Risk Analysis, Vol. 41, No. 9, 2021 DOI: 10.1111/risa.13633

The Role of Fairness in Early Characterization of New Technologies: Effects on Selective Exposure and Risk Perception

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Previous research suggests that when individuals have limited knowledge to make sense of new or emerging technologies, they may rely more on available cues, such as the fairness of those managing the risks, when developing their attitudinal and behavioral responses to the technology. To examine this further, we designed an online experiment ($N = 1{,}042$) to test the effects of risk managers' nonoutcome fairness on individuals' selective exposure to additional information and perceived risk. As the study context, we used the development of enhanced geothermal systems (EGS), which uses drilling to tap deep underground sources of heat for district heating and electricity and remains low in familiarity among the U.S. public. The results suggest that participants who read about the fair risk manager were subsequently more likely to have positive attitudes toward EGS development. In turn, those with more positive attitudes were more likely to select and read positively valenced articles about EGS, resulting in an indirect effect of the fairness condition. Although this study also explored whether uncertainty moderated this fairness effect on information seeking, it found no evidence. Additionally, when participants were exposed to information featuring fair risk managers, perceived risk decreased, an effect that was mediated by beliefs that EGS was controllable and not dreadful. These results underscore the importance of using practices that will increase nonoutcome fairness in the introduction of new technologies.

KEY WORDS: Fairness; information seeking; risk perception; selective exposure; uncertainty; enhanced geothermal systems

1. INTRODUCTION

Public resistance is a major concern for organizations seeking to promote innovative or novel technologies. During early stages of diffusion, complex technologies often face intense scrutiny from the public trying to understand their risks. Genetically modified (GM) foods, for example, met strong public opposition after receiving intensive coverage and rebuke by the media and activist campaigns in the 1990s (Bonneuil, Joly, & Marris, 2008). During this period, the public's focus of attention shifted from the benefits of the innovation to the risks of the technology, resulting in low acceptance of the technology across Western countries (Mohorčich & Reese, 2019). Exploring the potential for a similar public backlash, research has paid close attention to public perceptions and acceptance of various innovative technologies such as nanotechnology (Besley, Kramer, Yao, & Toumey, 2008; Cobb & Macoubrie, 2004; Schütz & Wiedemann, 2008), cultured meat (Laestadius & Caldwell, 2015; Siegrist & Sütterlin,

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2017), and autonomous vehicles (Brell, Philipsen, & Ziefle, 2019; Hulse, Xie, & Galea, 2018).

Nevertheless, early phases of diffusion are characterized by high levels of uncertainty. Whereas the public may demand reassuring evidence that a proposed technology is safe, legal, or ethical, guidelines do not typically require a "moratorium (on a technology) until all risks are identified and mitigated" (Gutmann, 2011, p. 20), allowing for technologies to advance while soliciting public input. Depending on the technology, reassuring evidence may be time consuming to produce, not readily available, and even if available, remain complicated and uncertain. Under these circumstances, individuals may rely on information easily accessible at the moment to make heuristic[1] judgments about the technology. For example, risk communication literature has documented how individuals use trust toward risk managers as a mental shortcut to judge technologies when these individuals lack the skills to fully comprehend the complexities of these technologies (Earle & Cvetkovich, 1995; Trumbo & McComas, 2003; Visschers & Siegrist, 2008).

In this study, we focus on the role of fairness as a heuristic cue available during early phases of a novel technology's deployment. When conclusive information about a technology's risk is unavailable, individuals may still observe the conduct of scientists and developers promoting the technology and develop impressions about their fairness through both mediated and interpersonal communication (Besley, McComas, & Waks, 2006; McComas, Trumbo, & Besley, 2007). Research suggests that individuals use perceptions about how fairly they are treated as an important cue to resolve uncertainties faced in daily lives (Lind, Kulik, Ambrose, & Park, 1993; van den Bos, 2001a). Accordingly, we seek to understand the effects of fairness on two outcomes that are particularly important during the early phase of a technology's deployment: information-seeking behaviors and risk perceptions.

First, we experimentally manipulate developers' fairness to test its effects on information seeking related to the new technology. Drawing on communication literature on selective exposure to information, we test the effects of fairness mediated via the attitude toward the focal technology. That is, if fairness shapes early attitudes toward a technology, this may have snowballing impacts by motivating biased seeking for either positive or negative information regarding the technology (Fig 1, solid arrows).

[1]We use the word "heuristic" here not in the sense of dual-processing theories in which it is often associated with nonconscious or automatic modes of reasoning. Instead, our use of the term is rooted in the fairness heuristic theory, which posits that individuals use fairness information as a cue to determine whether to defer to authority in the absence of information about the authority's trustworthiness.

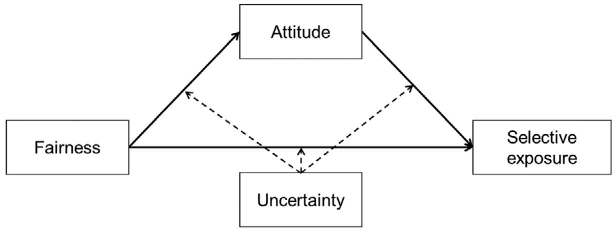

Fig 1. Conceptual model of the effect of experimentally manipulated nonoutcome fairness on selective exposure (solid arrows). The current study also explores whether experimentally manipulated uncertainty moderates this relationship (broken arrows).

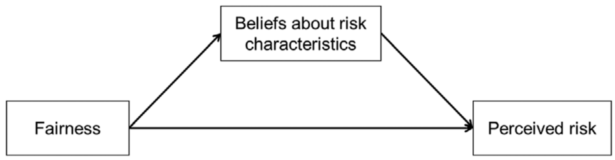

Fig 2. Conceptual model of the effect of experimentally manipulated nonoutcome fairness on perceived risk, mediated by beliefs about risk characteristics, which were beliefs that the risk is uncontrollable, dreadful, unknown to science, increasing, delayed in effects, and unobservable in this study.

Second, these effects of fairness on information seeking may be amplified when individuals are in a state of greater uncertainty caused by the novel nature of the technology. We also use an experimental manipulation to make this uncertainty either more or less salient to test whether uncertainty moderates the effects of fairness on selective exposure (Fig 1, broken arrows).

Finally, drawing on the psychometric paradigm (Slovic, 1987, 2000), we examine how beliefs about the risk's characteristics mediate the effects of fairness on perceived risk. Scant research has explored how perceptions of fairness associated with a technology and its developers influence early characterizations of risk, which may lead to critical downstream consequences such as perceived risk, acceptance of technology, and support for regulatory policies to reduce the risk. As a cue that may become available early to the public, we test how the fairness of developers behind a technology influences perception and characterization of a new technology's risk (Fig 2).

2. BACKGROUND

2.1. Fairness as a Heuristic in Judgments of Risk

Risk communication research has well established that people use various heuristics to make judgments about a hazard's risk even amid uncertainties. For instance, research on the affect heuristic shows that people rely on global affect, a pool of emotions associated with an object, as a heuristic to judge risks in the absence of coherent cognitions (Finucane, Alhakami, Slovic, & Johnson, 2000; Slovic, Finucane, Peters, & MacGregor, 2002). Accordingly, it is likely that early negative cues of a developer's fairness (e.g., aversion of public meetings) can lead to negative judgments about the technology they are promoting (e.g., risk is high and benefits are low).

Social psychological research on the fairness heuristic theory has shown how individuals use impressions about procedural fairness to evaluate authorities' trustworthiness and their decisions (Lind et al., 1993; Lind, Kray, & Thompson, 2001; Tyler, 1997; van den Bos, 2001a). Drawing on these findings, risk communication research has explored the implications of fairness in risk management decisions. Using a conceptual framework established in organizational behavior research (Colquitt, 2001), risk communication scholars have identified mainly four types of fairness—distributive, procedural, interpersonal, and informational. Distributive fairness, also referred to as outcome fairness (Besley, 2010), concerns whether individuals deem the result of a decision (e.g., the distribution of risks and benefits) to be equitable (Besley & McComas, 2005; McComas et al., 2007). On the other hand, the three types of fairness not pertaining to decision outcomes focus on perceptions about the decision process such as whether people feel allowed to voice their opinions (i.e., procedural fairness), the interactional experiences such as whether people feel they are treated with respect by the risk managers (i.e., interpersonal fairness), and the release of information such as whether people feel they received sufficient information regarding the decision (i.e., informational fairness; Besley & McComas, 2005; Colquitt, 2001; Greenberg, 1993; McComas et al., 2007).

Risk communication research on fairness has centered on the role of procedural, interpersonal, and informational fairness (i.e., nonoutcome fairness) in deliberative decision-making processes related to risk. This line of research is predicated on previous work illuminating how people use nonoutcome fairness as a heuristic to decide whether to defer to authorities or evaluate decision outcomes (Lind et al., 1993; van den Bos, 2001a). Although a few studies found that the role of nonoutcome fairness on decision acceptance weakened when issues are infused with strong emotions or moral mandates (Besley, 2012; Earle & Siegrist, 2008; Visschers & Siegrist, 2012), many studies have found a positive relationship between nonoutcome fairness and acceptance of the decision outcome (Besley, 2010, 2012; McComas & Besley, 2011; McComas et al., 2007, 2016; McComas, Besley, & Steinhardt, 2014; McComas, Lu, Keranen, Furtney, & Song, 2016; Siegrist, Connor, & Keller, 2012) or satisfaction with the decision-making process (McComas et al., 2007; McComas, Tuite, Waks, & Sherman, 2007).

2.2. Selective Exposure in Risk Information Seeking

Research on information seeking in risk communication research has mostly studied how much, rather than what kind of, information people seek. Influential models theorizing information-seeking processes in the field such as the risk information-seeking and processing model (RISP; Griffin, Dunwoody, & Neuwirth, 1999; Yang, Aloe, & Feeley, 2014) or the planned risk information-seeking model (PRISM; Ho et al., 2014; Kahlor, 2010; Willoughby & Myrick, 2016) mostly attempt to explain the amount of information people search for related to the hazard. In contrast, the *type* of information people look for has received relatively scant attention despite its potential importance. For example, after reading about a potential disease threatening their health, some individuals may seek information explaining protective measures against the disease, whereas others may selectively look for reassuring evidence that the disease is unlikely to afflict them personally. The latter form of information seeking may be considered as a maladaptive response in which one makes efforts to control the fear about the threat rather than address the threat itself (Witte, 1996).

We posit that in addition to the amount of information, the type of information people seek can also play a critical role in shaping early public opinions about a new technology. In this regard, it is important to understand how people make use of the limited types of cues that are available (e.g., the fairness of developers promoting a technology) when they make sense of a nascent technology and whether they become motivated to selectively expose themselves to certain types of information. In a broad sense, selective exposure refers to “any systematic bias in selected messages that diverges from the composition of accessible messages” (Knobloch-Westerwick, 2014, p. 6). Nevertheless, research has historically reported more on phenomena in which message recipients exercise a confirmation bias, favoring messages consistent with their predispositions such as attitudes (Jonas, Schulz-Hardt, Frey, & Thelen, 2001; Smith, Fabrigar, & Norris, 2008). Theoretical reasoning underlying this type of proattitudinal selective exposure is consistent with the cognitive dissonance theory, which predicts that individuals actively seek to reduce mental discomfort of holding conflicting beliefs or attitudes (Festinger, 1957).

Although a great deal of selective exposure studies focused on people’s pursuit of political information, recent research has begun exploring this phenomenon in the domain of science and risk information. Jang (2014) examined how people’s preexisting attitudes on four controversial technologies—stem cell, evolution, GM foods, global warming—affected their online news seeking behavior using unobtrusive observation. He found that participants were overall more attracted to news stories representing counterattitudinal views than proattitudinal views, an effect driven by articles covering stem cell and GM foods. In contrast, Knobloch and colleagues (2015) found that across four topics—fracking, biofuel, GM foods, and nanotechnology—participants were more likely to seek information congruent with their preexisting attitudes. Similarly, Feldman and Hart (2018) found that conservatives and Republicans were less likely to expose themselves to articles related to climate change relative to liberals–Democrats and moderates–Independents, a pattern mirroring the partisan divide on this issue and reflecting confirmation bias. Meppelink, Smit, Fransen, & Diviani (2019) also found that people preferred online health information articles that were consistent with their prior beliefs about vaccines and also rated such articles superior in quality to those inconsistent with their beliefs. Although evidence for proattitudinal and counterattituidnal selective exposure is somewhat mixed in these studies, research in the domain of politics has generally produced stronger evidence for the presence of proattitudinal selective exposure effects (Garrett, 2009; Knobloch-Westerwick & Meng, 2009; Knobloch-Westerwick, Johnson, Silver, & Westerwick, 2015). Considering how risk communication findings suggest a positive relationship between perceived fairness and favorable attitudes toward new technologies (McComas, Besley, & Yang, 2008; Siegrist et al., 2012; Visschers & Siegrist, 2012), we may hypothesize a positive indirect effect of fairness on selective exposure while attitudes toward the technology mediate this process.

H1a: Participants in the high fairness condition will have more positive attitudes toward EGS development than will those in the low fairness condition. (fairness effect)

H1b: Attitudes toward the technology will be positively related to the valence of the technology information sought for. (proattitudinal selective exposure)

H1c: Fairness will have a positive indirect effect on the valence of the technology-related information sought for, mediated by attitudes toward the technology.

Although we hypothesized an indirect effect of fairness on selective exposure in H1c, this does not necessarily imply a total effect in the same direction. We explore the presence of this total effect in an ancillary test.

RQ1: Does fairness affect the valence of technology-related information participants seek?

2.3. Uncertainty as a Moderator of Fairness Effects on Selective Exposure

Given the presence of mixed evidence in the literature regarding the direction of selective exposure to scientific information, understanding how individual or contextual characteristics influence selective exposure effects could help clarify their underlying processes (Smith et al., 2008). In the present study, we focused on the role of uncertainty characterizing nascent technologies as a potential moderator of fairness effects on selective exposure.

Research that has studied the main effects of uncertainty on information seeking has yielded mixed findings on whether resulting selective exposure serves to confirm or challenge preexisting beliefs and dispositions. Jang (2014), for example, found that those higher in self-assessments of scientific knowledge and religiosity exhibited selective exposure in a more proattitudinal direction. Similarly, Meppelink et al. (2019) reported that those high in health literacy, as measured with a simple quiz examining one's ability to interpret a nutrition label, were more likely to display confirmation bias in vaccine information seeking. These results can be interpreted as showing that those who feel more uncertain about a risk-related subject are inclined to seek counterattitudinal information, possibly motivated by the epistemic goal to learn the "truth."

However, other studies suggest that uncertainty can enhance attitude-confirming information seeking because people are motivated to establish clear positions regarding risky technologies. For example, Sawicki et al. (2011) found that participants who were experimentally primed to feel doubtful tended to engage more in proattitudinal selective exposure than did those who were primed with confidence. Interestingly, this trend was observed only when the topic was a novel issue less familiar to the participants (i.e., nuclear power) and not when the issue was more familiar to the participants (i.e., caffeine consumption). Similarly, another study by Sawicki and colleagues (2013) found that participants feeling that an issue (i.e., junk food tax) was unfamiliar were more likely to engage in proattitudinal selective exposure when they held ambivalent (i.e., conflicting) attitudes toward the issue rather than a univalent one, suggesting a strong motivation among individuals to establish coherent attitudes.

Social–psychological research has also paid attention to the role of uncertainty as a moderator of fairness effects. A number of studies on procedural fairness suggest that people are more likely to use procedural fairness as a cue in judgments under conditions of high uncertainty. These studies argue that, as a means of managing the uneasy feeling of uncertainty (e.g., when an authority's trustworthiness is unknown), individuals rely on procedural fairness information (Lind & van den Bos, 2002; van den Bos & Lind, 2002). For example, after being induced to write about situations in which they felt uncertain, fairness of an authority elicited more pronounced (i.e., extreme) emotional reactions than among those who were not primed with uncertainty (van den Bos, 2001b). Similarly, when asked about their support for a proposed water quality policy, community residents who felt they had low knowledge in environmental issues were more likely to rely on procedural fairness as a judgment cue relative to residents who felt they had high knowledge (See, 2009). Bearing important implications for nascent technologies, research also suggests that procedural fairness has a particularly large effect on judgments in earlier stages of interactions with authorities rather than later (Lind et al., 2001). Nevertheless, it remains unclear whether uncertainty would also moderate the fairness effects on selective exposure, and if so, whether such moderation would further amplify or attenuate the proattitudinal selective exposure effects of fairness hypothesized in H1b and H1c.

RQ2: Does uncertainty moderate proattitudinal selective exposure effects driven by exposure to fairness cues?

2.4. Fairness, Perceived Risk, and Beliefs of Risk Characteristics

Relatively few studies have focused on the relationship between fairness and perceived risk, which is curious considering how risk perceptions could be a more proximal outcome than decision acceptance, possibly mediating the effects of fairness on the latter construct. Although some studies have considered how procedural fairness is related to concern about risks (McComas & Besley, 2011; McComas et al., 2008) or reported the negative correlation between nonoutcome fairness and perceived risk (McComas et al., 2007, 2014; Ross, Fielding, & Louis, 2014; Siegrist et al., 2012), empirical evidence in these studies has mostly come from correlational data, making it difficult to specify the causal direction among key variables. Ample research suggests that trust, which is positively associated with fairness (Cvetkovich & Nakayachi, 2007; Kunreuther, Easterling, Desvousges, & Slovic, 1990; McComas et al., 2008; Mercer-Mapstone, Rifkin, Louis, & Moffat, 2018; Poortinga & Pidgeon, 2003; Sjöberg & Drottz-Sjöberg, 2001), is often negatively correlated with risk perceptions (Hung & Wang, 2011; Needham & Vaske, 2008; Visschers & Siegrist, 2008; Wachinger, Renn, Begg, & Kuhlicke, 2013). In a review of 45 empirical studies, Earle, Siegrist, and Gutscher (2007) found an overall negative effect of trust on risk perception. It thus appears reasonable to hypothesize a negative effect of fairness on perceived risk but the causal direction of this relationship must be better established with experimental evidence.

H2: Participants in the high fairness condition will perceive lower levels of risk toward a new technology than will those in the low fairness condition.

Furthermore, research needs to better clarify the underlying processes by which perceived fairness affects perceived risk, if at all. The psychometric paradigm of risk perceptions has shown how characterization of risky technologies and activities relates to perceived risk. After asking participants to rate risky activities on a list of characteristics (e.g., observability, controllability), these researchers extracted two factors, dread risk and unknown risk, the former of which was positively related to perceived risk and support for regulatory policies to reduce the risk (Slovic, 1987; Slovic, Fischhoff, & Lichtenstein, 1979). As a framework for studying sources of risk perception, the paradigm has been applied to a wide variety of contexts, facilitating understanding of how lay perceptions of risk differ from experts' (Lee, Mehta, & James, 2003; Slovic et al., 1995) and how different types of hazards compare against each other in perceived risk (Bostrom, 2008; Roth, Morgan, Fischhoff, Lave, & Bostrom, 1990).

Drawing on this approach, we tested the mediating effects of six risk characteristics judged to be relevant to our study context. Controllability and dreadfulness were chosen because these beliefs are linked to the catastrophic potential of seismic activity risks previous research has deemed important (Fernandez, Tun, Okazaki, Zaw, & Kyaw, 2018; Ho, Shaw, Lin, & Chiu, 2008; McClure, Walkey, & Allen, 1999; Ozdemir & Yilmaz, 2011). With implications particularly relevant to fairness, research applying the psychometric paradigm at the individual level found controllability to be associated with personal ability to reduce the risk and exercise choice in accepting the risk (Trumbo, 1996). Beliefs about whether the risk was known to science and increasing were measured to capture judgments about the initial status and trend of the risk which could be especially relevant to nascent technologies. The survey also asked whether the effects were immediate or delayed, which might be relevant to individuals' capacity to cope with the hazard's uncertainty and defer protective action to the future. Finally, observability of the risk was included to examine differences across individuals to viscerally process the risk associated with seismicity or other aspects of the technology.

RQ3: Do beliefs about risk characteristics (i.e., uncontrollable, dreadful, unknown to science, increasing, delayed, unobservable) mediate the effects of fairness on perceived risk?

2.5. Context of the Study

As the context of this study, we used an energy technology little known to the American public called enhanced geothermal systems (EGS; see below for evidence of low familiarity). Not to be confused with conventional geothermal methods, which extract heat energy from sources close to the Earth's surface such as naturally heated underground water, EGS uses drilling technologies similar to those of hydraulic fracturing to tap sources of heat that may sit several kilometers deep. This process enables geothermal operations to take place outside traditionally exploited areas with good surface-level heat sources such as active plate boundaries. Although EGS could serve as a scalable source of clean and renewable energy, it also poses risks of induced seismicity associated with its drilling and injection processes (Grigoli et al., 2018; Kim et al., 2018). With full-scale commercialization yet to be realized, knowledge of this technology presumably remains obscure among the public (Knoblauch, Trutnevyte, & Stauffacher, 2019). To test how fairness cues can influence proattitudinal selective exposure to information and early perceptions of novel risks, the current study manipulated the fairness of EGS developers deploying the technology in local communities and the uncertainty associated with EGS technology.

3. METHOD

The study was a 2 (fairness: high vs. low) × 2 (uncertainty: high vs. low) between-subjects factorial design experiment established online on Qualtrics in two parts. During the first part, participants read articles delivering experimental manipulations and completed the questionnaire. During the second part, participants carried out the information-seeking task while their click-through behaviors were unobtrusively recorded.

3.1. Participants

We recruited participants from Amazon MTurk with a payment of $2.50, and collected 1,150 complete responses. Because we used MTurk settings to limit participants to U.S. adults aged 18 or above, we excluded responses linked to GPS coordinates outside the United States, resulting in an analytic sample size of 1,042. Participants were 53% female, 75% white, and 37 years old in age on average. Slightly less than half of the participants (48%) had a bachelor's degree or higher, and about half of the participants (51%) identified themselves as middle class or higher. Median household income was in the $35,000–$49,999 bracket. About half of the participants identified (49%) as lower or lower middle class while another 44% identified as middle class. In accordance with our presupposition about the context, participants reported low familiarity with EGS technology on a 1 (low) to 7 (high) scale, $M = 1.89$, $SD = 1.34$. About 56% leaned at least somewhat liberal in contrast to 28% leaning at least somewhat conservative. To ensure variance in baseline uncertainty with seismic events, we also recruited about half of our participants from states with relatively high frequency of earthquakes (Alaska, Arizona, Arkansas, California, Colorado, Hawaii, Idaho, Kansas, Montana, Nevada, Oklahoma, Texas, Utah, Washington, Wyoming)[2] using MTurk settings.

3.2. Procedure

3.2.1. Uncertainty Manipulation

In the first message, participants read a simulated online news article including a descriptive overview about how EGS technology works. The article was titled "What Are Enhanced Geothermal Systems? Renewable Energy Source Delivers Promise." The first page of the article explained how EGS taps heat sources beneath the Earth's surface and what benefits this might bring. It also included a schematic diagram showing how EGS systems work alongside text explaining the technology's differences from conventional geothermal technology such as the use of deep drilling and water injection.

The second page of this article manipulated uncertainty while introducing the risks of this technology. In both the high and low uncertainty conditions, the text explained that risks of water loss and seismicity related to subsurface pressure changes were present but limited (e.g., "only detected by sensitive seismometers"). The high uncertainty condition explicitly added caveats to this description that there are uncertainties with this technology and that the strength of earthquakes can depend on factors such as fault structures. It also added that leading experts often disagree about earthquake risk estimates. However, these caveats were omitted in the low uncertainty condition. In addition, whereas the header of the second page in the low uncertainty condition simply read "Seismicity and water use may be minimal," the header of this page in the high uncertainty condition also included a conditional clause, "but it depends." While the article was created for the purposes of this study, it was reviewed by experts in EGS to ensure its scientific accuracy.

3.2.2. Fairness Manipulation

The second message manipulated the fairness of the EGS developers. In the high fairness condition, the article was titled, "EGS Development in Local Communities: Developers Known for Working Closely with Residents." The content of this article described how developers made considerable effort to discuss the technology through meetings, paying close attention to community members, which allowed them to "understand the concerns of the locals and address these problems beforehand." On the other hand, in the low fairness condition, the article provided a technocratic portrayal of the developers with the subtitle reading "Developers known for ensuring technical soundness." In contrast to developers in the high fairness condition, these developers were described as expending considerable effort in "simulated tests to obtain safety licenses," allowing them to "bypass community consent which is required for many other similar energy development projects."[3] This low fairness stimulus was designed to reflect the intertwined nature of nonoutcome fairness elements. Developers taking the technocratic approach here simultaneously disable opportunities for community members to express opinions (procedural fairness) and exhibit reluctance to share important information (informational fairness), both of which could signal snub and disrespect to community members (interpersonal fairness).

[2]These are 15 states that ranked highest in the tally of earthquakes by state 2010–2015 (M3+) according to the United States Geological Survey (2016).

[3]In addition to these two messages, an interactive block was included as a procedure to enhance the personal relevance of EGS. Participants first were led to believe that they were running a query through the U.S. Geological Survey (USGS) and the Department of Energy (DOE) database to see if EGS development would take place in their area soon. Results would always indicate that "there is an 80% chance that EGS development will occur in your area within the next 10 years." We randomized the order of the first message and interactive block for relevance enhancement. We collapsed the data from the two different orderings, following our data analysis finding no interaction or main effects of this ordering on our manipulation checks (i.e., perceived fairness) and dependent variables (i.e., perceived risk, risk characteristics, information-seeking).

3.2.3. *Information-Seeking Task*

Following completion of the questionnaire introduced after reading the two messages, participants entered the second part of the study, a news forum with a list of simulated news article headlines. They were instructed to select any of the headlines that they found interesting and take as much time as they would want to read the article. Although fictitious, these simulated articles were modeled after actual news stories covering EGS or other energy technologies. After reading an article, participants could either return to the main menu to choose other articles to read or stop reading to end the session. Thus, by study design, all participants had to choose and read at least one article before proceeding to the debriefing page.

In the forum, a list of eight news items appeared under the title "Enhanced Geothermal Systems News Bulletin" at the top with the titles and subtitles of each news item presented in randomized order (see the Appendix for the full list of news items). Among the eight news items, four were written to be positive stories about EGS or its developers while the other four were negative stories. The titles and subtitles in the list page clearly communicated the valence of each article's tone (i.e., positive or negative). At the bottom of each article, participants were asked if they wanted to read other articles about EGS or end the session. Upon expressing their preference to end the session, participants received a thorough debriefing message explaining the true purpose of the study, the fictitious parts of experimental stimuli, and how to receive their compensation.

3.3. Measurement

3.3.1. *Perceived Risk*

To measure perceived risk, we followed previous approaches that operationalized the construct as comprising elements of probability and severity assessments of risk (Rosen & Kostjukovsky, 2015; Yang, 2016). Agreement with two items were measured on a 7-point scale: "The negative consequences of EGS development in my town will be severe" and "The likelihood that EGS development in my town will pose great threat is high." These two items were reliable (Spearman–Brown: 0.912) and averaged into a scale of perceived risk.

3.3.2. *Risk Characteristics Beliefs*

To assess how fairness cues affect characterization of risk, we used a semantic differential scale with six scale points. Six items asked whether participants would describe the risk of EGS as (1) *controllable/uncontrollable*, (2) *dreadful/not dreadful*, (3) *unknown to science/known to science*, (4) *increasing/decreasing*, (5) *immediate effects/delayed effects*, and (6) *observable/unobservable* (items 2, 3, 4 reverse-coded). Applying the two-factor structure reported by Slovic (1987), neither the dread risk factor (items 1, 2, 4; $\alpha = 0.688$) nor the unknown risk factor (items 3, 5, 6; $\alpha = 0.475$) comprised reliable scales. Also, the six items were not reliable as a single scale ($\alpha = 0.698$). Accordingly, we treated each item as a separate characteristic in further analyses.

3.3.3. *Attitude Toward Technology*

Attitude toward EGS technology was measured with a single item, asking the extent to which one would support or oppose EGS development in one's town. This measure fits the definition of attitudes as a "psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor" (Eagly & Chaiken, 1993, p. 1), and is consistent with previous approaches, which categorized policy support as a type of attitude (Talaska, Fiske, & Chaiken, 2008). Responses were measured using a 7-point Likert-type scale (1 = *strongly oppose*, 7 = *strongly support*).

3.3.4. *Information Search Valence*

We calculated an index of information search valence with unobtrusively recorded data using an established approach (Sawicki et al., 2011). We subtracted the number of negative articles from the number of positive articles chosen by each participant and divided this number by the total number of articles selected. Thus, the value of this index ranged from −1 (selected only negative articles) to +1 (selected only positive articles). We considered a group as engaging in proattitudinal selective exposure to the extent that attitude toward technology and information search valence were in a positive relationship.

3.3.5. *Manipulation Check*

To determine whether our fairness manipulation was successful, we included four items asking participants to rate how fair, just, unbiased, and respectful the local developers were toward local residents using a slide bar scale of 0 to 100. The four items were reliable ($\alpha = 0.88$), and averaged into a single scale

Table I. Descriptive and Inferential Statistics of Dependent and Mediating Variables, Overall and between Fairness Conditions

			Overall ($n = 1{,}042$) vs. Midpoint		Low Fairness $n = 534$		High Fairness $n = 508$			
Dependent Variable	*M*	*SD*	*t*(1,040)	*p*	*M*	*SD*	*M*	*SD*	*t*(1,040)	*p*
Risk characteristics (1–6)										
Uncontrollable	3.37	1.40	2.93	0.003	3.49	1.38	3.25	1.42	2.66	0.008
Dreadful	3.12	1.31	9.39	<0.001	3.22	1.31	3.02	1.31	2.46	0.014
Unknown to science	3.17	1.40	7.54	<0.001	3.26	1.42	3.08	1.38	2.16	0.031
Increasing	3.71	1.20	5.66	<0.001	3.77	1.15	3.64	1.25	1.59	0.112
Delayed effects	4.04	1.22	14.46	<0.001	4.04	1.22	4.06	1.22	0.28	0.776
Unobservable	2.87	1.29	15.63	<0.001	2.94	1.30	2.80	1.28	1.81	0.071
Perceived risk (1–7)	3.11	1.51	19.05	<0.001	3.24	1.51	2.97	1.50	2.92	0.004
Attitude toward EGS (1–7)	4.85	1.72	15.83	<0.001	4.70	1.79	5.00	1.64	2.80	0.005
Information search valence (−1 to +1)	−0.31	0.85	11.56	<0.001	−0.29	0.86	−0.32	0.85	0.57	0.567

Note. T-test results for overall sample are one-sample *t*-tests against the scale midpoint for each variable. *T*-test results right to the two fairness columns are independent sample *t*-tests comparing the two conditions.

of perceived fairness. Also, as a check for the manipulation of uncertainty, a single item asked the extent to which one thinks there is uncertainty around the level of seismicity caused by EGS (1 = *no uncertainty at all*, 7 = *a great deal of uncertainty*).

3.4. Data Analysis

We used IBM SPSS Statistics Version 25 to run analyses in the family of general linear models. Mediation and moderated mediation analyses were executed using PROCESS module for SPSS version 3.1 (Hayes, 2018).

4. RESULTS

The manipulation checks indicated that manipulations for fairness and uncertainty were successful. The high fairness condition reported higher levels of perceived fairness, $M = 61.85$, $SD = 19.00$, than did the low fairness condition, $M = 45.17$, $SD = 22.45$, $t(1{,}040) = 12.91$, $d = 0.80$, $p < 0.001$. The high uncertainty condition reported higher levels of perceived uncertainty, $M = 4.82$, $SD = 1.40$, than did the low uncertainty condition, $M = 4.37$, $SD = 1.55$, $t(1{,}040) = 4.93$, $d = 0.30$, $p < 0.001$.

One-sample *t*-tests of dependent variable means indicated that, overall, relative to the scale midpoint (= 3.5), participants characterize EGS as a risk that was controllable, not dreadful, known to science, increasing, delayed in effects, and observable. On average, perceived risk was lower than the scale midpoint (= 4), attitude toward EGS was more positive than the midpoint (= 4), and the valence of searched information was negative (Table I).

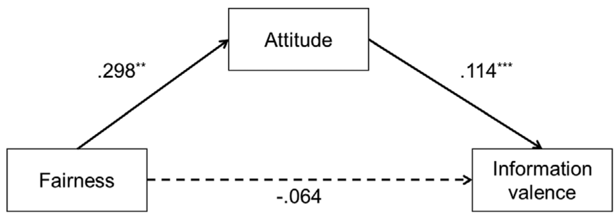

Fig 3. Model of the indirect effects of fairness on proattitudinal selective exposure operationalized as information search valence, mediated by attitude toward EGS. Indirect effect was statistically significant, bootstrapped 95% CI: [0.010, 0.060]. Path coefficients are unstandardized. Paths with broken arrows are not statistically significant. $^{***}p < 0.001$, $^{**}p < 0.01$.

H1a predicted that participants in the high fairness condition would express more positive attitudes toward EGS than would those in the low fairness condition. An independent sample *t*-test supported this hypothesis, $t(1{,}040) = 2.80$, $p = 0.005$, $d = .17$. H1b hypothesized that attitude toward EGS and valence of sought-for information would be positively correlated. This was also supported, $r(1{,}042) = 0.23$, $p < 0.001$. H1c predicted that attitudes toward EGS would mediate the relationship between fairness and information search valence in a pattern consistent with proattitudinal selective exposure. A mediation analysis using Model 4 of PROCESS (Fig 3) with 5,000 bootstrap samples found support for this hypothesis as reading about fair developers had a

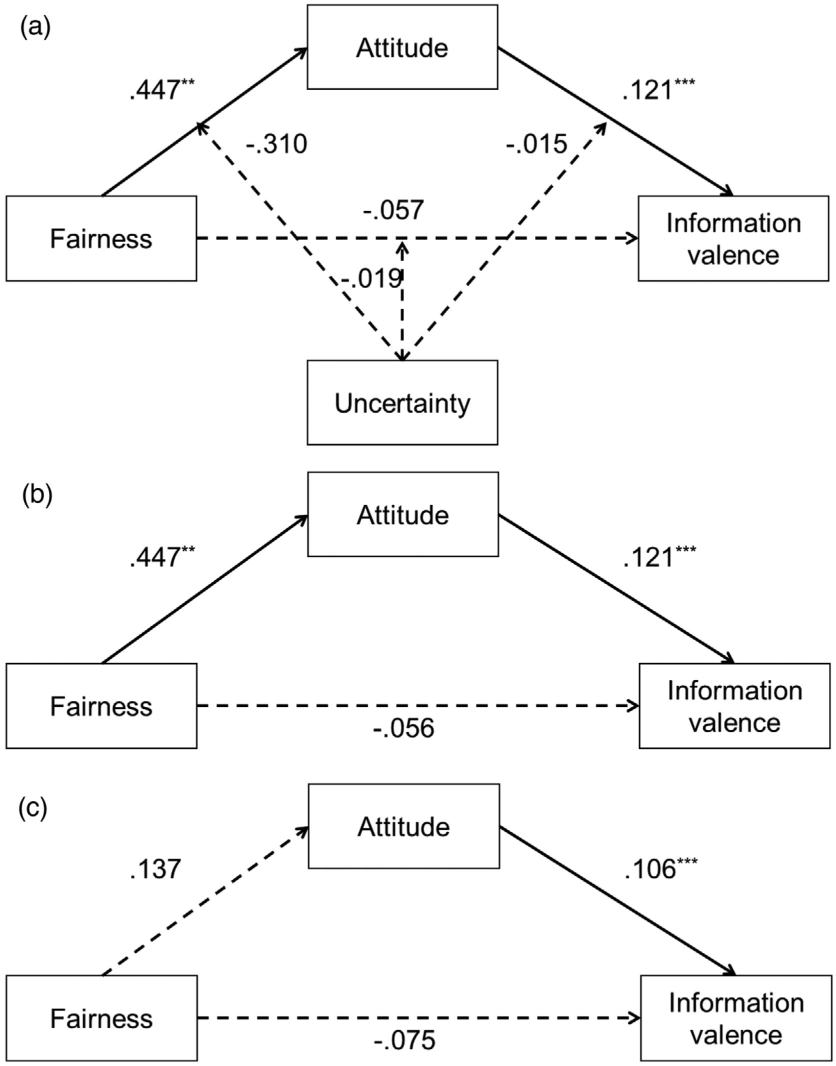

Fig 4. (a)–(c). Model of the indirect fairness effects on proattitudinal selective exposure operationalized as information search valence, moderated by uncertainty associated with EGS. Model (a) represents the moderated mediation tested. Models (b) and (c) are simple mediation models for participants in the low and high uncertainty conditions, respectively. Index of moderated mediation was not statistically significant, bootstrapped 95% CI: [−0.092, 0.008]. Path coefficients are unstandardized. Paths with broken arrows are not statistically significant. $^{***}p < 0.001$, $^{**}p < 0.01$.

positive indirect effect on information search valence mediated by attitude toward EGS, bootstrapped 95% CI: [0.010, 0.060]. Controlling for this indirect effect, the direct effect of fairness on information search valence was not significant, bootstrapped 95% CI: [−0.165, 0.037]. When these two effects were added, answering RQ1, the total effect was not significant, $t(1{,}040) = 0.57$, $p = 0.567$.

RQ2 asked whether uncertainty moderates the effect of fairness on proattitudinal selective exposure. Using Model 59 of PROCESS, we tested the moderating effects of uncertainty by adding this as a moderator of the two relationships comprising the indirect effect as well as the direct effect in the simple mediation model used to test H1c (Fig 4a). In the low uncertainty condition, the indirect effect of fairness on information search valence via attitude was significant, bootstrapped 95% CI: [0.019, 0.097]. In the high uncertainty condition, this indirect effect was not significant, bootstrapped 95% CI: [−0.017, 0.048]. However, the index of moderated mediation indicated that the moderating effect of uncertainty between the two conditions was not significant, bootstrapped 95% CI: [−0.092, 0.008]. Contrasts of models between the two uncertainty conditions (Figs 4b and 4c) suggested that the effect of fairness on attitudes was significant in the low uncertainty condition, $b = 0.45$, $SE = 0.15$, $p = 0.002$, but not in the high uncertainty condition, $b = 0.14$, $SE = 0.15$, $p = 0.375$, although the difference between these two coefficients was not statistically significant, $b = 0.31$, $SE = 0.21$, $p = 0.144$.

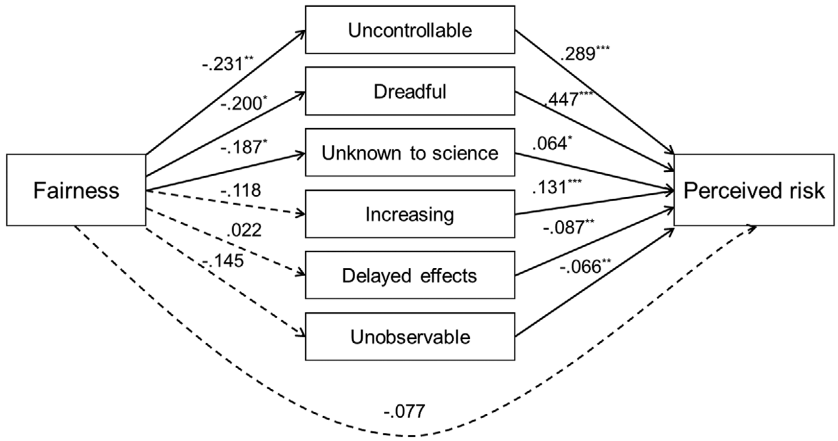

Fig 5. Model of fairness effects on perceived risk of EGS, mediated by risk characteristics beliefs. Indirect effects mediated by two risk characteristics beliefs emerged: uncontrollable, bootstrapped 95% CI: [−0.117, −.018] and dreadful, bootstrapped 95% CI: [−0.164, −0.018]. Path coefficients are unstandardized. Paths with broken arrows are not statistically significant. $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$.

H2 predicted that exposure to a description of EGS featuring fair developers would lead to lower levels of perceived risk. An independent sample *t*-test found support for this hypothesis, $t(1{,}040) = 2.91$, $p = 0.004$, $d = 0.18$, with participants in the high fairness condition perceiving lower risk than those in the low fairness condition. To answer RQ3, we examined whether the risk characteristics mediated the effects of fairness manipulation on perceived risk. The six characteristics were entered as parallel mediators using Model 4 of the PROCESS module with 5,000 bootstrap samples. In the resulting model (Fig 5), fairness reduced beliefs that EGS was uncontrollable, $b = -0.23$, $SE = 0.09$, $p = 0.008$, dreadful, $b = 0.20$, $SE = 0.08$, $p = 0.014$, and unknown to science, $b = -0.19$, $SE = 0.09$, $p = 0.031$. From these, two indirect effects of fairness on perceived risk emerged, mediated by the beliefs that the risk was uncontrollable, bootstrapped 95% CI: [−0.117, −0.018], and dreadful, bootstrapped 95% CI: [−0.164, −0.018], respectively. Controlling for the effects of the six mediators, the direct effect of fairness on perceived risk was not significant, bootstrapped 95% CI: [−0.215, 0.060].

As a *post hoc* analysis, we sought to combine our findings regarding the effects of fairness on proattitudinal selective exposure and perceived risk into a sequential mediation model. Following general wisdom in the field that perceived risk is an important antecedent of attitudes toward or acceptance of a technology (Paek & Hove, 2017), we tested perceived risk and attitude toward EGS as sequential mediators between fairness and information search valence using PROCESS Model 6 (Fig 6) with 5,000 bootstrap samples. The indirect effect mediated by perceived risk and attitude toward EGS was significant, bootstrapped 95% CI: [0.006, 0.041], but the two other indirect effects bypassing either of the mediators were not (fairness → perceived risk → information search valence: bootstrapped 95% CI: [−0.006, 0.026]; fairness → attitude → information search valence: bootstrapped 95% CI: [−0.007, 0.023]). That is, participants who read about the fair developers perceived less risk, which led to more positive attitudes toward EGS. Positive attitudes toward EGS, in turn, predicted seeking of more positive articles about EGS.

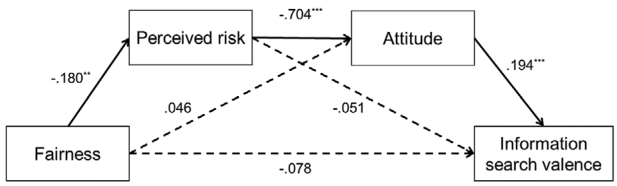

Fig 6. *Post hoc*model with perceived risk of and attitude toward EGS as sequential mediators in the indirect effect of fairness on proattitudinal selective exposure. Fairness had an indirect effect on information search valence only through both of these sequential mediators, bootstrapped 95% CI: [0.006, 0.041]. Path coefficients are unstandardized. Paths with broken arrows are not statistically significant. $^{***}p < 0.001$, $^{**}p < 0.01$.

5. DISCUSSION

Introducing a new technology to the public, especially those who will be exposed to its potential risks, is a communicative act. In democratic political systems, determining a technology's place in the society will often involve iterative deliberation among developers, risk managers, and the public. During early phases of the technology's diffusion, the social nature of these communicative acts will inevitably yield some cues besides the technology's own benefits and risks, which can also influence the public's attitude toward the technology. That is, the public may judge the behaviors of the developers promoting the technology and use such observations as cues guiding global judgments, especially when the technology is novel or complicated.

Overall, findings from this study add rare experimental evidence to the growing risk communication literature of fairness showing that cues indicative of risk managers' fairness can influence people's understanding of and orientation toward nascent technologies. Using a relatively unknown renewable energy technology, we manipulated the fairness of the developers operating in local contexts and the level of uncertainty associated with the technology. We tested the effects of fairness on selective exposure and perceived risk, outcomes presumably important in shaping early public opinions on new technologies, and the effects of uncertainty as a moderator of fairness effects on selective exposure.

Fairness positively influenced attitudes toward EGS, which led to selective exposure to more positive news articles about EGS. However, in discordance with findings reported in literature, uncertainty did not moderate the direction or degree of selective exposure tendencies. Although the findings may reflect a true irrelevance of uncertainty in how people appreciate fairness in contexts of nascent technologies, these findings may only pertain to the study's particular operationalization of uncertainty. For example, Poortvliet and Lokhorst (2016) distinguished experiential uncertainty, which places emphasis on one's affective responses experiencing uncertainty, from more cognitive conceptualizations of uncertainty (e.g., statistical uncertainty) and found that under high experiential uncertainty, open (vs. non-open) government communication induced greater positive effects on trust. In addition, because our uncertainty manipulation was subtle in effect size ($d = 0.30$), using alternative operationalizations may result in different findings in moderation effects on fairness. Future research can explore the role of different types of uncertainty in risk-related fairness to reach a more complete understanding of this subject.

Our findings indicate that fairness had a negative total effect on perceived risk, which was mediated by beliefs characterizing EGS as uncontrollable and dreadful. Although the overall indirect effect was not significant, fairness also decreased the belief that EGS was unknown to science, which was positively related to perceived risk. These particular mediation paths might concern what fairness signals in contexts of local energy development. Participants in the low fairness condition might have felt that the developers deprived community members' means to influence the siting decision (uncontrollable) by seeking to bypass community consent. Developers avoiding communication with the community could also validate suspicions that EGS operations might lead to severe accidents (dread) or that the developers do not have sufficient satisfactory answers to community members' concerns (unknown to science). Among these mediators, controllability and dread were two characteristics loading on the dread factor in the psychometric paradigm, which had profound downstream effects on perceived risk as well as other attitudes and behaviors (Mullet, Duquesnoy, Raiff, Fahrasmane, & Namur, 1993; Slovic, 1987). The signal value of fairness on other risk characteristics might have been less evident. For example, evaluating whether a risk is increasing or imminent requires temporal information, which is likely absent from a cross-sectional impression of fairness.

We acknowledge that the effect of fairness on selective exposure was only indirect, mediated by perceived risk and attitudes toward EGS and modest in size (bootstrapped 95% CI: [0.010, 0.060] on a scale of -1 to 1). Similarly, the size of the effect of fairness on perceived risk was small ($d = 0.18$). However, we also note that this might relate to our particular experimental manipulation, in which the low fairness condition message featured a technocratic risk manager with positive attributes not found in the high fairness condition. To rigorously isolate the effects of fairness, we sought to keep the message's tone toward EGS developers positive in both conditions. Accordingly, instead of featuring plainly vile developers that could easily invite condemnation in the low fairness condition, we depicted developers as dedicated to "technical soundness" instead of fairness. These two positive attributes are not mutually exclusive and experimental contrasts that control for the developers' technical commitment across conditions could produce greater effects than ours. One should also be careful interpreting the fairness effects we found as exclusively pertaining to nonoutcome fairness because our manipulation check did not allow us to rule out possible changes in perceptions of distributive fairness, despite our intentions to influence mainly nonoutcome fairness. We also note that our findings, based on an online convenience sample, cannot be generalized to the larger U.S. public. Although MTurk tends to afford a demographically diverse pool of generally conscientious and honest participants (Paolacci & Chandler, 2014), the sample is not representative of any group of the larger public.

In sum, our findings echo the general wisdom that has been preached in the public participation literature for decades that the public should be involved early in a fair process for successful decision making on risky subjects (Kunreuther, Fitzgerald, & Aarts, 1993; National Research Council, 1996, 2008). Doing so is not simply the right thing to do in a democratic society, but, in a more instrumental argument (Fiorino, 1990), also leads to important downstream processes that shape the public's characterization, perceptions, and information searching tendencies regarding the risk more favorably. Future research may further detail how these processes take place in actual risk management cases using alternative methodological approaches.

ACKNOWLEDGMENTS

This research was funded by the Cornell Atkinson Center for Sustainability.

APPENDIX

List of news items in the information search task (order randomized for each participant).

- **EGS developers issue "good neighbor" standards**

Binding rules expected to promote fair business conduct in communities

- **EGS companies sign declaration on community engagement**

Clear industry commitment to uphold community interests

- **Town sued for banning enhanced geothermal talk**

Anti-EGS groups condemn silencing of affected local residents

- **Pro-EGS lobby bribes local landowners to buy support**

Lobby group offers trips to landowners to fill public hearing with EGS supporters

- **Geothermal quake risks must be faced**

EGS drilling could cause earthquakes with severe consequences

- **Why enhanced geothermal is the new fracking**

New energy source bears striking similarities with natural gas extraction

- **Enhanced geothermal: The holy grail**

New technology is suitable to be the workhorse of the world's electrical system

- **EGS: Impressive advances in renewable energy technology**

Technology enables constant generation and heating possible almost everywhere

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