiegler (2016, p. 2) "[a] directed graph is defined by a set of nodes and a set of directed links between nodes. The graph is acyclic if it does not contain any directed path from a node to itself".

For example, in our study, a DAG *N* can look like this:

N: GE → risks for human health → decision maker opposes GE.

The relationships between these variables are modeled as a Bayesian network (e.g. Spiegler, 2016; Eliaz & Spiegler, 2020; Macauley & Song, 2022).

Eliaz and Spiegler (2020, pp. 3788-3789) assumed that these networks are "simplified causal networks". However, while DAGs based on Bayes' network *can* encompass causal relationships, they do not necessarily do so. More specifically, according to Spiegler, these Bayes' networks are representations of a person's (mis)perception of the *probabilities of dependence* between events, i.e. correlations. However, scholars of narrative economics, e.g. Spiegler (2016), Eliaz and Spiegler (2020), Akerlof and Snower (2016), proposed to interpret narratives as causal relationships. Researchers, such as Eliaz et al. (2022), Andre et al. (2022) or Macaulay and Song (2022) have adopted this interpretation.

In the literature, several reasons are provided for this. Andre et al. (2022, pp. 4-5) argue that understanding narratives as causal accounts "is in line with a broad theoretical literature on causality and causal inference (Ellis and Thysen, 2021; Olea et al., 2021; Pearl, 2009; Spiegler, 2020a,b, 2021)." Both Eliaz and Spiegler (2020) and Spiegler (2016) referred to Pearl (2009) and Sloman (2005), who proposed a causal interpretation. All three, i.e. Spiegler (2016), Eliaz and Spiegler (2020) and Andre et al. (2022) also referred to understandings in the psychology literature (Andre et al. 2022, p. 6): "Similarly, psychologists have argued that causality is at the core of narratives (Pennington and Hastie, 1992; Sloman and Lagnado, 2015; Trabasso and van den Broek, 1985)".

We think that our survey data may best be interpreted according to the differentiated understanding of Roos and Reccius (2021) who proposed that narratives are just an excerpt of a more complex reasoning. While in most cases, the narratives provided by the respondents can be interpreted as causal models, they still provide only a snippet of their thought structure that does not make a potential causality explicit. However, it is safe to say that respondents see a dependence between GE and the justifications they provided for their position. For the purpose of the present work, it is thus useful to represent narratives about GE as DAGs, but unnecessary to go as far as to assume causality, so we rather stick with this more conservative approach.

More specifically, in the present study, we made the identifying assumption that GE attitude is the outcome variable, dependent on moral narratives that the decision maker finds most convincing. That is, we assumed a decision maker has the options to decide whether to support or oppose GE. In order to do so, they consult what they know in relation to GE.
We thus explored the narratives that people use to justify their attitude towards GE. We employed Spiegler's approach to DAGs as probabilistic representations of dependence among a (potentially misspecified) set of options. Specifically, we looked at the frequencies of employed DAGs related to GE across a representative German sample, organized according to their addressed moral foundation.

In this, genetic engineering leads to, or is related to, a specific event. This event is normatively evaluated based on whether an underlying moral foundation is violated or catered to. Based on this evaluation, GE is either supported or opposed. Here, the narrative structure is as follows:

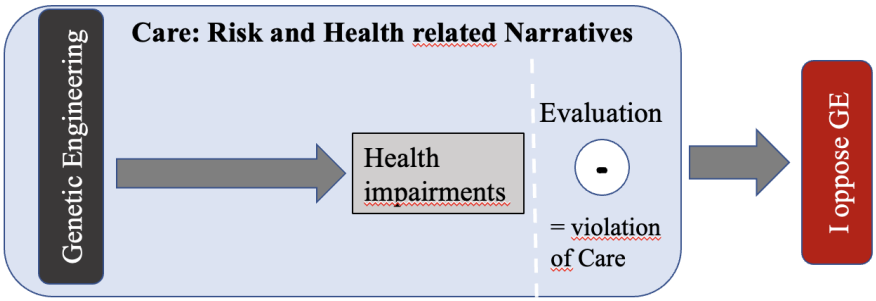
N: GE → consequence/related event → normative evaluation → resulting GE attitude.

For example, a decision maker may hold the belief that the consumption of GE food can lead to health impairments, e.g. cancer. Health concerns address the moral foundation

Care. Thus, the narrative gets evaluated against the Care foundation. Because health impairments harm life and health of an individual, they constitute a violation of the moral foundation Care. Thus, the result of the evaluation is negative and the decision maker opts to oppose GE. Adapted from Andre et al. (2022), Macaulay and Song (2022), and Eliaz and Spiegler (2020), Figure 1 illustrates our representation of this health narrative about GE.

Figure 1

Representation of GE Narratives as DAG, and Moral Evaluation



Note. The narrative that GE leads to health impairments is evaluated against the moral foundation Care. It is found to violate Care and thus evaluated as negative. As a consequence, the decision maker opposes GE.

The Study

Sample

We conducted an online survey in Germany in August and September 2019. The online panel was provided by Gapfish (https://gapfish.com/). This survey was representative for the population in Germany according to age, gender, income, level of education, and region (former east Germany, former west Germany, i.e., *alte* and *neue Bundesländer*, and Berlin). After excluding those participants who did not provide informed consent and stated to be younger than 18, or did not pass the attention check, 619 were included in the analysis. Of those, 49.8% (308) respondents were female and 50.2% (311) were male. The mean age was 44 years, SD = 14. 20% (124) stated an age between 18 and 29, 30.5% (189) stated an age between 30 and 45, 45.7% (283) stated an age between 46 and 65, and 3.7% (23) stated to be between 66 and 69 years old. Of included participants, 14.7% (91) resided in the former "eastern" region (including Berlin), 80,5% (498) resided in the former "western" region, and 4.8% (30) resided in Berlin.

31% stated to earn less than 25,000 € per year, 39.9% stated to earn between 25,000 € and 49,999 €, 17.8% stated to earn between 50,000 € and 69,999€ per year, 8.4% stated to earn between 70,000 € and 99,999€, and 2.9% stated to earn 100,000 € and more per year. Regarding the latest level of education, 73.3% selected to hold some kind of high school diploma, according to the German schooling system (29.7% "Hauptschulabschluss", 33.9% "Realschulabschluss", 9.7% "Allgemeine Hochschulreife"). 15.7% selected to hold some kind of university degree (University or University of Applied Sciences), 1.8% of respondents selected to hold no degree or other.

Table 1 reports on participants' free text responses to the prompt asking about the type of education they received. The answers were coded into groups by a research assistant.

Table 1

Type of Education – Coded Free Text Responses

Group	Examples (translated from German)	N
Business	Businessman, Office Clerk, Industrial Clerk	56
IT, Computer, Informatics & Electrical Engineering	Audio engineering, Electronics, Computer Science, Precision Mechanics, Information Processing	49
Media, Publishing, Film	Book Trade, (Digital) Media, Literature	19
Medicine, Nursing	Nursing, Dentistry, Social Work	47
Chemistry, Nutrition	Pharmacy, Chemical Technical Assistant, Bakery, Cook	26
Logistics, Transport	Bus/Truck Driver	23
Metal, Technology	Industry, Road Builder, Mining	36
Gastronomy/Hotel	Hotel Manager, Management	16
Craft	Carpenter, Locksmith, Molder, Office Machine Mechanic	66
Art, Architecture, Construction	Road Construction, Building Trade	15
Services	Florist, Hairdresser, Home Economics, Cosmetics	19
Social pedagogy	Psychology, Social work	8
Education	Teacher, Educator	20
Languages	Literature translation	3
Sports	Sports	2
Textile & Fashion	Clothing, Dressmaker, Leather goods	8
Security	Security Service	2
Administration, Public Service	Accountant, Tax Clerk, Police Enforcement Officer	54
Economy, Finance	Economics, Business Mathematics	45
Agriculture, Livestock	Animal Breeding, Animal Keeper, Horticulture	10
Trade, Sales	Retail, Wholesale	29
Not Interpretable, Nothing	Paderborn, n.A., Nothing	66
Total		**619**

Survey Flow

After providing informed consent, participants were asked for demographic information (gender, age, region, income, degree, type of education) based on the demographic standard items according to Lenzner et al. (2019). Subsequently, participants were asked to state whether they were in favor or against genetic engineering of plants for

human consumption (called Green Genetic Engineering) from a binary choice item (adapted from Inbar & Waldhof, 2022). This was followed by four seven-point Likert scale items asking how much participants are interested in GE, how important GE is to them, how much GE means to them, and how relevant this topic is for them for the next federal selection (adapted from Krosnick et al., 1993).

Then, an open text box question asked respondents what they imagine in front of their inner eye when thinking about GE (own measure). Participants could state up to five such subjective images and were asked if they saw each as positive or negative. This was followed by a seven-point Likert scale recording how emotional GE as a topic was for participants (adapted from Krosnick et al., 1993). Subsequently, in randomized order, participants were asked to select from a choice of eight pictures depicting emotions, which emotion they feel when thinking about GE (Matsumoto & Ekman, 1988). This question randomly alternated in order with another question asking, with seven-point Likert scales, how much they felt those emotions when thinking about GE (adapted from Barrett, 2004). Then, respondents were asked to indicate their grade of agreement with ten Likert-scale (seven-point) statements about regulatory preferences regarding GE in Germany (own measures). These statements addressed: strictness of regulation, field research, laboratory research, research at universities, research for commercial gains, import, export, free consumer choice, and labeling.

Following, participants were asked to write down the causal accounts (narratives) that led them to their previously stated position about GE. Specifically, participants were provided three free-text boxes, in which they could state their main reasons, organized according to personal importance.

Subsequently, participants were provided with the twenty most frequent reasons provided by official organizations in the public GE debate in Germany, based on Waldhof (2022b). Specifically, participants who stated to be against GE were asked to select the three most compelling reasons for their position from a pool of ten opposing reasons. Accordingly, participants who stated to be in favor of GE were asked to select the three most compelling supporting reasons for their position from a pool of ten. At the end of the survey, participants completed an attention check (own measure) and could provide voluntary feedback in a comment box.

The survey material (in German) as well as a Codebook detailing the included variables are available at https://doi.org/10.7910/DVN/FEC7OL.

Analyses and Findings

Transparency, Openness and Ethical Standards

Data and materials are available at https://doi.org/10.7910/DVN/FEC7OL[1]. Specifically, the file includes the survey materials (in German), participants' descriptions of the narratives and subjective images, the codings of the narratives according to moral foundations, all data for the regression, a codebook explaining all variables, the data for the correspondence analyses, and the code to reproduce the analyses. The questionnaire and methodology for this study was approved by the Ethics committee of the Leibniz Institute of Agricultural Development in Transition Economies (Certificate Reference Number: 03/2019).

Narratives about GE

Deductive Coding Procedure

To collect the narratives that participants used to reason about their attitudes towards GE, we included the following prompt in the survey:

> At the beginning of the survey, you indicated that you tend to have a [supporters: positive] [opponents: negative] view of the application of genetic engineering to crops overall. Can you briefly tell us your most important reasons for this? Please rank your reasons. If you have fewer than three reasons, simply leave the remaining fields blank.

Participants gave their answers in up to three free text boxes. Sometimes, respondents provided more than one narrative in a single text box. In these cases, entries were split and listed separately, which is why we have up to four narrative entries for some participants.

The coding procedure of the narratives was based on the methodological principles of content analysis according to Philipp Mayring (2015). This coding procedure is extensively described in the Appendix of Waldhof (2022b).

A research assistant deductively coded participants' responses according to the code systems developed in Waldhof (2022b). If a response contained a new narrative that was not addressed in the arguments of the official debate, i.e. not yet included in Waldhof (2022b), the research assistant paraphrased this as an additional narrative. All results of the deductive coding were checked by the first author and amended were necessary.

Based on the seminal literature on Moral Foundations Theory (e.g. Haidt, 2012; Graham et al., 2011; Iyer et al., 2012), Waldhof (2022a) developed a structural approach to identify latent moral foundations in text. This approach identified a unique contribution to a

[1] Waldhof, G. (2023). Replication Data for: "Understanding Moral Narratives as Drivers of Polarization about Genetically Engineered Crops". *Harvard Dataverse, V1*. https://doi.org/10.7910/DVN/FEC7OL

group's structure for each moral foundation. This unique contribution makes the foundations more distinguishable from one another in text. Following this approach, the first author allocated the narratives to the moral foundations. Broadly, the following contents determined the allocation:

- Care: general risks and benefits of GE, health of humans or animals,
- Fairness: behavior of involved actors in relation to rules, laws, and regulations, such as corruption, cheating, law-/rule-breaking,
- Loyalty: concerns of trust, or benefits and disadvantages for society as a whole, i.e, do actors exploit or contribute to social welfare,
- Authority: if narratives recited expert opinions as perceived legitimate authority,
- Liberty: concerns of civil liberties of affected people,
- Sanctity: concerns about nature, contamination, environment protection, biodiversity, or sustainability.

For more information on the applied procedure, see for example Mayring (2015), Waldhof (2022a), and Waldhof (2022b) and its Appendix.

General Results

Of the respondents included in the analysis, 33% (205/619) stated to be in favor of GE, 67% (414/619) stated to be against GE.

In the open text boxes, participants provided a total of 1226 entries. Of those, 1129 could be interpreted as narratives about GE and were coded according to topic and addressed moral foundation. The remainder were entries such as *don´t know*, *don´t care,* or *I cannot provide a reasoning.*

Of all 1129 narrative responses, 780 were provided by GE opponents, and 349 by GE supporters. The following section reports on these entered narratives and their underlying moral foundation.

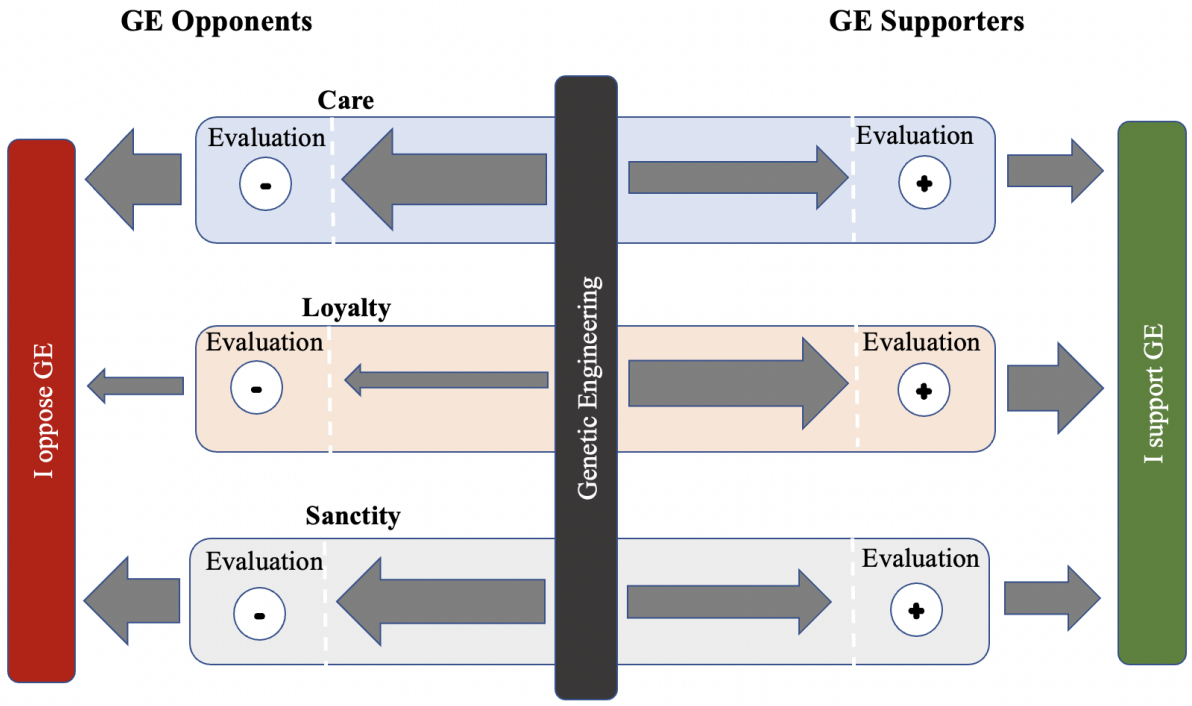
Moral Foundations addressed in Narratives

Of all 1129 narrative entries, Care is the most prominent moral foundation, being addressed in 40% (450/1129) of the narratives. Sanctity was addressed in 36% (406/1129) of all narratives. Loyalty was addressed in 23% (259/1129) of all narratives. The other three moral foundations according to MFT, i.e. Fairness, Authority, and Liberty, were not relevant to respondents. They were addressed in less than 1% of all narratives (Fairness: five times, Authority: never, Liberty: nine times).

While opponents focused most on Care – this foundation was addressed in 45% (351/780) of their narratives –, supporters focused most on Loyalty – in 41% (142/349) of their narratives. Sanctity was much more prominent among opponents, being addressed in 39% (306/780) of all their narratives. Contrary to that, Sanctity was addressed 29% (100/349) of the time by supporters. Care was addressed in 28% (99/349) of supporters' narratives; and Loyalty in 15% (117/780) of opponents' narratives. Figure 2 illustrates the relative frequencies of moral foundations in the narratives as DAGs.

Figure 2

Relative Frequencies of Moral Foundations addressed in Narratives about GE, represented as DAGs



Note. Arrow-thickness represents the relative frequencies of moral foundations addressed in narratives. Narratives get evaluated against the addressed moral foundation. If a narrative violates a moral foundation, the result is a negative evaluation and a rejection of GE. If a narrative caters to a moral foundation, the result is a positive evaluation and support of GE. The foundations Fairness, Liberty, and Authority (according to MFT) are not shown because they were addressed in less than one percent of the narratives.

Topics addressed in Narratives

While opponents and supporters mentioned similar broad topics, such as health, environment protection, or necessity, the resulting causal evaluations are quite different. For example, both supporters and opponents addressed health as a factor in their narrative leading to their GE attitude. However, while opponents stated that GE leads to health impairments

and they thus oppose the technology, supporters stated that GE leads to health benefits and they thus support GE. Table 2 and Table 3 provide an overview of the narratives and their frequencies, organized according to the addressed moral foundation. Both tables also include examples translated into English, as well as their German original in parentheses. Grammatical errors and misspellings are left as entered into the survey by respondents.

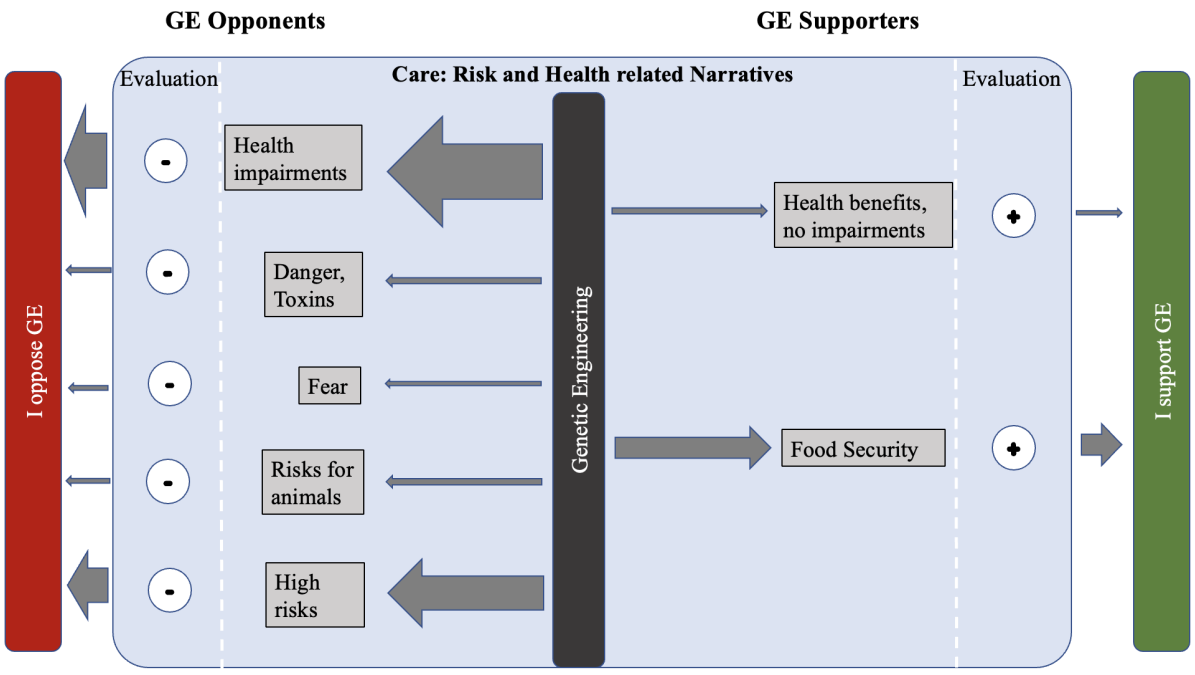
In the following, narratives are reported if they have been addressed at least 10 times. Figures 3–5 illustrate these narratives as directed acyclic graphs (DAGs), clustered according to the addressed moral foundations and topics.

Within the moral foundation Care, people stated risk and health-related narratives. For opponents, health impairments were the most frequently stated reason to reject GE overall (23%; 179/780), for example “unhealthy”, or “cancer risk”. The second most frequent reason to reject GE was that GE brings high risks as a technology (14%; 111/780), for example “incalculable risks”, “unpredictable intervention”. Also, within the Care foundation, opponents mentioned risks for animals (3%; 21/780), e.g. “cruelty to animals”, general danger (3%; 20/780), e.g. “it is dangerous”, and fear (2%; 13/780), e.g. “fear” as reasons for their opposition.

On the supporters’ side, respondents stated health benefits as a reason for their GE support (6%; 20/349), e.g. “healthier crops”, “healthy”. Even more frequently, they stated that GE supports food security (20%; 68/349), e.g. “sufficient staple food”, “end famine”.

Figure 3

Narratives mentioned within the Care foundation, represented as DAGs



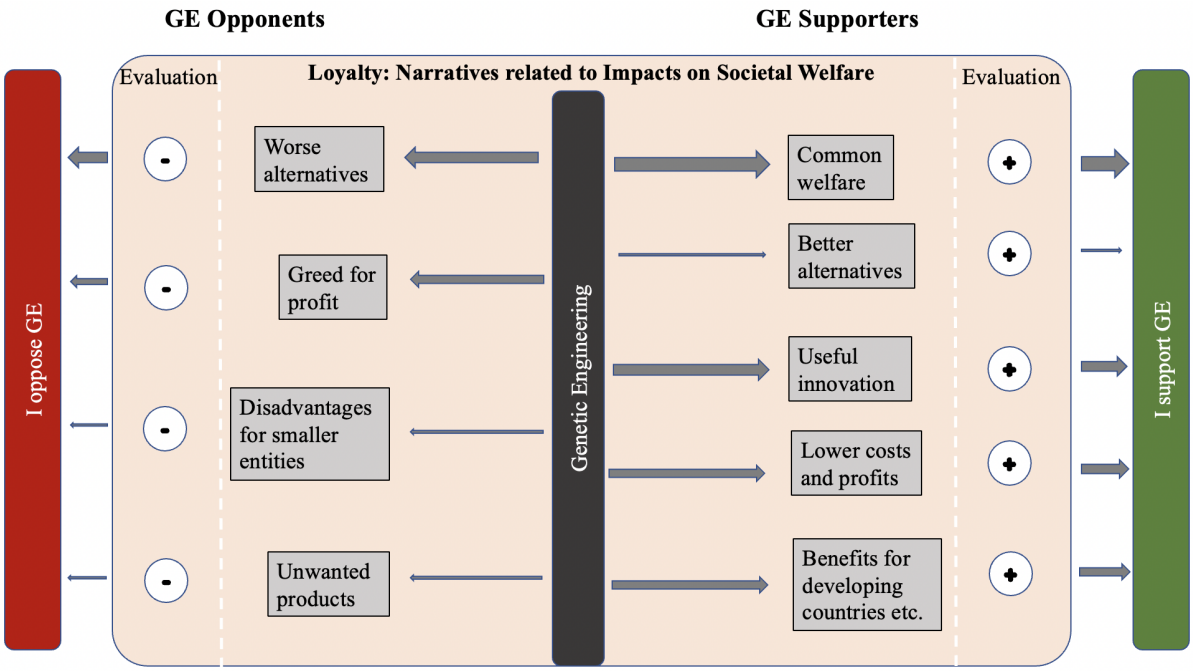
Note. Arrow-thickness represents the relative frequencies across *all* narrative-mentions in the survey responses. This usually results in thinner arrows for supporters because the number of self-proclaimed GE supporters is smaller than the number of self-proclaimed GE opponents.

Within the moral foundation Loyalty, participants addressed impacts on general societal welfare. Among supporters, the narrative of general common welfare through useful traits of GE was very common (13%, 44/349), e.g. “quality”, “effectiveness”. Supporters often mentioned the narrative that GE brings benefits for developing countries and farmers (7%, 26/349), e.g. “more yield for farmers”. Also, mentioning lower costs and profits was very common (7%; 26/349), e.g. “profitable”. Also, supporters often mentioned that they approve of GE because they promote research and innovation (10%; 35/349), e.g. “important for future”, “technological progress”, and because they see GE as the better alternative (3%; 10/349), e.g. “is already used today in an untargeted way by ‘crossbreeding’, genetic engineering is much more precise in this respect”.

Contrary to that, opponents stated within the Loyalty foundation that they oppose GE because they were unnecessary (5%; 39/780), e.g. “unnecessary”, “nonsensical”, or not wanted (2%; 16/780), e.g. “I would not buy”. Also, opponents stated that GE were only used for commercial gains (4%; 28/780), e.g. “profiteering”, “money-making at the expense of health” and brought disadvantages for smaller entities (such as small farmers) (1%; 10/780), e.g. “the farmers have more work”.

Figure 4

Narratives mentioned within the Loyalty foundation, represented as DAGs



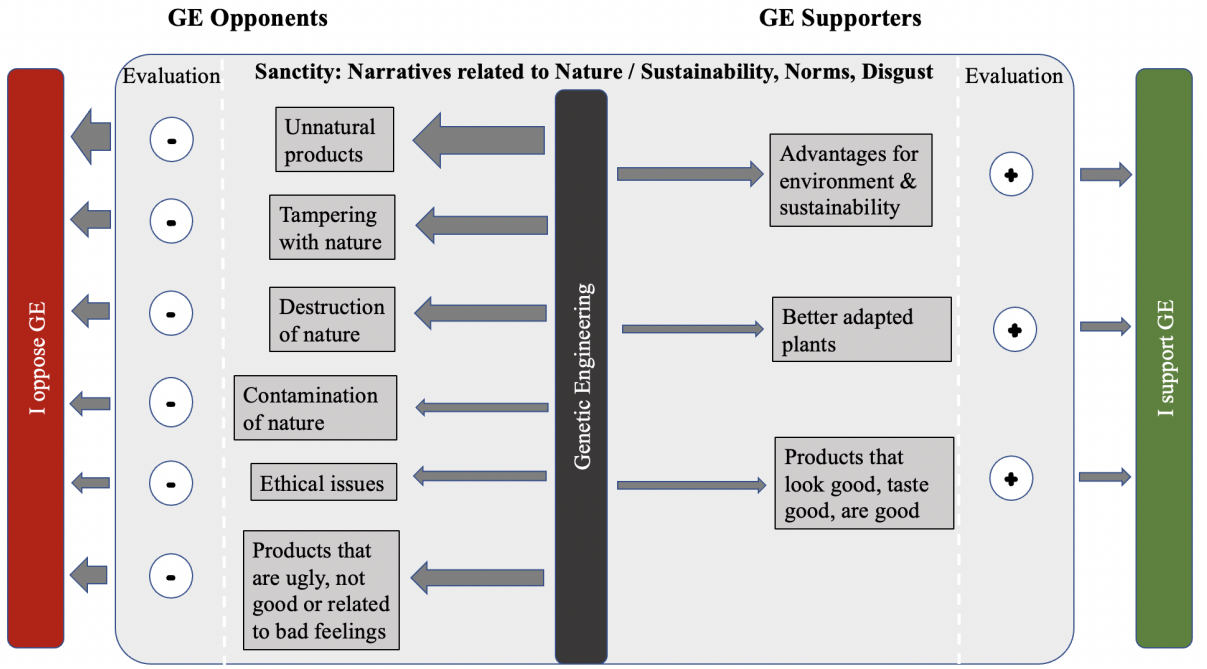
Note. Arrow-thickness represents the relative frequencies across *all* narrative-mentions in the survey responses. This usually results in thinner arrows for supporters because the number of self-proclaimed GE supporters is smaller than the number of self-proclaimed GE opponents.

Within the moral foundation Sanctity, issues related to nature and sustainability were addressed. To Sanctity also belong narratives related to norms, disgust or a general good or bad feeling. Opponents frequently stated here that GE are unnatural (11%; 89/780), e.g. “unnatural”, “against nature”, and a tampering with nature (7%; 57/780), e.g. “intrusion in nature”. Opponents also stated the risk of destroying nature through GE (7%; 52/780), e.g. “unpredictable consequences for nature”, “harms the environment” or the contamination of nature (4%; 28/780), e.g. “contamination of the soil”, “genetic engineering leads to more poison on fields”. Some mentioned ethical issues with GE (3%; 27/780), e.g. “unethical”, “plants are not toys!”. Other narratives provided by opponents were that GE are disgusting, ugly, not good, or are related to bad feelings (7%; 52/780). Examples are “have a bad feeling”, “disgusting”, “ugly”, and “gene manipulation is generally not good”.

Supporters quite often stated that GE does not lead to risks but advantages for environment, sustainability or biodiversity (12%; 43/349), e.g. “preservation of nature by planting new trees”, “greater biodiversity”. Supporters also mentioned the narrative that GE are better adapted to the environment than conventional breeds (8%; 28/349), e.g. “make drought land flourish again”. Some mentioned that they support GE because they look, taste, or are good (7%; 24/349), e.g. “looks better”, “more flavorful fruits”, “is good”.

Figure 5

Narratives mentioned within the Sanctity foundation, represented as DAGs



Note. Arrow-thickness represents the relative frequencies across *all* narrative-mentions in the survey responses. This usually results in thinner arrows for supporters because the number of self-proclaimed GE supporters is smaller than the number of self-proclaimed GE opponents.

Table 2

Coded narratives of GE opponents with examples and frequencies, organized according to addressed moral foundation

MFT	Paraphrased Narratives Opponents (n = 780)	Examples *(with German original)*	N
Care 45% (351)	Health impairments	"Unhealthy", "cancer risk" *("Ungesund", "Krebsrisiko")*	179
	High-risk technology	"Incalculable risks", "unpredictable intervention" *("Nicht kalkulierbare Risiken", "Unabsehbarer Eingriff")*	111
	Risks & disadvantages for animals	"Cruelty to animals" *("Tierquälerei")*	21
	Danger, toxic (for humans)	"It is dangerous" *("Es ist gefährlich")*	20
	Fear	"Fear" *("Angst")*	13
	Gaps in regulation are a threat to humans	"Lack of control mechanisms" *("Kontrollmechanismen fehlen")*	7
Fairness 1% (5)	Involved actors break rules of competition (e.g. corruption)	"Unseriousness", "the controls do not work anyway because the food lobby works against it to gain more profit" *("Unseriösität", "die kontrollen,funktionieren,doch,eh nicht,weil die lebensmittel lobby dagegen arbeitet,um mehr profit zu erlangen")*	5
Loyalty 15% (117)	GE are not necessary, there are better alternatives	"Unnecessary", "nonsensical" *("Unnötig", "Unsinnig")*	39
	GE are a symptom of greed for profit, only benefit large corporations	"Profiteering", "money-making at the expense of health" *("Profitgier", "Geldmacherei auf kosten von Gesundheit")*	28
	Consumers don't want GE	"I would not buy" *("Würde ich nicht kaufen")*	16
	Disadvantages for smaller entities	"The farmers have more work" *("Die Bauer haben mehr Arbeit")*	10
	Insufficient knowledge, test on GE	"Not yet properly researched" *("Noch nicht richtig erforscht")*	7
	Nobody informs the public	"Ignorance of customers", "the end user is not informed enough" *" (Unwissenheit von Kunden", "Der Endverbraucher wird nicht genug informiert")*	7
	High costs without benefits	"Too expensive", "high costs" *("Zu Teuer", "Höhe Kosten")*	3
	Irresponsible treatment of common goods, broken promises	"Economy and politics are not able to act responsibly", "no promises fulfilled" *("Wirtschaft und Politik sind nicht in der Lage verantwortlich zu handelm", "erfüllt keine Versprechen")*	5
	GE don't contribute to societal welfare	"Unsocial" *("unsozial")*	2
Authority 0% (0)			0
Liberty 0% (1)	Oppression of civil liberties	"Power of corporations" *("Macht der Konzerne")*	1
Sanctity	Unnatural	"Unnatural", "against nature" *("Unnatürlich", "wider der Natur")*	89

39% (306)	Tampering with nature	"Intrusion in nature", "intrusion in the biosphere" *("Eingriff in die Natur", "eingriff in die biosphäre")*	57
	Risk of destroying nature, threat to biodiversity, sustainability, GE cause resistancies	"Unpredictable consequences for nature", "harms the environment", "resistant pests" *("Unberechenbare Folgen für Natur", "Schadet der Umwelt", "resistente Schädlinge")*	52
	Ethical issues, Interference in god´s creation	"Unethical", "plants are not toys!", "playing God" *("Unethisch", "Pflanzen sind kein Spielzeug!", "Gott spielen")*	27
	GE are not good, you don´t do that	"Gene manipulation is generally not good" *("Gen Manipulation finde ich im allgemeinen nicht gut")*	17
	GE contaminate nature, risk of unintended mutations, Chemistry/ Pesticides/ toxics in nature	"Contamination of the soil", "chemistry", "GE leads to more poison on fields" *("Verseuchung vom Boden", "Chemie", "Gentechnik führt zu mehr Gift auf Feldern")*	28
	Bad feeling	"Bad feelings", "have a bad feeling" *("Schlechte Gefühle", "habe ein ungutes Gefühle")*	14
	Ugly, taste bad	"Ugly", "taste bad" *("Hässlich", "schmeckt nicht")*	11
	Disgusting	"Disgust", "disgusting" *("Ekel, "Ekelhaft")*	10
	Climate	"Climate" *("Klima")*	1

Table 3

Coded narratives of GE supporters with examples and frequencies, organized according to addressed moral foundations

MFT	**Paraphrased Narratives Supporters (n = 349)**	**Examples *(with German original)***	**N**
Care 28% (99)	GE contribute to food security	"Sufficient staple food", "end famine" *("Ausreichend Grundnahrungsmittel", "Hungersnot beenden")*	68
	Health benefits & no evidence for health impairments	"Healthier crops", "healthy", "healthier for people" *("Gesündere Pflanzen", gesund", "Gesünder für Menschen")*	20
	Not a high risk technology, no problems	"Controllable", "more accurate calculations and control over quality", "don't see any problems" *("Kontrollierbar", "Genauere Kalkulationen und Kontrolle über die Qualität", "sehe keine Probleme")*	6
	No higher risks for animals; advantages for animals	"Feed for animals" *("Futter für Tiere")*	5
Fairness 0% (0)			0

Loyalty 41% (142)	GE contribute to common welfare (successful endeavor), e.g. useful traits, promising potential	"Quality", "effectiveness", "new better plants can always be developed" *("Qualität", "Effektivität", "Es können immer neue bessere Pflanzen entwickelt werden")*	44
	GE yield lower costs and profits	"Profitable", "more yields possible" *("Profitabel", "mehr Erträge möglich")*	26
	GE research (and patents) promotes useful innovation	"Progress", "better medicine", "important for future", "Technological progress" *("Fortschritt", "bessere Medizin", "Wichtig für Zukunft", "technologischer Fortschritt")*	35
	Benefits for developing countries, small farmers, farmers, consumers, companies	"More yield for farmers" *("Mehr Ertrag für Bauerns")*	26
	GE is necessary and the better alternative	"is already used today in an untargeted way by 'crossbreeding', genetic engineering is much more precise in this respect" *("wird durch 'Kreuzen' heute schon ungezielt angewendet, Gentechnik ist da viel genauer")*	10
	World peace	"World peace" *("Weltfrieden")*	1
Authority 0% (0)			0
Liberty 2% (8)	GE do not interfere with freedom of choice but enable more freedom for farmers	"People who need it", "free market economy" *("Menschen die das benötigen", "Freie Marktwirtschaft")*	8
Sanctity 29% (100)	There is no higher environmental risk of GE compared to conventional breeding, but there are advantages (e.g. less pesticides)	"Preservation of nature by planting new trees", "development of healthy plants", "more environmentally friendly", "less use of pesticides" *("Erhaltung der Natur durch Pflanzung neuer Bäume", "Entwicklung gesunder Pflanzen", "umwelt freundlicher", "Weniger Einsatz von Pestiziden")*	26
	Is good, perfection, my opinion	"Is good", "perfection", "my opinion" *("Ist gut", "Perfektion", "Meine Meinung")*	15
	GE do not threat biodiversity/ sustainability, but support it	"Greater biodiversity", "extinction of plant species is prevented", "sustainable" *("größere Artenvielfalt", "Aussterben der Pflanzenarten wird verhindert", "nachhaltig")*	17
	GE are (better) adapted to the environment than conventional breeds	"More independent of weather", "can thrive in drought food", "make drought land flourish again" *("Vom Wetter unabhängiger", "Kann in dürre Lebensmittel gedeihen lassen", "Dürre Land wieder aufblühen lassen")*	28
	(healthy) appearance, taste, natural	"More flavorful fruits", "healthy appearance", "looks better" *("Geschmackvollere Früchte", "gesundes Aussehen", " Sieht besser aus")*	9
	Adoption to climate change	"Good for adapting to climate change" *("gut geeignet", "um sich an den Klimawandel anzupassen")*	5

Discussion

Our general attitude measure confirmed previous findings of a widespread GE opposition in Germany (e.g. Inbar & Waldhof, 2022; Freitag, 2013; Zwick, 1998; Kennedy & Thigpen, 2020; BfR, 2022). Moreover, as could be expected, the narratives of GE opponents contained negative consequences of GE, while the narratives of GE supporters contained positive consequences of GE. The fact that the majority of respondents seemed so attentive to negative narratives about GE accords with research on negativity bias that argues that negative information is much more impactful for human sense-making (see for example Vaish et al., 2008; Soroka et al., 2019; Pinker, 2018).

In general, the stated narratives most frequently addressed the Care foundation. This is mainly due to the heavy focus on general risks and health risks by opponents. A potential explanation for this provides an own unpublished pilot study, in which we found that GE opponents show significantly more risk aversion than do GE supporters. The finding is also in line with previous research on GE attitude that emphasized risk and benefit perceptions as a factor of GE attitude (see for example Yue et al., 2015; Siegrist, 1999; Lee et al., 2018). At the same time, while Care was the most frequently addressed foundation among opponents, it was only the third most frequent foundation among supporters.

The moral foundation Sanctity is highly relevant for opponents, being addressed second most frequently. As suggested by Scott et al. (2016), concerns of nature and naturalness are particularly important to GE opponents – and indeed, according to our analysis, these constitute a decisive part of opposing narratives within the Sanctity foundation. In particular, many opponents stated that they find GE to be unnatural, which is in line with findings by Hoogendoorn et al. (2021). Moreover, Scott et al. (2018) theorize that GE are perceived as unnatural because they are made by humans, i.e. through human interference. Indeed, many opposing narratives addressed a potential *intrusion in nature* and related ethical issues. These findings confirm work by Rozin (2005) who proposed that not the characteristics of a product but its process of creation is relevant for people's evaluation of whether it is considered (un)natural.

This also means that people who reject GE because they are made by humans will not be open to potential benefits of the technology because they reject their development per se.

Moreover, in line with research by Scott et al. (2016) who found that GE opposition is related to disgust sensitivity, opponents in our study also referred to GE as "disgusting" or "ugly".

At the same time, within the Sanctity foundation, naturalness was not among the topics addressed in supporting narratives. Rather, supporters often stated potential benefits of GE for the environment, or that GE would be better adapted to the environment. Potentially, naturalness is not a relevant category for evaluation among supporters.

Loyalty was the most frequently addressed foundation among supporters and third most frequent among opponents. In this foundation, narratives addressed the question of whether the technology is generally useful for society. Interestingly, previous research on GE attitude suggested that trust in related actors and institutions is a decisive factor (Siegrist, 1999; Siegrist, 2000; Kajale et al., 2015; Kimenju et al., 2008; Yue et al., 2015). This is also how the official public debate in Germany is conducted (see Waldhof, 2022b), i.e. official representatives use many ad hominem arguments, appear to discredit their opponents and compete for trust by the public. Many examples by official representatives refer to company greed, or exploitation by "big players" or a general market skepticism.

However, this is not reflected in the narratives that respondents stated, which only rarely indicated trust as being relevant for their reasoning. Similarly, topics such as market skepticism or greed and exploitation by large corporations were irrelevant in the narratives that respondents mentioned.

Furthermore, it is striking that narratives addressing the Loyalty foundation were so predominant among supporters, taking up 41% of all narratives mentioned. These mainly addressed general welfare as well as benefits for developing countries. Even within the Care foundation, supporters most often stated the narrative that GE helps to combat famine – a cause of which, as residents in Germany, they are likely not affected by directly.

Taking the narratives together, it seems as though respondents agreed that they would not see personal benefits through the use of GE in plants. If they saw advantages, then these were perceived to benefit others, seemingly those in poorer countries. Even such supporting narratives that stated scientific progress, beneficial traits, and innovation, were quite general and without a hint to potential beneficiaries. These narratives may seem to signal a general optimism and technology openness rather than being directly related to GE.

Interestingly, some narratives referred to causal relationships for which a potential link to GE as a technology is actually not direct, or may even be reversed. Take the example of potential intoxications of the soil due to pesticides. Some media outlets and NGOs reported that farmers had overused pesticides on fields where pesticide-resistant GE plants are grown (see for example Greenpeace, 2011). In this example, such an overuse would be caused by the behavior of farmers and not by the technology directly. Moreover, agricultural economists

and natural scientists report that GE plants can lead to a *reduction* of pesticide use (Klümper & Qaim, 2014). This would even reverse the relationship between GE and pesticide use.

Another example is a potential abuse of GE products by large corporations to increase their market power at the expense of the common good. Here also, the technology is not bad per se, but is used in a way that is detrimental to society.

Moreover, respondents sometimes did not state causes or reasons but more so personal impressions or emotions. Examples are mentions that GE would be "ugly", "disgusting", "perfection", "looks better" or evoke "bad feelings". Such entries can be seen as indicators that GE attitudes are at least partly based on emotional intuitions and gut feelings.

Correspondence Analyses

Recall that respondents were provided three free text boxes to enter the narratives that led them to their GE attitude. These were coded according to content and moral foundation. In cases in which respondents provided more than one narrative in a text box, entries were split and listed separately as a fourth response. In the present section, we report on co-occurring moral foundations. Therefore, we look at mentioned narratives, as well as responses such as "Don´t know", which were labeled as "nA". For this purpose, we provide the results of correspondence analyses with contingency tables and chi-square tests. These analyses were conducted using the R-package *gmodels* (Warnes et al., 2022).

All except two participants (617/619) provided an entry for the first narrative. A second response was provided by 379/619 participants, a third by 218/619 participants. 12 participants provided a fourth response. Because so few participants provided a fourth narrative, we exclude this from the analysis. To not lose statistical power while still making use of all the entries provided, we deal with this greatly varying number of entries by running separate chi-square tests: For the first and second entry, the differences in mentions are highly significant ($p = 0.0000$). For the first and third entry, the differences are also highly significant ($p = 0.0000$). For the second and third entry, differences were not significant ($p = 0.4394$). Thus, Table 4 and Table 5 report on the descriptive results of the co-occurrences of the first and second entry, and of the first and third entry.

Table 4

Contingency table of the first and second narrative-mentions

	2nd Narrative						Row
1st Narrative	Care	Fairness	Liberty	Loyalty	Sanctity	nA	Total
Care	**65**	5	2	**39**	**57**	2	170

Fairness	1	1	0	1	0	0	3
Liberty	0	1	1	0	0	0	2
Loyalty	19	6	1	31	23	3	83
Sanctity	**49**	4	0	24	**35**	4	116
nA.	0	0	0	1	1	3	5
Column Total	134	17	4	96	116	12	379

Table 5

Contingency table of the first and third narrative-mentions

1st Narrative	3rd Narrative						Row Total
	Care	Fairness	Liberty	Loyalty	Sanctity	nA	
Care	**28**	3	1	20	**39**	2	93
Fairness	1	0	0	0	0	0	1
Liberty	0	0	1	0	0	0	1
Loyalty	13	3	3	17	15	1	52
Sanctity	**26**	0	0	15	**26**	0	67
nA.	0	0	0	0	3	1	4
Column Total	68	6	5	52	83	4	218

In both tables, it stands out that Care and Sanctity narratives most frequently co-occurred. Moreover, Care and Loyalty are among the most frequent co-occurrences between the first and second narrative (Table 4).

That most co-occurrences laid among the foundations Care, Loyalty, and Sanctity can be explained by the fact that these are addressed most frequently in general. It also seems plausible that respondents addressed the same foundation in each of their narrative mentions because they may find one topic particularly important, e.g. health or environment protection. However, the co-occurrence between Care and Sanctity is striking. Between the first and second narrative-mentions, Care and Sanctity made up the second and third most frequent contingency; and between the first and third narrative-mentions, they made up the most frequent contingency.

A potential explanation for this is that respondents saw the same underlying cause for their mentioned narratives. For example, if they perceive GE as not normal or unnatural, it can be this deviation from the known, that makes the technology risky, dangerous, unhealthy (Care) as well as detrimental for the environment (Sanctity).

Comparison of Spontaneous Narrative Mentions and Selections

In the survey, one prompt asked participants to select and rank the three most convincing narratives for their own position from a pool of ten for each, supporters and

opponents. These provided narratives were based on the content analysis of arguments used by official representatives in the German GE debate in Waldhof (2022b).

In the present study, opponents most frequently ranked "GE plants have disadvantages for human health." (number of rankings: 236/1242). The second highest rank got "GE plants contaminate nature" (number of rankings: 193/1242). The third highest rank got the narrative "pesticides intoxicate nature" (number of rankings: 186/1242). Ranked the least was "GE for plants did not live up to its promises." (number of rankings: 28/1242).

These findings are in line with the spontaneous mentions of narratives reported above. Health concerns (Care) were most prominent in the spontaneous mentions as well, followed by concerns related to the environment (Sanctity). Interestingly, while a worry about the motives of large corporations did play a smaller role in the spontaneous mentions reported above (29/831), this type of narrative was selected much more frequently when provided to participants (174/1242, Rank 4). One potential explanation for this is that the motives of large corporations are not among the most important reasons for people's GE attitude, but they find them to be particularly convincing, and thus use this narrative to support their position towards GE without necessarily seeing it among the most important aspects.

Supporters most frequently ranked "GE for plants is necessary because of the current grand challenges (hunger, climate change). And it is our best alternative." (116/615). Ranked the second highest was "GE has many advantages for developing countries, small farmers, companies, and consumers (e.g. cost reduction, yield)." (106/615). Ranked the third highest was "GE for crops is very beneficial for society because of beneficial traits (e.g. vitamin-enriched, drought-resistant)." (99/615). Ranked the least by supporters was "Over years, NGOs have used their campaigns to spread false, frightening myths about GE for crops and thus manipulated the public with fake news." (31/615).

These findings align with the spontaneous mentions made by supporters, which also mainly addressed concerns of health and hunger (Care), and even more so benefits for general welfare and developing countries (Loyalty).

Survey comments

Roughly half of the respondents filled the voluntary comment section at the end of the survey (44%; 275/619). A research assistant coded these inductively into topics and groups (according to the procedure proposed by Mayring, 2015). Of those comments, 89 (32%) did not contain actual feedback (e.g. "no"). 29 (11%) complimented on the survey, e.g. through wishing for more surveys like this or stating that they liked the survey. Interestingly, all other

comments (58%; 159/275) were further explanations about how respondents saw the topic. Of those comments, most re-emphasized that it is not good to tamper with nature (14%; 39/275). The remainder mentioned topics such as trust in producers, policies, and scientists, but also openness towards GE. This further indicates that the topic is important and relevant to many, particularly to opponents, and particularly in relation to nature and trust.

Subjective Images of GE

In one prompt, we asked participants to describe what they picture when thinking about GE. The prompt read:

> When we think of biotechnologies, we see certain images before the inner eye. What do you associate with green genetic engineering? Please describe in keywords what image you have in mind when you think of green genetic engineering. Please limit yourself to a maximum of 5 words. When I think of green genetic engineering, I see...
>
> Below the prompt, participants could describe their mental models in an open text box.

The purpose of investigating respondents' subjective images about GE was to gain a better understanding of which mental models participants may hold. Mental models are – potentially inaccurate – simulations of a part of reality, based on generalizations, and analogies (Gentner, 2001). With that, they allow people to make inferences in order to judge or behave (Lucas & Mai, 2022).

Coding Procedure

Participants provided a total of 2139 very brief descriptions of their images about GE. The responses were coded by the first author, applying an inductive coding procedure according to Philipp Mayring (2015). Specifically, the first author systematically went through the responses and paraphrased them into topics. The author then organized these topics according to groups and subgroups.

For consistency with the above narrative analysis, the author also deductively coded these topics according to the six moral foundations following the structural approach developed in Waldhof (2022a). However, identifying potential moral foundations in the subjective images is not straightforward. This is because moral foundations (Haidt, 2012) coordinate social interaction and thus guide evaluations about a benefit or a detriment to a person or a group. In our prompt however, participants were asked to describe their imagination about GE, and not an interpretation of their perceived consequences for humanity. Thus, while most of the entries do transport a normative evaluation (e.g. "cripple",

"mutant", "beautiful"), the relationship to human wellbeing often remains ambiguous. This makes the allocation to the six moral foundations somewhat interpretative. For example, an opponent described "fruits in winter". Here, it is not clear if the respondent thought that this is a beneficial trait of GE that could contribute to preventing hunger (i.e. Care), or if this was off-putting to the participant because it does not correspond to what they know or perceive as normal (i.e. Sanctity).

In cases which remained unclear, the coding author consulted the other entries of the same respondent and decided for a foundation that best reflected the overall picture the respondent described. For example, one opponent provided the answer "a plant with many blossoms". Here, this could be seen as a generally more efficient use of resources (i.e. Loyalty), or as something that is weird or not normal (i.e. Sanctity). The other entries of the same respondent were "clone", "wrong colors", "against nature" and "an unnatural-seeming plant with many sprouts". Based on these responses, it seems most reasonable to allocate the example to the theme "not normal" (i.e. Sanctity).

However, the allocation to the moral foundations should still be taken with caution because we cannot reliably interpret consequences for human wellbeing that participants may have had in mind when describing their subjective images about GE.

Moreover, many entries were neutral (e.g. "tree", "flower"), which makes it impossible to infer a normative evaluation from the answers. These entries could not be allocated to a moral foundation and are thus listed separately.

Findings

The 619 respondents included in the analysis provided an average of M = 3.46 entries. 67% (1432/2139) of all entries were made by GE opponents, 33% (707/2139) were made by GE supporters. 80 responses were excluded from the analysis because they were either not interpretable or statements such as "don´t know" or "nothing" (54 by opponents, 26 by supporters). Thus, 2059 responses were included in the analysis, 1378 made by opponents, 681 made by supporters. This corresponds well to the relationship between self-proclaimed opponents and supporters in the survey (67% : 33%). Table 6 provides an overview of the coded subjective images of GE. We provide groups and subgroups of themes, including examples.

By far most of these subjective images could be organized to the Sanctity foundation. 64% of mentions by opponents and 51% of mentions by supporters pertain to this category. Most of those describe something that is not normal, or unusual, i.e. 41% among all mentions

made by opponents, and 47% among all mentions made by supporters. Mostly, this relates to the optimization or perfection of plants. For example, opponents pictured “a plant with many blossoms” or “designer fruits”. Supporters pictured plants that “grow everywhere” or are “flawless”. Also typical in this theme were descriptions of supersized plants, such as “XXL potatoes” or “huge monster plants” among opponents, and “huge tomatoes” or “masses of plants” among supporters. Common were also images that described something artificial, strange, or unnatural. For example, opponents mention “fake plants”, “squared tomato” or “unpure variety”; supporters mention “clone”, “gaudy colors”, or “unnatural”.

Within the Sanctity foundation, 14% of opponents’ entries also described images that appeared somewhat post-apocalyptic. I.e., when thinking about GE, many opponents seem to picture images such as “cripple”, “mutants”, “dead”, or “deserted environment”.

The second biggest group overall were mentions that are neutral. 16% of mentions by opponents were allocated here. Among supporters, even 33% of all their mentions can be categorized as neutral. For opponents, these mostly refer to nutrition, e.g. “corn”, “crop”, “soy”. For supporters, these mostly refer to research and modern technology, e.g. “progress”, “experiments”, “laboratory” or “experiments”.

Also common were subjective images pertaining to Care and Loyalty, although Care was more frequent among opponents (14% of opponents’ entries), and Loyalty was more frequent among supporters (11% of supporters’ entries). Related to Care, opponents mostly mentioned health risks (8%), such as “unhealthy” and “diseases”. Supporters mostly mentioned issues of food security (2%), e.g. “fight hunger”. Related to Loyalty, opponents mainly addressed excess, greed, and power (3%) through descriptions such as “overproduction”, “price gouging”, or “dumping wages”. Within Loyalty, supporters mostly (4%) stated that GE was “useful” or “great”.

Images related to Fairness were only mentioned by opponents, as rarely as six times. These relate to rule violations, e.g. “plant theft” or “dubious activities”. Subjective images related to Authority and Liberty were not mentioned.

Discussion

These findings only somewhat align with the described narratives reported above. Topics related to Fairness, Authority, and Liberty were neither relevant in the stated narratives, nor in the stated subjective images. Moreover, similar to the described narratives, Care was more frequently addressed by opponents and Loyalty was more frequently addressed by supporters.

However, both of these foundations played a much smaller role in respondents' subjective images. Interestingly, health concerns, which were the most prominent narrative used to justify GE opposition, played a relatively small role in the subjective images (8% of opponents' mentions, and 2% of supporters' mentions). Similarly, while societal welfare was most frequently used to justify GE support, it played a smaller role in the subjective images (9% of supporters' mentions and 1% in opponents' mentions).

Contrary to that, themes related to Sanctity were much more prominent in the subjective images than in the described narratives. As mentioned above, mostly descriptions of an unnatural, optimized, perfect, supersized or strange plant stand out here. These take up the largest proportions of mentions of not only opponents, but supporters alike.

Rozin (2005) theorized that people judge whether a product is natural or not based on its process of creation, rather than its characteristics. In line with that, the present findings give rise to the assumption that both, opponents as well as supporters, find GE abnormal, strange, or unnatural. The difference between both would then only be that, while this leads to a negative evaluation of GE for opponents, for supporters it does not. This adds a new perspective on previous research about GE attitude that usually inferred that only opponents would see GE as unnatural (Hoogendoorn et al., 2021, Scott et al., 2018, Scott et al., 2016).

In addition to that, GE supporters seemed to indeed picture an optimistic outlook into a potential future that profits of the biotechnology, while opponents pictured a future with GE to become a catastrophe. This is in line with previous research that found evidence that GE supporters and opponents adhere to different worldviews (see Waldhof, 2022b; Siegrist, 1999; Zwick, 1998).

Generally, respondents' subjective images of GE transported more emotion and affect than the narratives do. This makes sense since our narrative probe asked for a reasoning about causal relationships, while the subjective images probe asked about impressions.

What really stands out is, however, that so many respondents generally perceived GE as something strange, perfect, or unnatural. They seemed to think that GE does not fit what they are used to. Even more so, the post-apocalyptic picture that opponents painted in 14% of their entries is striking. Inevitably, these are reminiscent of science fiction movies that draw (post-)apocalyptic scenarios. Most likely, people's forecasts about the future of new technologies, as well as popular science fiction movies, are interdependent. While research postulates that science fiction movies are thought of as mirroring contemporary hopes, fears, and forecasts about the future (Miles, 1993), they are also thought of as influencing how people think of the future impact of new technologies (Livingston, 1969).

Table 6

Topics of subjective images about GE, organized according to addressed moral foundations, including translated examples and frequencies

GE Opponents N(entries) = 1378				**GE Supporters N(entries) = 681**			
MFT	**Theme (Subtheme)**	**Examples (translated from German)**	**N**	**MFT**	**Theme (Subtheme)**	**Examples (translated from German)**	**N**
Care 14% (187)	Health risks	"Unhealthy", ("new/ unknown) diseases", "cancer"	8% (110)	**Care 5% (34)**	Food security	"Fight hunger"	2% (17)
					Health benefits	"healthy"	1% (10)
	(Uncontrollable) high risks	"Uncontrollable", "unresearched", "unpredictable"	3% (39)		Health risks	"unhealthy"	1% (5)
	Animal welfare, bad breeding conditions	"Intensive mass animal farming", "insects die"	3% (38)		Danger	"Danger", "burning amazon"	0% (2)
Fairness 0% (6)	Rule violation	"Dubious activities", "not fair", "plant theft"	0% (6)	**Fairness (0)**			
Loyalty 6% (78)	Excess, greed, power	"More profit", overproduction", "price gouging", "dumping wages"	3% (43)	**Loyalty 11% (72)**	Good, useful	"Useful, "great"	4% (25)
	Involved actors	"Monsanto", "Bayer", "USA"	1% (12)		Economic benefits	"More options", "cost reduction"	3% (19)
	Unnecessary	"Unnecessary", "bullshit"	1% (11)		Welfare	"Fulfillment of demand", "farmers better off"	2% (17)
	Protests, campaign	"Debate", "protests"	0% (6)		Protests, campaigns	"Emotions", "protests"	1% (6)

	Lies, broken promises		“Suspicion”, “lies”	0% (3)		Involved actors		“Monsanto”, “Bayer”, “USA”	1% (5)
	Capitalism		“Capitalism”	0% (3)					
Authority (0)					**Authority (0)**				
Liberty (0)					**Liberty (0)**				
Sanctity 64% (888)	Not normal / unusual	Enhancement of plants 229	Optimization (125): “plant grows faster”, “more fruits in one plant” Perfection (104): “designer fruits”, “fruits in winter”, “looks perfect”, “colorful”	41% (568)	**Sanctity 51% (348)**	Not normal / unusual	Enhancement of plants 211	Optimization (177): “diverse plants”, “grow everywhere”, “resistant” Perfection (34): “beautiful”, “identical”, “flawless”	47% (318)
		Supersized 129	“XXL potatoes”, “huge monster plants”				Supersized 53	“Huge tomatoes”, “masses of plants”	
		Unreal, artificial 72	“Fake plant”, “no taste”, “unrealistic colors”				Strange 32	“Gaudy colors”, “weird”, “meaty salad”	
		Strange 66	“Weird plant”, “squared tomato”, “clone”				Unreal, artificial 11	“Watery”, “clone”	
		Unnatural 61	“Unpure variety”, “unnatural plant”, “exotic plant”				Unnatural 8	“unnatural”	
		Change of nature 8	“Climate changes”, “ecosystem changes”				Supernatural 3	“Paradise”, “usable on other planets”	
		Supernatural 3	“Alien”						

	Post-apocalyptic images	“Cripple”, “mutants”, “dead”, “deserted environment”	14% (188)		Environmental benefits	“environment protection”	3% (22)
	Tampering with nature, god's creation, ethical concerns	“Scamping in nature”, “useless manipulation”	4% (56)		Pesticides	“pesticides”	0% (3)
	Environmental risk	“Environment pollution”, “reduced biodiversity”	3% (36)		Conservation of naturalness	“Organic farming”, “strict protection of natural plants”	0% (3)
	Bad, wrong	“Don´t like”, “uncool”	2% (25)		Bad	“bad”	0% (2)
	Disgusting images	“Monster”, “disgust”, “despicable being”					
	Distance	“Not in Germany”	0% (3)				
Neutral 16% (219)	Nutrition / agricultural products	“Corn” **(51)**, “crop”, “soy”	9% (128)	**Neutral 33% (227)**	Laboratory, research, modern technology	“Progress”, “experiments”, “laboratory”, “microscope”	15% (105)
	Laboratory, research, modern technology	“Robots”, “modernity”, “petri dish”	3% (44)		Nutrition / agricultural products	“Corn” (26), “crop”, “apple” “cotton”	14% (92)
	Environment	“Environment”, “tree”, “flowers”	2% (23)		Environment / plants	“Flower”, “tree”	3% (22)
	Agriculture	“Farmer”, “harvester”, “sheep”	1% (19)		Animals	“Frog”, “fish”, “bees”	1% (6)
	Human	“Human”	0% (5)		No difference	“Just as ordinary plant”	0% (2)

Note. Percentages refer to the total number of opponents’ entries, or supporters’ entries, respectively.

Regressions

We were interested in the relative importance of moral narratives compared to other socioeconomic factors, such as age, and more intuitive factors, such as emotions. Therefore, we ran a regression model to identify the covariates that have a significant effect on GE attitude as outcome variable. To find out which moral narratives are significantly related to GE attitude, we included respondents' entries to the first open narrative text box in the regression model. This is for two reasons: First, only about half of respondents provided a second entry, and only about a third provided a third entry. In order to not lose statistical power, we only included the first entry, which almost everyone provided (617/619). Second, since we asked respondents to order their answers according to rank, we can assume that the first answer is also considered the most relevant.

The data included in the regression, a codebook detailing all variables, and the code to reproduce the analyses are available at https://doi.org/10.7910/DVN/FEC7OL[2].

Based on previous research and our own preliminary analyses of the variables included, we hypothesized the variables to show effects on GE attitude as follows:

- Moral foundations: We only expected narratives related to Care, Loyalty, and Sanctity to be relevant in our regression model, because Fairness, Authority, and Liberty have almost never been addressed. Moreover, previous research linked GE opposition to fear and risk aversion (Royzman et al., 2017; Rzymski & Królczyk, 2016; Ventura et al., 2016; Kahan, 2016). And because these are characteristics of the Care foundation, we expected Care to be positively related to GE opposition. Furthermore, because GE opposition has been linked to disgust and protected values (Scott et al., 2016), and disgust is a moral emotion related to the Sanctity foundation, we expected Sanctity to show a significant positive effect on GE opposition. And because Loyalty was addressed much more frequently by GE supporters, we expected Loyalty narratives to be positively related to GE support.
- Gender: We ran a chi-squared test that showed a highly significant ($p = 0.0000$) relationship between gender and attitude – in which women were more likely to state to be against GE than men. This effect has also been shown in previous studies (e.g., Chen, 2011; Liu et al., 2014; Yue et al., 2015), so we expected to replicate this here.

[2] Waldhof, G. (2023). Replication Data for: "Understanding Moral Narratives as Drivers of Polarization about Genetically Engineered Crops". *Harvard Dataverse, V1*. https://doi.org/10.7910/DVN/FEC7OL

- Age: We ran a point-biserial correlation showing a small effect in which age accounts for 2.9% of the variability of GE attitude. We thus expected older respondents to be more likely to reject GE than younger respondents.
- Region, Level of Income, and Level of Education: A preliminary chi-squared test showed no significant relationship between GE attitude and respondents living in the former GDR region or elsewhere in Germany. Moreover, preliminary chi-square tests showed no significant relationship between GE attitude and level of income and level of education. We thus expected there to be no significant relationship between GE attitude and region, level of income, or level of education.
- Interest, importance, meaning, relevance for voting, and emotionality: Previous research has related GE attitude, and GE opposition in particular, to moral beliefs and moral convictions (Inbar & Waldhof, 2022; Scott et al., 2016). Because moral beliefs and convictions are related to strong emotional reactions and motivations to act (Ginges et al., 2007; Skitka et al., 2005; Skitka & Bauman, 2008; Tetlock, 2003), we predicted that GE opponents also tend to score higher on these importance items than GE supporters.
- Extent of specific emotions: Because we expected respondents to have consistent positions and emotional experiences, we expected GE opponents to report stronger negative emotions significantly more often when thinking about GE, and GE supporters to report stronger positive emotions significantly more often when thinking about GE. Moreover, Scott et al. (2016) have shown a relationship between GE opposition and the emotion disgust, so we expected to replicate this here.
- Sentiment about mental models: similar to the expected results related to emotions, we expected a strong positive effect between GE opposition and experienced negative sentiment when thinking about images related to GE. Vice versa, we expected GE supporters to experience positive sentiment in relation to images about GE significantly more frequently.
- Preferences for regulations: We expected GE opponents to prefer stricter regulations for GE than supporters, because otherwise participants' responses would not be consistent with their stated positions. Moreover, because people's narratives about GE indicate skepticism towards commercial gains, we expected GE research at universities to be more accepted than research for commercial

purposes. Similarly, because participants' narratives about GE indicate concerns about the contamination and destruction of nature, we expected GE research in laboratories to be more accepted than research in the field.

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Procedure

Because we were interested in potential significant effects of the included predictor variables on the outcome variable, we used a linear model, specifically, an ordinary least square regression model (OLS).[3] Greene (2019, ch. 17.2.6 and example 17.3) points to the fact that the results from a linear probability model (LPM) deliver approximate results for the average marginal effects of the logit and probit models, a point also outlined by e.g., Jacob and Levitt (2003). Advantages of the LPM are simplicity and robustness (Greene, 2019, p. 721). We therefore restricted our reported results to the LPM case. Results of a logit model are qualitatively similar.

We tested for heteroscedasticity both visually and analytically. A plot and histogram of the residuals showed a quite homogeneous distribution of the residuals.[4] However, the Breusch-Pagan test (Breusch & Pagan, 1979) rejected the null hypothesis of homoscedasticity and a curve in the plotted line also indicated heteroscedasticity.[5] To account for this, we calculated heteroscedasticity consistent (i.e. robust) standard errors type HC3 for our model (Hayes, 2007).[6]

Furthermore, in order to check for multicollinearity, we calculated the variance inflation factor (VIF) for each of the covariates.[7] While all variables were below the cutoff-point of 5 (Midi & Bagheri, 2010; Ringle et al., 2015; Chatterjee & Price, 1991; Hair et al., 1995), some showed quite high factors, i.e. close to or above 4.5. All of these belonged to the regulatory preferences, i.e. commercial field research about GE (*RegFieldComm*; 4.48), import of GE (*RegImport*; 4.64), export of GE (*RegExport*; 4.88), and leaving consumers with a choice about GE (*RegChoice*; 4.90).

Because of these high VIFs, we applied the general-to-specific procedure (GETS), in which those variables with the least favorable t-values are systematically excluded.[8] This

[3] For our regression calculations, we used the R-packages *Readxl* (Wickham & Bryan, 2022) and *MASS* (Venables & Ripley, 2002).

[4] We used the R-package *Summarytools* (Comtois, 2022).

[5] We used the R-packages *Lmtest* (Zeileis & Hothorn, 2002), *Zoo* (Zeileis, & Grothendieck, 2005), and *Parallel* (R Core Team, 2021).

[6] We calculated this with the R-packages *Sandwich* (Zeileis, 2004; Zeileis et al., 2020) and *Estimatr* (Blair et al., 2022).

[7] We calculated the VIFs with the R-package *Car* (Fox & Weisberg, 2019).

[8] To apply the GETS-procedure, we used the R-packages *Gets* (Pretis et al., 2018) and *Zoo* (Zeileis & Grothendieck, 2005).

procedure resulted in a reduction of our model by seven variables. As expected from the VIFs, all excluded variables concern the regulatory preferences.

Results and Interpretation

Table 7[9] reports the results of the linear model with robust standard errors, before and after applying the GETS procedure. Here, we describe and discuss the results of the reduced model with robust standard errors.

Our reduced OLS model estimated nine covariates to have a significant, or close to significant, marginal effect on GE attitude. These were moral narratives related to Loyalty (*MERGED_MFT_NARRATIVE1LOYALTY*), not wanting or not being able to provide a narrative (*MERGED_MFT_NARRATIVE1nA*), the level of education (*Degree*), the sentiment felt in relation to the first, second, and third subjective image (*Sentiment1, Sentiment2, Sentiment3*), the extend of anger felt when thinking about GE (*EmoAnger*), the extend of joy felt when thinking about GE (*EmoJoy*), and requiring a label of GE foods in Germany (*RegChoiceLabel*).

- As predicted, we found a highly significant positive relationship between moral narratives within the Loyalty foundation and GE support. However, the other moral narratives showed no significant effect. Interestingly, there is a significant positive effect between GE support and statements such as “I don’t know” or “I don't care” when asked about the supporting narratives. That GE supporters were significantly more often unable or unwilling to provide a supporting narrative to their position makes sense given that previous research has shown that they are generally less convicted about the topic, and more likely to change their position when challenged (Inbar & Waldhof, 2022). Potentially, these were respondents who are not firm in their position and might not have followed the public discourse about GE in Germany. Thus, they might not have been aware of the narratives addressed in this discourse and were thus unable to state one that they find most motivating for their position. Similarly, these respondents might not have engaged with the controversy, so they tended to select GE support because they see no immediate problem.
- Against our prediction, and against previous research findings, we found no significant relationship between gender and GE attitude, as well as between age and GE attitude. Potentially, previously shown effects of these variables are better

[9] This table was produced with the R-package *Stargazer* (Hlavac, 2022).

explained by other variables in the model that show significant effects, e.g. respondents' level of education, or sentiments related to subjective images about GE.

- In line with our hypothesis, we found no significant effect of the region of residence, and the level of income on GE attitude. However, we found the level of education to have a significant positive effect on GE support. This suggests that information does have an impact on GE attitude. We assume that this particularly applies to knowledge on general biology and genetics which is taught in higher class levels of high school.
- Against our prediction, interest, importance, relevance for voting and emotionality did not indicate a significant relationship with GE attitude. Potentially, the relevance of the topic has decreased, and people generally did not care as much and did not react as strongly to GE as in earlier studies. Comparing the histograms and means of the items of both supporters and opponents shows that responses were generally close to the midpoint (0), indicating that generally, GE was generally not more important to participants than other topics.
- Against our prediction, the extent of specific emotions felt when thinking about GE did not have a significant effect on GE attitude. However, the extent of anger felt when thinking about GE is an almost significant predictor of GE opposition ($p < 0.1$), and the extent of joy felt when thinking about GE is an almost significant predictor of GE support ($p < 0.1$). Potentially, as proposed above, the relevance of GE as a topic has decreased, and people's emotional reactions were less strong.
- As expected, sentiments related to subjective images about GE and GE attitude showed significant and highly significant effects. While not all five sentiments showed a significant effect, three out of five did.
- As mentioned above, the GETS procedure reduced the number of variables for regulatory preferences included in the model from ten to three, because of multicollinearity. Of those remaining three, the request of a free choice for consumers about GE – on condition that GE foods are labeled – is a highly significant predictor of GE support.

In total, these results somewhat indicate that moral narratives and emotional intuitions about GE are more predictive of GE attitude than socioeconomic characteristics.

Table 7

Regression Results

	Dependent variable:	
	GE Attitude	
	(1)	(2)
Gender	0.01	0.01
	(0.04)	(0.04)
Age	0.001	0.001
	(0.001)	(0.001)
Region	0.01	0.02
	(0.05)	(0.04)
Income	-0.02	-0.01
	(0.02)	(0.02)
Degree	0.03**	0.03**
	(0.01)	(0.01)
Interest	-0.004	-0.002
	(0.01)	(0.01)
Importance	-0.003	-0.01
	(0.02)	(0.02)
Meaning	0.003	0.01
	(0.02)	(0.02)
Voting	0.002	-0.003
	(0.01)	(0.01)
Sentiment1	-0.1*	-0.1**
	(0.1)	(0.1)
Sentiment2	-0.1*	-0.1*
	(0.1)	(0.1)
Sentiment3	-0.2***	-0.2***
	(0.1)	(0.1)
Sentiment4	-0.01	-0.01
	(0.1)	(0.1)
Sentiment5	-0.1	-0.1
	(0.1)	(0.1)
Emotionality	0.01	0.01
	(0.01)	(0.01)
EmoContempt	0.01	0.01
	(0.02)	(0.02)
EmoAnger	-0.04**	-0.03*
	(0.02)	(0.02)
EmoFear	-0.02	-0.02
	(0.02)	(0.02)
EmoDisgust	-0.01	-0.004
	(0.01)	(0.01)

EmoJoy	0.01	0.02*
	(0.01)	(0.01)
EmoSurprise	0.01	0.01
	(0.01)	(0.01)
EmoSadness	-0.002	-0.002
	(0.01)	(0.01)
RegStrict	0.01	0.01
	(0.01)	(0.01)
RegFieldUni	-0.01	0.004
	(0.01)	(0.01)
RegFieldComm	-0.001	
	(0.02)	
RegLabUni	-0.02	
	(0.01)	
RegLabComm	0.01	
	(0.01)	
RegImport	0.01	
	(0.02)	
RegExport	0.03	
	(0.03)	
RegChoice	0.01	
	(0.02)	
RegChoiceLabel	0.01	0.03***
	(0.01)	(0.01)
RegNoChoice	0.01	
	(0.01)	
MERGED_MFT_NARRATIVE1LIBERTY	0.7	0.7
	(0.5)	(0.5)
MERGED_MFT_NARRATIVE1LOYALTY	0.2***	0.2***
	(0.1)	(0.1)
MERGED_MFT_NARRATIVE1nA	0.1	0.1**
	(0.1)	(0.1)
MERGED_MFT_NARRATIVE1SANCTITY	-0.1	-0.04
	(0.04)	(0.04)
Constant	0.4***	0.4***
	(0.1)	(0.1)
Observations	347	352
R^2	0.6	0.6
Adjusted R^2	0.6	0.6
Residual Std. Error	0.3 (df = 310)	0.3 (df = 322)
F Statistic	15.8*** (df = 36; 310)	18.1*** (df = 29; 322)
Note:		*p<0.1; **p<0.05; ***p<0.01

Conclusion and future directions

Contributing to the emerging narrative research in economics, we identified people's (mis)conceptions and moral evaluations of genetic engineering for human consumption.

Specifically, Roos and Reccius (2021) postulate that narrative research needs to extend its inquiry into the identification of people's belief system in order to understand the *meaning* of narratives. Motivated by this request, we identified the moral foundations within people's narratives, and collected descriptions of participants' subjective images of GE, as well as their sentiments. We did so by conducting a content analysis and by applying the methodological approach for identifying moral foundations in text developed in Waldhof (2022a).

We showed how this methodological approach yields novel – and previously overlooked – insights into the polarized debate about GE. Specifically, we provide insights into the belief systems that lead people to come to different conclusions about GE. We thus contribute to the investigation of narratives in economics, moral beliefs in narratives, research on polarization and polarized debates, expectation formation, voting behavior and policy preferences, moralization and moral psychology, as well as GE attitude and technology adoption. The main conclusions are described in the following.

First, our findings suggest a significance of moral intuitions and moral foundations for narrative research in economics. Specifically, we provided evidence that moral narratives that address the Loyalty foundation are a significant predictor of GE support. Moreover, affective narratives stating that GE should be prohibited (or approved) because they *look better,* are *ugly*, *disgusting*, *perfection*, or evoke *bad feelings*, indicate that GE attitudes are - at least in part – based on emotions, intuitions and gut feeling. Contrary to that, many socioeconomic factors such as age, gender, region, or income did not show a significant relationship with GE attitude. Consequently, building on the literature about moral emotions and moral intuitions (see for example Haidt & Joseph, 2004; Haidt, 2001; Ditto et al., 2009), we can infer that moral intuitions are an important driver of GE attitude.

This is in line with previous research that found moral concerns to be related to GE attitude (Inbar & Waldhof, 2022; Scott et al., 2016), even when controlling for risk perceptions and demographics (Sjöberg, 2008; Tanaka, 2004). Our findings indicate that collectively shared moral narratives are impactful for the approval or rejection of GE, and thus for related policy preferences.

Second, our findings indicate that there are considerable differences between the narratives that are led by official public representatives and those that people found most crucial in our study. While environment protection was relevant in the narratives that

opponents mentioned, it was not as prominent for people as the public debate insinuates (see for example Waldhof (2022b). Even more so, aspects such as market skepticism and corporate behavior play a large role in the public debate (Waldhof, 2022b), but were almost irrelevant in the narratives that people reported as their causal account for their position.

Third, the fact that issues related to corporate greed and market skepticism were almost never among respondents' spontaneous mentions of narratives, but were among the most selected narratives when provided to respondents, suggests motivated reasoning within the selection question. As indicated above, the term motivated reasoning refers to a phenomenon in which people provide arguments that strengthen their position rather than reflecting the actual line of reasoning that they might have had (see for example Druckman & McGrath, 2019; Epley & Gilovich, 2016; Kunda, 1990). I.e., respondents' provided reasoning might be motivated by wanting to foster their position, rather than by an open deliberation to reach a conclusion.

Fourth, the public debate among official representatives is often conducted with diametrically opposed narratives. For example, while BUND (n.d.) discusses potential health risks, Leopoldina (2021) argues that GE can have benefits for health. Or, while the Heinrich Böll foundation (Mertens, 2022) argues that GE increases the use of pesticides, Bayer argues that GE reduces the use of pesticides (Bayer, 2022).

Interestingly, and contrary to that, our research suggests that diametrically opposed narratives are not decisive for the diverging attitudes among the public. Rather, they may focus on different moral aspects that lead to different positions towards the technology. One example are potential health impairments, addressed in the Care foundation. These were extremely popular among opposing narratives. However, health benefits only played a very small role among supporting narratives. Rather, within the Care foundation, supporters focused on food security. Another example is the perception of naturalness. Considering the overwhelming proportion of both opponents and supporters, who described GE as something that is not normal, it is likely that opponents and supporters alike thought of GE as something unnatural. This thought is based on previous research that found that when people describe something as natural, they actually mean normal, i.e. something they are used to (Scott & Rozin, 2020). Then, GE opponents and supporters may not differ in their understandings of naturalness, or normality, but in the *relevance* it has for their position. Since supporters were asked which narratives led to their position, it can be derived that naturalness, or normality, is not an aspect that led to their support.

The here identified focus on different moral aspects also manifests itself in a focus on different moral foundations. While opponents stated much more narratives within Care and Sanctity, supporters focused heavily on Loyalty narratives. Specifically, opponents focused on health threats (Care) as well as environmental risks and unnaturalness (Sanctity); and supporters focused on general welfare, progress and benefits for developing countries (Loyalty).

This carves out the interesting observation that both, GE supporters and opponents, may have actually *agreed* that they personally, as well as their immediate surroundings, would be no direct beneficiaries of GE. Rather, the difference may just be that supporters focused more on narratives that suggested general welfare and development aid.

Thus, our findings suggest that rather than diametrically opposed narratives about GE, diverging foci on moral issues seem to be decisive for the polarization about GE. Without applying qualitative content analysis and MFT here, these novel insights could not have been generated.

The present study also yields a practical recommendation for improving science communication and public debates. The analysis suggests that to the German public, immediate benefits, particularly related to health and the environment, remain largely unclear and intangible. Thus, for scientists engaged in the debate, it seems sensible to point out and explain such immediate benefits much more strongly.

Moreover, it may be useful to get involved in a debate about naturalness. As supporters seem to also find GE unnatural without this being decisive for their attitude, it might be worth debating when and if naturalness should be pivotal for approving or rejecting GE as a technology.

At the same time, it has to be considered that the causal relationship between GE attitude and the predictor variables has to be interpreted with caution. In the present study, we included the identifying restriction that GE attitude is dependent on the other variables included in the study. However, this direction of dependency is not unambiguous. For example, from our study we cannot infer whether respondents felt a negative emotion *that then* led them to reject GE, or whether people experience a negative emotion when thinking about GE *because* they reject the technology. Based on the theory of moral emotions and moral foundations (see for example Haidt, 2007; Haidt, 2012), we assumed that negative (moral) emotions guide people towards a rejecting GE.

Similarly, we cannot infer from this study whether respondents considered a variety of narratives about GE and *then* formulated their attitude based on the narrative they find most

convincing, or whether the narratives were post hoc rationalization of e.g., a preceding gut feeling about GE. Because of the phenomenon of motivated reasoning addressed above, the latter may indeed be a reasonable alternative. In the present paper, as explained above, we assumed the former i.e., that people are drawn to the narrative that best fits into their belief system, and then formulate their attitude based on this confirming narrative.

Our approach for identifying the moral content of narratives can also be applied to other settings. For example, polarizing issues such as vaccine hesitancy, renewable energy sources, or climate change may hold moral conflicts in popular narratives whose identification may be the first step towards their solving.

References

Akerlof, K. G. A., & Kranton, R. E. (2010). *Identity Economics*. Princeton University Press.

Akerlof, G. A., & Kranton, R. E. (2000b). Economics and identity. *The Quarterly Journal of Economics*, *115*(3), 715–753. https://doi.org/10.1162/003355300554881

Akerlof, G. A., & Shiller, R. J. (2009). *Animal spirits: How human psychology drives the economy, and why it matters for global capitalism.* Princeton University Press.

Akerlof, G. A., & Snower, D. J. (2016). Bread and bullets. *Journal of Economic Behavior & Organization, 126*, 58–71. https://doi.org/10.1016/j.jebo.2015.10.021

Amin, A. B., Bednarczyk, R. A., Ray, C. E., Melchiori, K. J., Graham, J., Huntsinger, J. R., & Omer, S. B. (2017). Association of moral values with vaccine hesitancy. *Nature human behaviour*, *1*(12), 873–880. https://doi.org/10.1038/s41562-017-0256-5

Andre, P., Haaland, I., Roth, C., & Wohlfart, J. (2022). Narratives about the Macroeconomy. *CRC TR 224 Discussion Paper Series*. Retrieved Jan, 14, 2023 from https://ideas.repec.org/p/bon/boncrc/crctr224_2022_350.html

Antoci, A., Ferilli, G., Russu, P., & Sacco, P. L. (2020). Rational populists: the social consequences of shared narratives. *Journal of Evolutionary Economics*, *30*(2), 479–506. https://doi.org/10.1007/s00191-019-00659-2

Arts, W., & Gelissen, J. (2001). Welfare States, Solidarity and Justice Principles: Does the Type Really Matter? *Acta Sociologica, 44*(4), 283–299. https://doi.org/10.1177/000169930104400401

Ash, E., Gauthier, G., & Widmer, P. (2022). RELATIO: Text semantics capture political and economic narratives. *arXiv.* https://doi.org/10.48550/ARXIV.2108.01720

Ash, E. & Hansen, S. (2022). *Text Algorithms in Economics* [invited submission at Annual Review of Economics]. Retrieved Nov. 20, 2022 from https://elliottash.com/wp-content/uploads/2022/08/annual_reviews_chapter-2022-08-16.pdf

Bachmann, O., Gründler, K., Potrafke, N., & Seiberlich, R. R. (2019). Partisan bias in inflation expectations. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3477717

Barrett, L. F. (2004). Feelings or Words? Understanding the Content in Self-Report Ratings of Experienced Emotion. *Journal of Personality and Social Psychology, 87*(2), 266–281. https://doi.org/10.1037/0022-3514.87.2.266

Bayer Global. (2022). *Führt Gentechnik zu einem steigenden Verbrauch von Pflanzenschutzmitteln* [Will genetic engineering lead to increased consumption of crop protection products]? Retrieved Dec. 24, 2022 from

https://www.bayer.com/de/de/hsdf-fuehrt-gentechnik-zu-einem-steigenden-verbrauch-von-pflanzenschutzmitteln

Beckert, J. (2016). *Imagined Futures: Fictional Expectations and Capitalist Dynamics*. Harvard University Press. http://www.jstor.org/stable/j.ctvjnrvrw

Benabou, R., Falk, A., & Tirole, J. (2020). Narratives, Imperatives, and Moral Persuasion. *Working Papers*. Retrieved Jan, 14, 2023 from https://ideas.repec.org/p/pri/econom/2020-49.html

Biden, S., Smyth, S. J., & Hudson, D. (2018). The economic and environmental cost of delayed GM crop adoption: The case of Australia's GM canola moratorium. *GM Crops & Food*, *9*(1), 13–20. https://doi.org/10.1080/21645698.2018.1429876

Blair, G., Cooper, J., Coppock, A., Humphreys, M., & Sonnet, L. (2022). *Estimatr: Fast estimators for design-based inference. R package version 1.0.0.* Retrieved Jan. 14, 2023, from https://CRAN.R-project.org/package=estimatr

Blancke, S., Van Breusegem, F., De Jaeger, G., Braeckman, J., & Van Montagu, M. (2015). Fatal attraction: the intuitive appeal of GMO opposition. *Trends in Plant Science*, *20*(7), 414–418. https://doi.org/10.1016/j.tplants.2015.03.011

Breusch, T. S., & Pagan, A. R. (1979). A Simple Test for Heteroscedasticity and Random Coefficient Variation. *Econometrica: Journal of the Econometric Society*, *47*(5), 1287. https://doi.org/10.2307/1911963

Bundesinstitut für Risikobewertung [BfR]. (2022). *BfR-Verbrauchermonitor 08|2022* [BfR Consumer Monitor 08|2022]. Retrieved Oct. 27, 2022, from https://www.bfr.bund.de/cm/350/bfr-verbrauchermonitor-08-2022.pdf

Bund für Umwelt und Naturschutz Deutschland e.V. (BUND) – Friends of the Earth Germany [BUND]. (n.d.). *Gentechnisch veränderte Lebensmittel: ungeklärte Risiken für die Gesundheit* [Genetically modified foods: unresolved risks to health]. Retrieved Dec. 26, 2022, from https://www.bund.net/themen/landwirtschaft/gentechnik/risiken/gesundheit/

Chatterjee, S., & Price, B. (1991). *Regression analysis by example (2nd ed.).* New York, NY: Wiley.

Chen, M. F. (2020). Moral extension of the protection motivation theory model to predict climate change mitigation behavioral intentions in Taiwan. *Environmental Science and Pollution Research,* 27(12), 13714-13725. https://doi.org/10.1007/s11356-020-07963-6

Chen, Mei-Fang (2011). The gender gap in food choice motives as determinants of consumers' attitudes toward GM foods in Taiwan, *British Food Journal*, Vol. 113(6), 697-709. https://doi.org/10.1108/00070701111140052

Comtois, D. (2022). *Summarytools: Tools to quickly and neatly summarize data. R package version 1.0.1.* Retrieved Jan. 14, 2023, from https://CRAN.R-project.org/package=summarytools

Connor, M., & Siegrist, M. (2010). Factors influencing people's acceptance of gene technology: The role of knowledge, health expectations, naturalness, and social trust. *Science Communication*, *32*(4), 514–538. https://doi.org/10.1177/1075547009358919

Cookson, J.A., Engelberg, J. E., Mullins, W., & Chen, H. (2020). Does partisanship shape investor beliefs? Evidence from the COVID-19 pandemic. *The Review of Asset Pricing Studies*, *10*(4), 863–893. Retrieved Oct. 27, 2022, from https://ideas.repec.org/p/osf/socarx/rwhse.html

D'Acunto, F., Hoang, D., Paloviita, M., & Weber, M. (2021). *IQ, Expectations, and Choice.* Chicago Booth Research Paper No. 19-20, Fama-Miller Working Paper, Retrieved Jan, 14, 2023 from https://ssrn.com/abstract=3451486

Day, M. V., Fiske, S. T., Downing, E. L., & Trail, T. E. (2014). Shifting liberal and conservative attitudes using moral foundations theory. *Personality and Social Psychology Bulletin,* 40(12), 1559–1573. https://doi.org/10.1177/0146167214551152

Diaf, S., Döpke, J., Fritsche, U., & Rockenbach, I. (2022). Sharks and minnows in a shoal of words: Measuring latent ideological positions based on text mining techniques. *European Journal of Political Economy*, *102179*, 102179. https://doi.org/10.1016/j.ejpoleco.2022.102179

Ditto, P. H., Pizarro, D. A., & Tannenbaum, D. (2009). Motivated moral reasoning. In D. M. Bartels, C. W. Bauman, L. J. Skitka, & D. L. Medin (Eds.), *Moral judgment and decision making* (pp. 307–338). Elsevier Academic Press. https://doi.org/10.1016/S0079-7421(08)00410-6

Döpke, J., Fritsche, U., & Waldhof, G. (2019). Theories, Techniques and the Formation of German Business Cycle Forecasts: Evidence from a survey of professional forecasters. *Jahrbücher für Nationalökonomie und Statistik*, *239*(2), 203–241. https://doi.org/10.1515/jbnst-2018-0018

Druckman, J. N., & McGrath, M. C. (2019). The evidence for motivated reasoning in climate change preference formation. *Nature Climate Change, 9(*2), 111–119. https://doi.org/10.1038/s41558-018-0360-1

Dürnberger, C. (2019). Normative concepts of nature in the GMO protest. A qualitative content analysis of position papers criticizing green genetic engineering in Germany. *Food Ethics*, *4*(1), 49–66. https://doi.org/10.1007/s41055-019-00046-4

Eliaz, K., Galperti, S., & Spiegler, R. (2022). *False narratives and political mobilization*. In arXiv [econ.TH]. Retrieved Jan, 14, 2023 from http://arxiv.org/abs/2206.12621

Eliaz, K., & Spiegler, R. (2020). A model of competing narratives. *American Economic Review*, *110*(12), 3786–3816. https://doi.org/10.1257/aer.20191099

Ellemers, N., van der Toorn, J., Paunov, Y., & van Leeuwen, T. (2019). The Psychology of Morality: A Review and Analysis of Empirical Studies Published From 1940 Through 2017. *Personality and Social Psychology Review*, *23*(4), 332–366. https://doi.org/10.1177/1088868318811759

Enke, B. (2020). Moral values and voting. *The Journal of Political Economy*, *708857*, 000–000. https://doi.org/10.1086/708857

Epley, N., & Gilovich, T. (2016). The mechanics of motivated reasoning. *The Journal of Economic Perspectives: A Journal of the American Economic Association, 30*(3), 133–140. https://doi.org/10.1257/jep.30.3.133

Feinberg, M., Kovacheff, C., Teper, R., & Inbar, Y. (2019). Understanding the process of moralization: How eating meat becomes a moral issue. *Journal of Personality and Social Psychology, 117*(1), 50–72. https://doi.org/10.1037/pspa0000149

Fernbach, P. M., Light, N., Scott, S. E., Inbar, Y., & Rozin, P. (2019). Extreme opponents of genetically modified foods know the least but think they know the most. *Nature human behaviour*, *3*(3), 251–256. https://doi.org/10.1038/s41562-018-0520-3

Freitag, B. (2013). *Die Grüne-Gentechnik-Debatte. Der Einfluss von Sprache auf die Herstellung von Wissen* [The green genetic engineering debate. The influence of language on the production of knowledge]. Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-01749-1

Fritsche, U., & Puckelwald, J. (2018). Deciphering professional forecasters' stories - analyzing a corpus of textual predictions for the German economy. *Macroeconomics and Finance Series*. https://ideas.repec.org/p/hep/macppr/201804.html

Fox, J., & Weisberg, S. (2019). *An {R} Companion to Applied Regression, Third Edition.* Thousand Oaks CA: Sage. Retrieved Jan. 14, 2023, from https://socialsciences.mcmaster.ca/jfox/Books/Companion/

Gapfish. (2022). *GAPF!SH.* Retrieved on Dec. 22, 2022 from https://gapfish.com/

Gentner, D. (2001). Mental models, psychology of. In *International Encyclopedia of the Social & Behavioral Sciences* (pp. 9683–9687). Elsevier.

Gentzkow, M., Kelly, B., & Taddy, M. (2019). Text as data. *Journal of Economic Literature*, *57*(3), 535–574. https://doi.org/10.1257/jel.20181020

Ginges, J., Atran, S., Medin, D., & Shikaki, K. (2007). Sacred bounds on rational resolution of violent political conflict. *Proceedings of the National Academy of Sciences,* 104(18), 7357–7360. https://doi.org/10.1073/pnas.0701768104

Graham, J., Haidt, J., & Nosek, B. A. (2009). Liberals and conservatives rely on different sets of moral foundations. *Journal of personality and social psychology*, *96*(5), 1029.

Graham, J., Nosek, B. A., Haidt, J., Iyer, R., Koleva, S., & Ditto, P. H. (2011). Mapping the moral domain. *Journal of Personality and Social Psychology*, *101*(2), 366–385. https://doi.org/10.1037/a0021847

Graham, J., Nosek, B. A., & Haidt, J. (2012). The moral stereotypes of liberals and conservatives: exaggeration of differences across the political spectrum. *PloS One*, *7*(12), e50092. https://doi.org/10.1371/journal.pone.0050092

Graham, J., Haidt, J., Motyl, M., Meindl, P., Iskiwitch, C., & Mooijman, M. (2018). Moral foundations theory: On the advantages of moral pluralism over moral monism. In K. Gray & J. Graham (Eds.), *Atlas of moral psychology* (pp. 211–222). The Guilford Press.

Greenpeace e.V. (2015). *Zwei Jahrzehnte des Versagens. Die gebrochenen Versprechen der Agro-Gentechnik* [Two decades of failure. The broken promises of agro-genetic engineering]. Retrieved Oct. 27, 2022, from https://www.greenpeace.de/publikationen/zwei-jahrzehnte-versagens

Greenpeace e.V. (2020). *Tabelle 6: Meinungen zu gentechnisch veränderten Lebensmitteln* [Table 6: Opinions on genetically modified foods]. Retrieved Oct. 31, 2022, from https://www.greenpeace.de/publikationen/20-jahre-gentechnik-bilanz-greenpeace-20150311_0.pdf

Grimmer, J., Roberts, M. E., & Stewart, B. M. (2022). *Text as data: A new framework for machine learning and the social sciences*. Princeton University Press.

Haidt, J. (2001). The Emotional Dog and Its Rational Tail: A Social Intuitionist Approach to Moral Judgment. *Psychological Review*, 108, 814–834.

Haidt, J. (2003). The moral emotions. In R. J. Davidson, K. R. Scherer, & H. H. Goldsmith (Eds.), *Handbook of affective sciences* (pp. 852–870). Oxford University Press.

Haidt, J. (2007). The New Synthesis in Moral Psychology. *Science (New York,*

N.Y.), *316*(5827), 998–1002. https://doi.org/10.1126/science.1137651

Haidt, J. (2008). Morality. *Perspectives on Psychological Science*, *3*(1), 65–72. https://doi.org/10.1111/j.1745-6916.2008.00063.x

Haidt, J. (2012). *The Righteous Mind: Why Good People Are Divided by Politics and Religion*. Penguin Books.

Haidt, J., & Graham, J. (2007). When Morality Opposes Justice: Conservatives Have Moral Intuitions that Liberals may not Recognize. *Social Justice Research*, *20*(1), 98–116. https://doi.org/10.1007/s11211-007-0034-z

Haidt, J., & Joseph, C. (2004). Intuitive Ethics: How Innately Prepared Intuitions Generate Culturally Variable Virtues. *Daedalus*, *133*(4), 55–66. http://www.jstor.org/stable/20027945

Haidt, J., & Kesebir, S. (2010). Morality. In S. T. Fiske, D. T. Gilbert, & G. Lindzey (Eds.), *Handbook of social psychology* (pp. 797–832). John Wiley & Sons, Inc.. https://doi.org/10.1002/9780470561119.socpsy002022

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1995). *Multivariate data analysis.* Englewood Cliffs, NJ: Prentice-Hall.

Hayes, A. F., & Cai, L. (2007). Using heteroskedasticity-consistent standard error estimators in OLS regression: an introduction and software implementation. *Behavior Research Methods, 39*(4), 709–722. https://doi.org/10.3758/bf03192961

Hlavac, M. (2022). *Stargazer: Well-Formatted Regression and Summary Statistics Tables. R package version 5.2.3.* Retrieved 14 Jan, 2023, from https://CRAN.R-project.org/package=stargazer

Hofstetter, M., Krautter, A., Oeck, S., Toewe-Rimkeit, S. (2011). *Hintergrund Landwirtschaft. Landwirtschaft. Was wollen wir essen? Gift und Gentechnik – nein danke* [Background Agriculture. Agriculture. What do we want to eat? Poison and genetic engineering - no thanks]*!* Greenpeace.de. Retrieved Dec. 26, 2022, from https://www.greenpeace.de/publikationen/greenpeace-hintergrund-landwirtschaft-h03032.pdf

Hoogendoorn, G., Sütterlin, B., & Siegrist, M. (2021). Tampering with Nature: A Systematic Review. *Risk Analysis: An Official Publication of the Society for Risk Analysis, 41*(1), 141–156. https://doi.org/10.1111/risa.13619

Inbar, Y., & Waldhof, G. (2022, July 27). Mitigating Consequence Insensitivity for Genetically Engineered Crops. Accepted at: *Journal of Experimental Psychology: Applied.* https://doi.org/10.31234/osf.io/bnq8c

Iyer, R., Koleva, S., Graham, J., Ditto, P., & Haidt, J. (2012). Understanding libertarian morality: the psychological dispositions of self-identified libertarians. *PloS One*, *7*(8), e42366. https://doi.org/10.1371/journal.pone.0042366

Jelveh, Z., Kogut, B., & Naidu, S. (2014). Political Language in Economics. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2535453

Kahan, D. M. (2016). Scientists discover source of public controversy on GM food risks: bitter cultural division between scaredy cats and everyone else! *Cultural Cognition Project.* Retrieved Jan. 14, 2023, from http://culturalcognition.squarespace.com/blog/2016/4/21/scientists-discover-source-of-public-controversy-on-gm-food.html

Kahneman, D. (2011). *Thinking, fast and slow.* Farrar, Straus and Giroux.

Kajale, D. B., & Becker, T. C. (2015). Factors Influencing Young Consumers' Acceptance of Genetically Modified Food in India. *Journal of Food Products Marketing*, *21*(5), 461–481. https://doi.org/10.1080/10454446.2013.845866

Kennedy, B., & Thigpen, C. L. (2020). Many publics around world doubt safety of genetically modified foods. *Pew Research Center.* Retrieved Oct. 27, 2022, from https://www.pewresearch.org/fact-tank/2020/11/11/many-publics-

Kimenju, S. C., & De Groote, H. (2007). Consumer willingness to pay for genetically modified food in Kenya. *Agricultural Economics (Amsterdam, Netherlands)*, *38*(1), 35–46. https://doi.org/10.1111/j.1574-0862.2007.00279.x

Klümper, W., & Qaim, M. (2014). A Meta-Analysis of the Impacts of Genetically Modified Crops. *PloS One*, *9*(11), e111629. https://doi.org/10.1371/journal.pone.0111629

Koleva, S., Beall, E., & Graham, J. (2017). Moral foundations theory: Building value through moral pluralism. In *International Handbooks in Business Ethics* (pp. 521–530). Springer Netherlands.

Krosnick, J. A., Boninger, D. S., Chuang, Y. C., Berent, M. K., & Carnot, C. G. (1993). Attitude strength: One construct or many related constructs? *Journal of Personality and Social Psychology*, 65, 1132–1151.

Kubin, E., Puryear, C., Schein, C., & Gray, K. (2021). Personal experiences bridge moral and political divides better than facts. *Proceedings of the National Academy of Sciences of the United States of America*, *118*(6), e2008389118. https://doi.org/10.1073/pnas.2008389118

Kunda, Z. (1990). The case for motivated reasoning. *Psychological Bulletin,* 108(3), 480–498. https://doi.org/10.1037/0033-2909.108.3.480

Lee, J. Y., Popp, M. P., Wolfe, E. J., Nayga, R. M., Jr, Popp, J. S., Chen, P., & Seo, H.-S. (2018). Information and order of information effects on consumers' acceptance and valuation for genetically modified edamame soybean. *PloS One*, *13*(10), e0206300. https://doi.org/10.1371/journal.pone.0206300

Lenzner, T., Hadler, P., Neuert, C., Klingler, M., Wolf, M., & Sarafoglou, A. (2019). *Demographische Standards* [Demographic Standards]. GESIS - Pretest Lab. https://doi.org/10.17173/PRETEST75

Liu, Ruixin; Wu, Linhai; Shan, Lijie; Li, Hua (2014). Consumer's Risk Perception of Genetically Modified Food and its Influencing Factors: Based on the Survey in Jiangsu Province, China, *The Open Biotechnology Journal*, Vol. 8, 30-35.

Livingston, D. (1969). Science fiction as a source of forecast material. *Futures, 1*(3), 232–238. https://doi.org/10.1016/0016-3287(69)90026-3

Lucas, B. J., & Mai, K. M. (2022). Illumination and elbow grease: A theory of how mental models of the creative process influence creativity. *Organizational Behavior and Human Decision Processes*, *168*(104107), 104107. https://doi.org/10.1016/j.obhdp.2021.104107

Macaulay, A., & Song, W. (2022). Narrative-Driven Fluctuations in Sentiment: Evidence Linking Traditional and Social Media. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4150087

Matsumoto, D., & Ekman, P. (1988). *Japanese and Caucasian Facial Expressions of Emotion (JACFEE) and Neutral Faces (JACNeuF)*. JACNeuF.

Mayring, P. (2015). *Qualitative Inhaltsanalyse: Grundlagen und Techniken* [Qualitative content analysis: basics and techniques]. Julius Beltz.

Mertens, V. M. (2022). Gentechnisch veränderte Pflanzen & mehr Pestizide [Genetically modified crops & more pesticides]. *Heinrich-Böll-Stiftung*. Retrieved December 26, 2022, from https://www.boell.de/de/2022/01/12/gentechnisch-veraenderte-pflanzen-mehr-pestizide

Midi, H., & Bagheri, A. (2010, July). Robust multicollinearity diagnostic measure in collinear data set. In *Proceedings of the 4th international conference on applied mathematics, simulation, modeling* (pp. 138–142). World Scientific and Engineering Academy and Society (WSEAS).

Miles, I. (1993). Stranger than fiction: How important is science fiction for futures studies? *Futures, 25*(3), 315–321. https://doi.org/10.1016/0016-3287(93)90139-k

Misch, A., Kristen-Antonow, S., & Paulus, M. (2021). A question of morals? The role of moral identity in support of the youth climate movement Fridays4Future. *PLOS ONE*, 16(3), e0248353. https://doi.org/10.1371/journal.pone.0248353

Moon, W., & Balasubramanian, S. K. (2004). Public attitudes toward agrobiotechnology: The mediating role of risk perceptions on the impact of trust, awareness, and outrage. *Review of Agricultural Economics*, *26*(2), 186–208. https://doi.org/10.1111/j.1467-9353.2004.00170.x

Nationale Akademie der Wissenschaften Leopoldina. (n.d.). *Thema im Fokus. Das Potenzial der Grünen Gentechnik* [Topic in focus. The potential of green genetic engineering]. Retrieved Dec. 26, 2022, from https://www.leopoldina.org/wissenschaft/gruene-gentechnik/gruene-gentechnik-nutzen/

Nationale Akademie der Wissenschaften Leopoldina, Union der Deutschen Akademien der Wissenschaften, Deutsche Forschungsgemeinschaft. (2019). *Wege zu einer wissenschaftlich begründeten, differenzierten Regulierung genomeditierter Pflanzen in der EU* [Towards a scientifically based, differentiated regulation of genome-edited plants in the EU]. Retrieved Oct. 28, 2022, from https://www.leopoldina.org/uploads/tx_leopublication/2019_Stellungnahme_Genomeditierte_Pflanzen_web.pdf

Nationale Akademie der Wissenschaften Leopoldina, Deutsche Forschungsgemeinschaft, Acatech, Union der Deutschen Akademien der Wissenschaften. (2015). *Chancen und Grenzen des genome editing* [Opportunities and limitations of genome editing]. Retrieved Oct. 28, 2022, from https://www.leopoldina.org/uploads/tx_leopublication/2015_3Akad_Stellungnahme_Genome_Editing.pdf

National Academies of Sciences, Engineering, and Medicine (2016): Genetically Engineered Crops: Experiences and Prospects. Washington, *DC: The National Academies Press*. https://doi.org/10.17226/23395

Nickerson, R. S. (1998). Confirmation bias: A ubiquitous phenomenon in many guises. *Review of General Psychology: Journal of Division 1, of the American Psychological Association*, *2*(2), 175–220. https://doi.org/10.1037/1089-2680.2.2.175

Pearl, Judea. (2009). *Causality: Models, Reasoning, and Inference.* Cambridge: Cambridge University Press.

Pennington, N., & Hastie, R. (1992). Explaining the evidence: Tests of the Story Model for juror decision making. *Journal of Personality and Social Psychology, 62*(2), 189–206. https://doi.org/10.1037/0022-3514.62.2.189

Pennycook, G., & Rand, D. G. (2019). Lazy, not biased: Susceptibility to partisan fake news is better explained by lack of reasoning than by motivated reasoning. *Cognition*, *188*, 39–50. https://doi.org/10.1016/j.cognition.2018.06.011

Pies, I., Waldhof, G. & Valentinov, V. (2021). Diskursblockaden in der Debatte um grüne Gentechnik — Analysen und Reformempfehlungen aus ordonomischer Sicht [Discourse Blockages in the Debate on Green Genetic Engineering - Analyses and Reform Recommendations from an Ordonomic Perspective]. *in: Edmund Rehwinkel-Stiftung der Landwirtschaftlichen Rentenbank (Hrsg.): Green Deal — Was kommt auf die Land- und Ernährungswirtschaft zu?, Schriftenreihe der Rentenbank, Band 37, Frankfurt a.M., S. 93-146.*

Pinker, S. (2018). *The media exaggerates negative news. This distortion has consequences.* Retrieved Jan. 05, 2021, from https://www.theguardian.com/commentisfree/2018/feb/17/steven-pinker-media-negative-news

Pretis, F., Reade, J.J., & Sucarrat, G. (2018). Automated general-to-specific (GETS) regression modeling and indicator saturation for outliers and structural breaks. *Journal of Statistical Software*, *86*(3), 1-44. https://doi.org/10.18637/jss.v086.i03

Qaim, M. (2020). Role of new plant breeding technologies for food security and sustainable agricultural development. *Applied Economic Perspectives and Policy*, *42*(2), 129–150. https://doi.org/10.1002/aepp.13044

R Core Team. (2021). R: A language and environment for statistical computing. *R Foundation for Statistical Computing,* Vienna, Austria. Retrieved Jan. 14, 2023, from https://www.R-project.org/

Ringle, C.M., Wende, S. & Becker, J.M. (2015) *SmartPLS.* SmartPLS GmbH, Boenningstedt. Retrieved Dec. 19, 2022, from http://www.smartpls.com

Roos, M., & Reccius, M. (2021). *Narratives in economics.* ArXiv [Econ.GN]. https://doi.org/10.48550/ARXIV.2109.02331

Royzman, E., Cusimano, C., & Leeman, R. F. (2017). What lies beneath? Fear vs. disgust as affective predictors of absolutist opposition to genetically modified food and other new technologies. *Judgment and Decision Making, 12*(5), 446–480.

Rozin, P. (1999). The process of moralization. *Psychological Science, 10*(3), 218–221. https://doi.org/10.1111/1467-9280.00139

Rozin, P. (2005). The Meaning of "Natural": Process More Important Than Content. *Psychological Science,* 16(8), 652–658. https://doi.org/10.1111/j.1467-9280.2005.01589.x

Rzymski, P., & Królczyk, A. (2016). Attitudes toward genetically modified organisms in Poland: to GMO or not to GMO?. *Food Security,* 8(3), 689–697. https://doi.org/10.1007/s12571-016-0572-z

Schwartz, S. (2007). Value orientations: measurement, antecents and consequences across nations. *In: Measuring attitudes cross-nationally –Lessons from the European Social Survey.* Jowell, R.; Robersts, C.; Fitzgerald, R.; Gillian, E. (eds.). Sage Publications.

Scott, S., Inbar, Y. & Rozin, P. (2019). *In Europe and the United States, Most GE Food Opposition is Moral and Responds Specifically to Moral Countering.* [Manuscript submitted for publication]. Olin Business School, Washington University in St. Louis.

Scott, S. E., Inbar, Y., Wirz, C. D., Brossard, D., & Rozin, P. (2018). An overview of attitudes toward genetically engineered food. *Annual Review of Nutrition,* 38(1), 459–479. https://doi.org/10.1146/annurev-nutr-071715-051223

Scott, S. E., Inbar, Y., & Rozin, P. (2016). Evidence for absolute moral opposition to genetically modified food in the United States. *Perspectives on Psychological Science: A Journal of the Association for Psychological Science*, *11*(3), 315–324. https://doi.org/10.1177/1745691615621275

Scott, S. E., & Rozin, P. (2020). Actually, natural is neutral. *Nature Human Behaviour, 4*(10), 989–990. https://doi.org/10.1038/s41562-020-0891-0

Shayo, M. (2009). A model of social identity with an application to political economy: Nation, class, and redistribution. *The American Political Science Review*, *103*(2), 147–174. https://doi.org/10.1017/s0003055409090194

Shiller, R. J. (2017). Narrative economics. *American Economic Review*, *107*(4), 967–1004. https://doi.org/10.1257/aer.107.4.967

Shiller, R. J. (2019). *Narrative economics. How stories go viral and drive major economic events.* Princeton University Press.

Shiller, R. J. (2020). Popular economic narratives advancing the longest U.S. expansion 2009-2019. *Journal of policy modeling 42(4), 791–798.*

Shweder, R. A., Mahapatra, M., & Miller, J. G. (1987). Culture and moral development. In J. Kagan & S. Lamb (Eds.), *The Emergence of Morality in Young Children* (pp. 1-83). University of Chicago Press.

Shweder, R. A., Much, N. C., Mahapatra, M., & Park, L. (1997). The "big three" of morality (autonomy, community, divinity) and the "big three" explanations of suffering. In A. M. Brandt & P. Rozin (Eds.), *Morality and health* (pp. 119–169). Taylor & Frances/Routledge.

Siegrist, M. (2000). The Influence of Trust and Perceptions of Risks and Benefits on the Acceptance of Gene Technology, *Risk Analysis*, Vol. 20(2), 195-203.

Siegrist, M. (1999). A Causal Model Explaining the Perception and Acceptance of Gene Technology, *Journal of Applied Social Psychology,* Vol. 29(1), 2093-2106. https://doi.org/10.1111/j.1559-1816.1999.tb02297.x

Siegrist, M., Connor, M., & Keller, C. (2012). Trust, confidence, procedural fairness, outcome fairness, moral conviction, and the acceptance of GM field experiments: Trust, fairness, and acceptance of GM field experiments. *Risk Analysis: An Official Publication of the Society for Risk Analysis*, *32*(8), 1394–1403. https://doi.org/10.1111/j.1539-6924.2011.01739.x

Sjöberg, L. (2008). Genetically modified food in the eyes of the public and experts. *Risk Management, 10(3), 168–193. https://doi.org/10.1057/rm.2008.2*

Skitka, L. J., Bauman, C. W., & Sargis, E. G. (2005). Moral conviction: another contributor to attitude strength or something more? *Journal of Personality and Social Psychology*, *88*(6), 895–917. https://doi.org/10.1037/0022-3514.88.6.895

Skitka, L. J., & Bauman, C. W. (2008). Moral conviction and political engagement. *Political Psychology, 29, 29 – 54*.

Skitka, L. J., & Mullen, E. (2002). The dark side of moral conviction. *Analyses of Social Issues and Public Policy,* 2, 35–41.

Sloman, S. (2005). *Causal models: How people think about the world and its alternatives*. Oxford University Press New York.

Sloman, S. A., Fernbach, P. M., & Ewing, S. (2009). Causal models: The representational infrastructure for moral judgment. In D. M. Bartels, C. W. Bauman, L. J. Skitka, & D. L. Medin (Eds.), *Moral judgment and decision making* (pp. 1–26). Elsevier Academic Press. https://doi.org/10.1016/S0079-7421(08)00401-5

Sloman, S. A., & Lagnado, D. (2015). Causality in thought. *Annual Review of Psychology*, *66*(1), 223–247. https://doi.org/10.1146/annurev-psych-010814-015135

Soroka, S., Fournier, P., & Nir, L. (2019). Cross-national evidence of a negativity bias in psychophysiological reactions to news. *Proceedings of the National Academy of*

Sciences of the United States of America, *116*(38), 18888–18892. https://doi.org/10.1073/pnas.1908369116

Spiegler, R. (2020a). Behavioral implications of causal misperceptions. *Annual Review of Economics*, *12*(1), 81–106. https://doi.org/10.1146/annurev-economics-072219-111921

Spiegler, R. (2020b). Can agents with causal misperceptions be systematically fooled? *Journal of the European Economic Association*, *18*(2), 583–617. https://doi.org/10.1093/jeea/jvy057

Spiegler, R. (2021). On the behavioral consequences of reverse causality. In *arXiv [econ.TH]*. http://arxiv.org/abs/2110.12218

Spiegler, R. (2016). Bayesian networks and boundedly rational expectations. *The Quarterly Journal of Economics*, *131*(3), 1243–1290. https://doi.org/10.1093/qje/qjw011

Tanaka, Y. (2004). Major psychological factors affecting acceptance of gene-recombination technology. *Risk Analysis* 24:1575–83.

Tetlock, P. E. (2003). Thinking the unthinkable: Sacred values and taboo cognitions. *Trends in Cognitive Sciences,* 7(7), 320–324. https://doi.org/10.1016/S1364-6613(03)00135-9

Tetlock, P. E., Kristel, O. V., Elson, S. B., Green, M. C., & Lerner, J. S. (2000). The psychology of the unthinkable: taboo trade-offs, forbidden base rates, and heretical counterfactuals. *Journal of Personality and Social Psychology*, 78(5), 853. https://doi.org/10.1037/0022-3514.78.5.853

Then, C., & Bauer-Panskus, A. (2017). Russisches Roulette mit der biologischen Vielfalt [Russian roulette with biodiversity]. *Testbiotech e.V.* Retrieved 19 Apr, 2018, from https://www.testbiotech.org/content/russisches-roulette-mit-der-biologischen-vielfalt

Tosun, J., & Schaub, S. (2017). Mobilization in the European public sphere: The struggle over genetically modified organisms. *The Review of Policy Research*, *34*(3), 310–330. https://doi.org/10.1111/ropr.12235

Trabasso, T., & van den Broek, P. (1985). Causal thinking and the representation of narrative events. *Journal of Memory and Language*, *24*(5), 612–630. https://doi.org/10.1016/0749-596x(85)90049-x

Triandis, H. C. (1995). *Individualism & collectivism.* Westview Press.

Van Dalen, H. P. (2019). Values of economists matter in the art and science of economics. *Kyklos: International Review for Social Sciences*, *72*(3), 472–499. https://doi.org/10.1111/kykl.12208

Van Eenennaam, A. L., De Figueiredo Silva, F., Trott, J. F., & Zilberman, D. (2021). Genetic engineering of livestock: The opportunity cost of regulatory delay. *Annual Review of Animal Biosciences*, *9*(1), 453–478. https://doi.org/10.1146/annurev-animal-061220-023052

Vaish, A., Grossmann, T., & Woodward, A. (2008). Not all emotions are created equal: the negativity bias in social-emotional development. *Psychological Bulletin, 134*(3), 383–403. https://doi.org/10.1037/0033-2909.134.3.383

Venables, W. N., & Ripley, B. D. (2002). *Modern Applied Statistics with S. Fourth Edition.* Springer, New York. ISBN 0-387-95457-0

Ventura, V., Frisio, D. G., Ferrazzi, G., & Siletti, E. (2016). How scary! An analysis of visual communication concerning genetically modified organisms in Italy. *Public Understanding of Science,* 1-17. https://doi.org/10.1177/0963662516638634

Voelkel, J. G., & Feinberg, M. (2018). Morally reframed arguments can affect support for political candidates. *Social Psychological and Personality Science,* 9(8), 917–924. https://doi.org/10.1177/1948550617729408

Waldhof, G. (2022a). *A Structural Approach to Moral Foundations Theory – for Theory Development and a more reliable Application in Latent Content Analyses* [Chapter2, Manuscript submitted for publication]. Department of Socioeconomics, Hamburg University.

Waldhof, G. (2022b). *Opponents and supporters of genetically engineered foods emphasize distinct moral foundations and exhibit a clash of two diverging worldviews* [Chapter 3, Manuscript submitted for publication]. Department of Structural Change, Leibniz Institute of Agricultural Development in Transition Economies.

Warnes, G.R., Bolker, B., Lumley, T., & Johnson, R.C. (2022). *gmodels: Various R Programming Tools for Model Fitting. R package version 2.18.1.1.* [Contributions from Randall C. Johnson are Copyright SAIC-Frederick, Inc. Funded by the Intramural Research Program, of the NIH, National Cancer Institute and Center for Cancer Research under NCI Contract NO1-CO-12400]. Retrieved Jan. 14, 2023, from https://CRAN.R-project.org/package=gmodels

Waytz, A., Iyer, R., Young, L., Haidt, J., & Graham, J. (2019). Ideological differences in the expanse of the moral circle. *Nature Communications*, *10*(1), 4389. https://doi.org/10.1038/s41467-019-12227-0

Wickham, H., & Bryan, J. (2022). *Readxl: Read excel files. R package version 1.4.1.* Retrieved Jan. 14, 2023, from https://CRAN.R-project.org/package=readxl

Yue, C., Zhao, S., Cummings, C., & Kuzma, J. (2015). Investigating factors influencing consumer willingness to buy GM food and nano-food, *J Nanopart Res*, Vol. 17, 283-302. https://doi.org/10.1007/s11051-015-3084-4

Zeileis, A., & Hothorn, T. (2002). *Diagnostic Checking in Regression Relationships. R News 2(3), 7-10.* Retrieved Jan. 14, 2023, from https://CRAN.R-project.org/doc/Rnews/

Zeileis, A. (2004). Econometric computing with HC and HAC covariance matrix estimators. *Journal of Statistical Software,* *11*(10), 1-17. https://doi.org/10.18637/jss.v011.i10

Zeileis, A., & Grothendieck, G. (2005). Zoo: S3 infrastructure for regular and irregular time series. *Journal of Statistical Software,* 14(6), 1-27. doi:10.18637/jss.v014.i06

Zeileis, A., Köll, S., & Graham, N. (2020). Various versatile variances: An object-oriented implementation of clustered covariances in R. *Journal of Statistical Software,* *95*(1), 1-36. https://doi.org/10.18637/jss.v095.i01

Zwick, M.M. (1998). *Wertorientierungen und Technikeinstellungen im Prozeß gesellschaftlicher Modernisierung. Das Beispiel Gentechnik* [Value Orientations and Technology Attitudes in the Process of Social Modernization. The example of genetic engineering.]. Arbeitsbericht 106 edit. der TA-Akademie Stuttgart.