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Fictional scenarios, real concerns: science fiction and perceptions of human genome editing

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Abstract

This research addresses the association between attention to science fiction and public opinion of human genome editing (HGE). Using a nationally representative survey, our results show that attention to science fiction is associated with both risk and benefit perception of the technology. In addition, results show that, at higher levels of attention to science fiction, the levels of concern from conservatives (ordinarily predisposed to negative views toward science) and from liberals (ordinarily predisposed to positive views toward science) come closer to being the same. This research contributes to our understanding of debates about controversial science.

Keywords

Public engagement with science and technology; Public perception of science and technology

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The plot in BBC America's science fiction series *Orphan Black* focuses on a set of characters who discover that they are genetically identical clones. In one episode, a clone sits at a computer as her genetic code is revealed letter-by-letter. The screen shows the usual: G, A, T, C. However, the last line catches her attention: "This organism and derivative genetic material is restricted intellectual property". As it turns out, the clones are the unwitting participants in a science experiment for a corporation intent upon "perfecting" humanity by altering human genetics.

Although the genetic technologies in *Orphan Black* are imaginary, this study focuses on connections between attention to science fiction and perceptions of the real technology of human genome editing (HGE). We are concerned with science fiction because it directly addresses the social aspects of science, such as power and politics [Maynard, 2018], and frequently offers vivid pictures of science and of scientists. Further, science fiction also offers nonexperts with a way to think about genetics and science more broadly: evidence shows that nonexperts use science fiction metaphors and narratives as a means to express their beliefs about genetics

and to make sense of the technology [Roberts, Archer, DeWitt & Middleton, 2019], meaning science fiction could be useful for engagement purposes.

Using the cultivation framework, which centers on the idea that television cultivates a social reality for citizens, particularly citizens who have higher television consumption levels [Gerbner, 1987], this study asks if science fiction would be associated with perceptions of HGE. In other words, does science fiction cultivate perceptions of HGE? Another aspect of cultivation concerns how heavy consumption of television can diminish differences in views between subgroups where differences would otherwise be expected [Gerbner, Gross, Morgan & Signorielli, 1980]. Today, there are several deep divisions among subgroups as they concern science, such as political affiliation, religiosity, and deference to scientific authority (further discussed below), all of which are associated with positive or negative perceptions of science. This study asks if attention to science fiction diminishes differences in perceptions of HGE among these subgroups.

Using a large-scale ($N = 1,600$), representative sample, this research extends our understanding of the relationship between attention to science fiction and public opinion, as results show that attention to science fiction was positively associated with risk and benefit perceptions of HGE. Results also show that, at higher levels of attention to science fiction, views of HGE from liberals and conservatives come closer together. Ultimately, our findings suggest that science fiction shouldn't be sidelined when it comes to understanding views of scientific issues.

Context

Human genome editing

Before moving on, a brief explanation of the technology is useful. Gene editing technologies like CRISPR (an acronym for "clustered regularly interspaced short palindromic repeats") offer unprecedented ways to manipulate genes in plants, animals, and human beings [National Library of Medicine, 2022]. Gene-editing technologies have potential benefits, such as enabling the development of therapeutic or preventive measures for many diseases and conditions, but also risks, such as catastrophic health effects for persons receiving gene-editing treatments. Moreover, there are ethical issues, such as germline editing where future children have no opportunity to consent to treatment [National Academies of Sciences, Engineering, and Medicine, 2017].

Though gene-editing technologies had been around for some time, in late 2015, *Science* magazine named CRISPR as its Breakthrough of the Year [Science News Staff, 2015]. Around the same time, the National Academies of Sciences, Engineering, and Medicine (NASEM) held a global summit to discuss issues surrounding gene editing and the U.S. Congress prohibited public funding of efforts that would edit human embryos; events like these spurred media coverage [The Annenberg Public Policy Center of the University of Pennsylvania, 2018], giving the technology a higher profile. In the years since, gene editing has continued to raise both controversy — a scientist claimed to have edited the genes of twin baby girls [Normile, 2018] — as well as promise — as research showed that CRISPR could be especially useful for Covid-19 testing [Zimmer, 2020].

Cultivation of perceptions toward science and genetics

One way to connect media consumption with perceptions of science is the cultivation framework. This framework describes how exposure to television content over time shapes perceptions; key to cultivation is the idea that television can shape perceptions particularly among viewers with heavy television diets [Gerbner, Gross, Morgan & Signorielli, 1986; Morgan & Shanahan, 2010]. Importantly, the cultivation framework concerns television content as a whole, not just programming that is high-brow, as entertainment is a common source of learning about science [Gerbner, 1987]. There is a sizable body of literature that addresses the cultivation effects of television on science [see below, but also for example Bauer, 2002; Brossard & Dudo, 2012; Good, 2009; Shanahan, Morgan & Stenbjerre, 1997; for an overview, see Shanahan, 2017]. Cultivation was originally conceptualized in the broadcast television era, but cultivation as a method, with its focus on media influence and perceptions of reality, is relevant to modern media environments [Ruddock, 2020].

Scholars have also argued that incorporating genre is a useful way to update the framework [for a review, see Lee & Niederdeppe, 2011]. This update is important given that digital technologies have splintered audiences into ever-smaller groups. Further, there is empirical evidence that different genres generate unique effects [Carveth & Alexander, 1985; Kahlor & Eastin, 2011]. One science-related study showed that local television viewing was associated with beliefs that cancer is largely unavoidable, controlling for other factors [Lee & Niederdeppe, 2011].

Another justification for the inclusion of genre is on the production side, as producers have different motivations for their stories. For example, while commercial studios may produce content that reflects traditional social hierarchies, a study showed that authorial documentaries, or those produced independently of broadcast networks, are more likely to be diverse and include directors and characters that are from minority groups; the idea is that independent producers make different creative decisions than executives of commercial television [Borum Chattoo, Aufderheide, Merrill & Oyebolu, 2018]. Producer motivations matter because individuals have more access than ever to content that is not produced by large, commercial studios.

Next, in the cultivation framework, the relationships between media and perceptions can be better understood by examining the nature of the content, as perceptions should reflect what is consumed. First, in the case of science, early studies of science on television found that science was linked with "future, fantasy, and danger" [Gerbner, Gross, Morgan & Signorielli, 1981]. Stereotypic images such as "the mad scientist" and themes such as scientists "playing God", or "science run amok" predominated [Shanahan, 2017]. Scientists have been portrayed both positively and negatively: for every single bad scientist there were five good scientists (but in comparison, there was only one bad doctor for every 19 good doctors) [Gerbner, 1987]. More recent research shows that scientists are being portrayed in a more charitable manner: 80% of scientists on television were portrayed as "good", 16% as "mixed" but only 3% as "bad" [Dudo et al., 2011].

Second, a study that specifically focused on science fiction film found similar results. The study, which covered more than 200 films, showed that science was

depicted as dangerous (in 60% of films), as causing intentional or unintentional damage (58%), and as going out of control (35%). Technologies were also frequently kept a secret (48%). The rogue "solitary scientist", who works outside of a traditional lab without peers who might offer ethical guidance, appears in 42% of films [Weingart, Muhl & Pansegrau, 2003].

Third, genetics is a popular topic in the genre. Science fiction reflects social anxieties about genetic technologies, such as Aldous Huxley's *Brave New* World [Turney, 1998]. The themes present in early written works — the unknown social and political consequences of science, human hubris, and power — frequently appear in modern science-fiction productions. Science fiction has addressed the idea that human-directed genetic changes can be used to "improve" human beings (often with disastrous consequences) [Kirby, 2007], and narratives about genetic technologies are often political, following a typical pattern where some benefit from the technology and others are excluded [Escudero Pérez, 2014]. There is also the question of the ethics of genetic changes that are nonconsensual and created for the wishes of others [Kirby & Gaither, 2005]. Geneticists have been portrayed as geniuses with unethical scientific practices [Weingart et al., 2003]. But other films, like those involving disease outbreaks, show genetic scientists as heroic "bio-political" actors, disobeying orders from government agencies and superiors because it is necessary [Lynteris, 2016].

Effects of cultivation

Turning to effects, there is no predominant narrative; sometimes there is a positive relationship between television and perceptions of science and sometimes there is a negative relationship. Television use is associated with both optimism and reservations about science, reflecting the "dual nature" of programming that includes both positive and negative portrayals of science [Nisbet et al., 2002]. Notably, this pattern seems to be holding, as more recent research found that perceptions that "science works for good" and "scientific work is dangerous" are both higher as time with television increases; the same pattern holds as watching science fiction on television from time to time or on a regular basis [Brewer & Ley, 2021].

The duality of portrayals plays out elsewhere. Results have shown that heavy viewing is associated with lower levels of confidence in science [Gerbner et al., 1986] and an increased likelihood to agree that science "makes life change too fast" [Gerbner, 1987]. Further, time with television has been shown to have a negative association with science knowledge; the issue is that science knowledge has a positive association with attitudes toward science [Dudo et al., 2011].

On the other hand, attention to entertainment television has been associated with support for agricultural biotechnology [Besley & Shanahan, 2005]. Further, one study showed that science fiction programming had almost no association with attitudes on its own, but was associated with television science news use, which in turn was associated with positive attitudes toward science [Brossard & Dudo, 2012]. Another study also showed a nonsignificant relationship between watching science fiction and support for using gene editing [Dawson, Paintsil, Bingaman & Brewer, 2022].

Heavy viewing flattens value differences

Heavy use of television is a key concern of cultivation, and heavy use can result in negative attitudes toward science, even among individuals who would normally be predisposed to have positive attitudes [Dudo et al., 2011]. Put another way, individuals who might normally have positive attitudes toward science end up having a more negative view if they watch a lot of television. In some cases, their attitudes end up resembling the attitudes of people who are *not* predisposed to have positive attitudes. This perceptual convergence is called mainstreaming. Mainstreaming happens when individuals with heavy television diets, regardless of their predispositions, gravitate toward the perspective offered by television [Gerbner et al., 1980].

For example, consider the relationship between education and views of science. Studies show that higher levels of education are associated with positive orientations toward emerging technologies [Besley & Shanahan, 2005; Ho, Brossard & Scheufele, 2008]. By that logic, someone who took science courses in college should have positive views toward science. However, heavy consumption of television can change this relationship: one study showed that, at heavy levels of television viewing, there was a negative relationship between taking college science courses and attitudes toward science [Dudo et al., 2011]. Further, the Dudo et al. [2011] study showed that having no college science courses was associated with more positive attitudes at higher levels of television viewing, suggesting mainstreaming was occurring.

Next, while education is a reliable predictor of opinions toward science, value predispositions are also fundamental to the formation of perceptions. Individuals process science information from media through the lens of personal factors [Bates, 2005]. Three important value dispositions shaping perceptions about science today include deference to scientific authority, religiosity, and ideology. There is evidence for mainstreaming as it concerns education, but the question we address is whether mainstreaming occurs for value predispositions as well.

First, deference to scientific authority concerns scientific exceptionalism and the idea that the opinions of scientists are more important than the public's when it regards scientific matters [Brossard & Shanahan, 2003]. Higher levels of deference to scientific authority are associated with positive perceptions of science; deference to scientific authority has been associated with trust in scientific and government institutions as sources of information about emerging technologies [Anderson, Scheufele, Brossard & Corley, 2012], and it has been shown to be a reliable predictor of support for controversial technologies [Brossard & Nisbet, 2007; Ho et al., 2008; Lee & Scheufele, 2006]. A recent study showed that deference to scientific authority was a stronger predictor of support for nuclear energy, nanotechnology, and synthetic biology than other value predispositions (e.g. religiosity, party identification) as well as attention to science media [Akin et al., 2021]. Next, religiosity concerns the amount of guidance that religion plays in one's life. Evidence shows that higher levels of religiosity are associated with less positive perceptions of emerging technologies such as nanotechnology [Brossard, Scheufele, Kim & Lewenstein, 2009; Scheufele, Corley, Shih, Dalrymple & Ho, 2009], embryonic stem cell research [Nisbet, 2005; Nisbet & Goidel, 2007], and HGE [Scheufele et al., 2017], and when it concerns benefits, individuals with creationist

beliefs are less likely to have optimism about medical genetics [Allum, Sibley, Sturgis & Stoneman, 2014]. Finally, political affinities can predict orientations toward science. Evidence shows that liberalism is associated with higher levels of trust in science as an institution [Gauchat, 2012], but conservativism is associated with seeing fewer benefits and more risk with emerging technologies [Binder, Cacciatore, Scheufele, Shaw & Corley, 2012] and it is negatively associated with support for emerging technologies [Ho et al., 2008]. In sum, value predispositions are powerful predictors of perceptions of science. If mainstreaming is occurring, there would be a convergence in perception even though it is not expected. But this is unknown, especially given that science fiction content includes positive and negative portrayals of science and scientists.

Research questions

This investigation concerns establishing whether there is a connection between attention to science fiction and benefit perception, risk perception, and negative attitudes (concern) toward HGE.

Research question 1 (RQ1): Are higher levels of attention to science fiction associated with higher levels of benefit and risk perception of human gene editing technology?

Research question 2 (RQ2): Are higher levels of attention to science fiction associated with attitudes toward human gene editing technology?

If mainstreaming occurred for HGE, it could look like this: people who would normally have positive perceptions of HGE, but who also consume a heavy amount of science fiction, could have perceptions that look more like the perceptions of someone who was predisposed to have negative views (or vice versa). Thus:

Research question 3 (RQ3): Are higher levels of attention to science fiction associated with mainstreaming of attitudes toward human gene editing technology?

Methods

This study uses a nationally representative survey collected with U.S. adults aged 18 years and older from December 2016 to January 2017 by the survey firm YouGov.

The final sample size was 1,600 with a completion rate of 41.7%. Respondents were matched to a sampling frame on gender, age, race, education, political ideology, party identification, and political interest to ensure representativeness. Post-stratification weights for the overall sample were applied for all analyses.

Dependent variables

Human gene editing benefit perception was measured by asking respondents how likely they think that human gene editing will "help fix human health problems and diseases", "remove stigmas around birth defects and genetic diseases", and "improve the economy through medical and research advances" where 1 = *not at all likely* and 7 = *certain* ($M = 4.0$, SD $= 1.3$). These items were averaged to create a single variable (*Cronbach's alpha* $= .81$).

Human gene editing risk perception was measured by asking respondents how likely human gene editing will "lead to unintended human health problems", "lead to discrimination against those who are or are not genetically edited", "increase economic inequality between rich and poor people", and "give some people too much power to change the course of human development", where 1 = *not at all likely* and 7 = *certain* ($M = 4.4$, SD = 1.3). These items were averaged to create a single variable (*Cronbach's alpha* = .77).

Negative attitude, or concern, toward human gene editing was measured by asking respondents how strongly they agreed with the statements that human gene editing "messes with nature", "allows humans to play God", and "includes too many unknowns to be conducted safely", where 1 = *strongly agree* and 7 = *strongly disagree* ($M = 3.3$, SD = 1.4). Original items were reverse coded; lower numbers indicate agreement. These items were averaged to create a single variable (*Cronbach's alpha* = .83).

Control variables

To ascertain the extent to which attention to science fiction is associated with perceptions of HGE, several variables were included as controls because of known associations with perceptions of science. Demographic controls included age [Siegrist, Gutscher & Earle, 2005], gender [Siegrist, 2000], and education [Ho et al., 2008]. Age was measured as a continuous variable ($M = 46.7$, SD = 16.8), gender was measured as a dichotomous variable with male coded as 0 and female coded as 1 (48.5% male; 51.5% female). Education was measured by the highest level of education respondents attained (six levels, *median* = 3 "some college, but no degree").

Factual knowledge is associated with higher levels of support for science [Ho et al., 2008]. Knowledge was measured through nine items such as "over time, human DNA has picked up pieces of DNA from different species and viruses that naturally mixed in with human DNA". Respondents were given the option to answer "definitely true", "likely true", "likely false", "definitely false", and "don't know". Answers were coded or into true/false. An additive measure ranging from 0 to 9 was created, where higher numbers reflect greater knowledge ($M = 4.5$, SD = 2.6).

There were two news variables, each assessed with the question, "how much attention do you pay to news stories about the following topics?" where 1 = *none* and 5 = *a lot*. Attention to national government and politics was a single item ($M = 3.6$, SD = 1.1). Attention to scientific news was measured by asking respondents to rate their attention to three topics: one, "science and technology", two, "political or ethical implications of emerging technologies such as gene editing", and three, "new scientific tools or developments (such as CRISPR-Cas9)" ($M = 2.7$, SD = .9). The items were averaged to create a since variable ranging from 1 to 5 (*Cronbach's alpha* = .84).

Moderating variables

Next, the values were included. Importance of religion was measured by the extent of guidance provided by religion in everyday life on a scale ranging from 0 = *no*

guidance at all to 10 = *a great deal of guidance* and recoded into four categories (*median* = 3 "somewhat important", SD = 1.2). Ideology was measured using a 7-point scale (1 = *very liberal*, 7 = *very conservative*) to indicate respondents' social and economic ideologies, and an index was made of the two items ($M = 4.1$, SD = 1.6, *Spearman's Rho* = .88). Deference to scientific authority was measured by asking respondents to assess the degree of their approval of two statements about scientists: "scientists know best what is good for the public" and "scientists should do what they think is best, even if they have to persuade people that it is right", where 1 = *strongly disagree* and 7 = *strongly agree*. The two items were averaged to create a composite measure ($M = 3.7$, SD = 1.5, *Spearman's Rho* = .62). Interaction terms were created by multiplying the standardized scores of religiosity, ideology, and deference to scientific authority with attention to science fiction.

The primary independent variable of interest, attention to science fiction, was measured by asking, "How much attention do you pay to each of the following?" where respondents indicated their attention to "science fiction-related TV shows" and "science fiction-related movies". Each item was measured on a 5-point ordinal scale ranging from 1 = *none* to 5 = *a lot* ($M = 2.8$, SD = 1.2) and averaged to create the variable (*Spearman's Rho* = .86).

Results

To obtain results, we conducted a hierarchical ordinary least squares (OLS) regression where the independent variables were entered into blocks according to their assumed causal order [Cohen, Cohen, West & Aiken, 2003]. During data collection, all participants were randomly assigned to five experimental conditions, as part of a separate study [Howell et al., 2022]. Because the experimental manipulations were not of primary interest, they are not reported here but their effects were controlled by including dummy variables within the models.

Table 1 shows the zero-order correlations. Generally, the data show expected relationships between independent and dependent variables. For example, results show that religiosity has a negative correlation with benefit perception.

Table 1. Zero-order correlations.

	Zero-order benefit perception	*Zero-order risk perception*	*Zero-order concern*
Age	−.03	.00	−.05*
Gender (Female = 1)	−.06*	.07**	−.15***
Education	−.05*	.08***	.03
Importance of religion	−.14***	.17***	−.28***
Ideology (Conservative = high)	−.22***	.04	−.24***
Deference to scientific authority	.43***	−.14***	.27***
Knowledge	.17***	.20***	−.02***
Attention to political news	.06*	.11***	−.04***
Attention to science news	.19***	.11***	.10***
Attention to science fiction	.25***	.08**	.09***

* $p < .05$. ** $p \leq .01$. *** $p \leq .001$.

Table 2. Results of regression analyses showing main and interactive effects. Cell entries are final standardized regression coefficients for blocks 1 to 4, and before-entry standardized regression coefficients for block 5.

	Benefit perception	*Risk perception*	*Concern*
Block 1: Demographics and values			
Age	.07**	−.06*	.05
Gender (Female = 1)	.02	.08**	−.14***
Education	.02	.01	.07***
Importance of religion	.01	.19***	−.16***
Ideology (Conservative = high)	−.05	−.02	−.13***
Inc. R^2 (%)	5.7***	4.0***	10.4***
Block 2: Deference and perceptions			
Deference to scientific authority	.38***	−.14***	−.15***
Inc. R^2 (%)	13.5***	1.5***	2.2***
Block 3: Knowledge and media attention			
Knowledge	.09***	.20***	.13***
Attention to political news	.00	.03	−.07**
Attention to science news	.05*	.03	.13***
Inc. R^2 (%)	2.3***	4.8***	2.0**
Block 4: Science fiction			
Attention to science fiction	.17***	.08**	.00
Inc. R^2 (%)	2.2***	.5**	.00
Block 5: Interactions			
Attention to science fiction × Deference to scientific authority	–	–	.00
Attention to science fiction × Importance of religion	–	–	.03
Attention to science fiction × Ideology	–	–	.07***
Inc. R^2 (%)			.01***
Total R^2 (%)	25.5***	11.4**	17.3**

* $p < .05$. ** $p \leq .01$. *** $p \leq .001$.

Table 2 shows the results of the regression analyses, and Figure 1 shows the interaction. There is an overall pattern where attention to science fiction is associated with the dependent variables, though the relationship between attention to science fiction and concern is moderated by political ideology.

In terms of the research questions, the answer to RQ1 is yes, there is an association between attention to science fiction and risk and benefit perceptions. However, there was no main effect on attention to science fiction on concern, thus the answer to RQ2 is no. However, there is an interaction with party identification, showing a mainstreaming effect, thus, the answer to RQ3 is both yes and no, as two of the three value dispositions of interest did not show an interaction.

Discussion

In this study, we showed how attention to science fiction is associated with benefit perception, risk perception, and concern about human gene editing, adding to

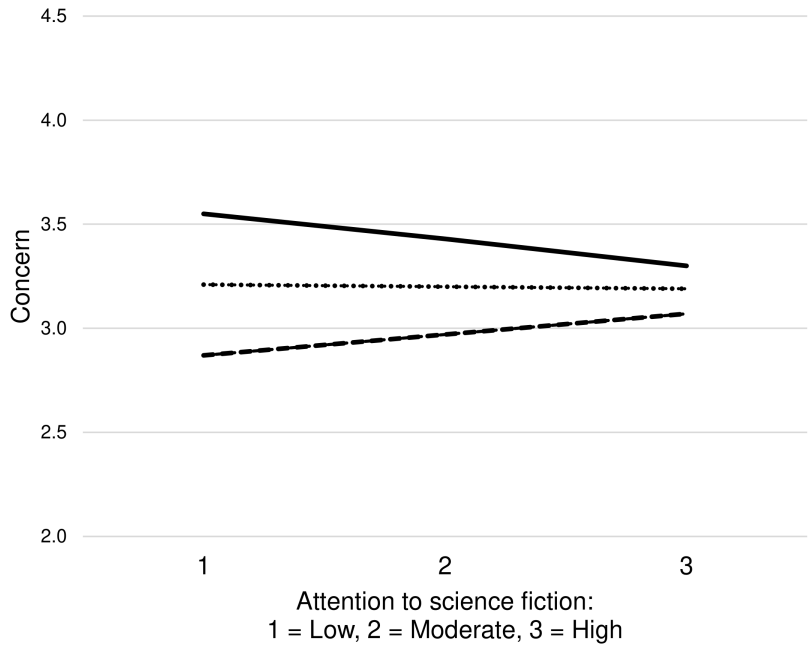

Figure 1. Interaction between attention to science fiction with ideology on attitudes toward human gene editing. The solid (top) line represents liberals, the line with small dots (middle) represents moderates, and the line with large dashes (bottom) represents conservatives. Note. Scale on Y-axis is partially displayed.

previous studies that utilize the cultivation framework to explore connections between entertainment media and opinions of science [Brossard & Dudo, 2012; Dahlstrom & Scheufele, 2010; Dudo et al., 2011; Shanahan et al., 1997]. These findings have implications for scholars concerned with public opinion of emerging technologies as well as practitioners who seek to engage audiences with them. As the future controversial scientific research and discoveries are likely to be decided as part of a political process [Scheufele, 2014] understanding the influences on public opinion of technologies such as gene editing takes on political importance.

Before moving on to the discussion, we note limitations. Cultivation is a theory of media effects, where the idea is that television affects perceptions over time. Thus, we recognize that cultivation is an effects theory, while simultaneously noting that cross-sectional data do not provide causal leverage in the traditional sense. Further, we do not have a precise accounting of positive and negative portrayals of scientists and science. However, this is an area for future research: given the explosion of content enabled by digital technologies, there is a need to take a fresh look at portrayals of scientists and science. This is especially important in the modern media environment, as many citizens encounter science both factual and fictional from traditional (e.g. print, television) and new media (e.g. online video, podcasts online news, social media); in the case of new media, content delivery is often tailored to individual preferences by an algorithm. And people form their perceptions of science based on a variety of media, only a sliver of which are captured in our accounting of content and our measurement of its effects. Thus, a new accounting is needed.

In addition, although cultivation as initially conceptualized assumes a one-directional process from content producer to viewer, one model of cultivation

considers how viewers have distinct motivations for certain kinds of content especially when the content delivers a "transportive experience", and will return to the content because it is enjoyable [Bilandzic & Busselle, 2008]. Notably, the aforementioned study found that individual transportability (broadly, the tendency to get lost in a story) was associated with transportation into science fiction; further, results showed that higher levels of transportation was associated with making estimates about "bad" outcomes of science (e.g. food shortages due to genetically modified crops) after watching science fiction.

Although this study makes use of the cultivation framework to explain the connections between consuming science fiction and perceptions of HGE, there are other ways to test these mechanisms, such as testing narrative transportation. Narratives feature characters that can connect at a psychological level [for a review of narrative, see Kaplan & Dahlstrom, 2017], that other formats may not.

Further, although science fiction may feature science that is unreal, producers create realism by imbuing unreal creatures in contexts that people understand (through the use of production techniques to create movement, for example), which creates perceptual realism — even if what one sees is not real, it is perceived as such, enhancing its "persuasiveness" [Kirby, 2003]. We take it as a given that not everyone will be interested in science, which gives the presence of science into popular culture, and making the experience rewarding, ever more important.

Turning now to the results, portrayals of science in science fiction are a mix of positive and negative. Thus, our findings align with the assumptions of cultivation in that perceptions track to content, as attention to science fiction was associated with both risk and benefit perception. However, note that attention to science news has a positive, but not significant, relationship to risk perception, but attention to science fiction has a positive and significant association with risk perception. Studies have shown that science news consumption is almost always associated with positive outlooks toward science [Nisbet & Goidel, 2007; Nisbet et al., 2002] as well as technologies including embryonic stem cell research [Ho et al., 2008; Nisbet & Goidel, 2007], nanotechnology [Ho, Scheufele & Corley, 2010], and genetically modified crops [Besley & Shanahan, 2005]. Speaking specifically of coverage of gene editing, news coverage between 2012 and 2018 tended to be positive or balanced more often than negative [The Annenberg Public Policy Center of the University of Pennsylvania, 2018]. Another study of news articles published between 2012 and 2017 showed that while 96.1% of the articles mentioned benefits (e.g. developing treatments for genetic conditions), 61.4% featured concerns (e.g. concerns about unintended consequences) about gene editing [Marcon, Master, Ravitsky & Caulfield, 2019].

However, it seems that the presence of a different kind of content makes a difference in perception. This result speaks to findings that address exposure diversity or being exposed to many kinds of content. One cultivation study showed that exposure diversity is associated with concern for environmental risks above and beyond exposure time alone [Dahlstrom & Scheufele, 2010]. Something similar could be happening here: individuals whose main source of information about science is news could be missing alternative perspectives from fictional accounts. Future research could explore this possibility.

These results also speak to studies that address science as a cultural institution with meanings and societal implications beyond the facts that science produces [Davies, Halpern, Horst, Kirby & Lewenstein, 2019]. Davies et al. [2019] note that storytelling has proven to be an effective and engaging avenue for communicating science, as extant research shows that narratives can be more effective than facts as it concerns engaging audiences [for a review, see Dahlstrom, 2014]. Other research shows that most people differentiate between science and science fiction and they can use science to understand science [Hughes & Kitzinger, 2008], even if a particular program is devoid of verifiable fact.

Further, thinking about science communication as a part of culture offers opportunities to reach audiences that might not be reached by traditional science programming. One study measured several forms of culture, including forms that are popular, not the exclusive purview of upper classes. This study gathered more than 1,400 responses and found that about half the sample (45%) had low interest in science-related content, but higher interest in other forms of content, such as television programming [Roberts, Milne, Middleton, Patch & Morley, 2022]. Of course, this represents an opportunity for science communicators on the production side (working with producers to incorporate more science content through partnerships with entities such as the Science & Entertainment Exchange). But there is also opportunity on the learning side: Roberts et al. [2022] argue that it is important to pay attention to what people already know (e.g., science references from pop culture) and build engagement efforts from there. Other scholars agree with this approach, as popular culture offers a space where people make sense of their world. For example, people use both fictional and real politicians to make judgements about what is right and wrong as it concerns politics [van Zoonen, 2005] and utilize popular culture forums as a space for political discussion [Graham, 2012]. This framework, with people drawing upon popular culture to make judgements, can be extended to the realm of science. Rather than a top-down "deficit" approach, this is a bottom-up "connection" approach: leveraging what people are familiar with to address important topics in science.

Next, that there was no mainstreaming effect for deference to scientific authority and religiosity suggests that some value predispositions are deep-seated and less likely to be influenced by fictional narratives, or perhaps any media at all. Our results align with a large body of research that shows strong predictive power of deference to scientific authority [Howell, Wirz, Scheufele, Brossard & Xenos, 2020] and religiosity [Brossard et al., 2009].

However, there was a mainstreaming effect for ideology. Studies, such as those mentioned above, show that conservatism is typically associated with negative views toward emerging technologies, whereas liberalism is associated with positive views. But the results of this study show that conservativism is associated with less negative attitudes about HGE at higher levels of attention to science fiction. At the same time, liberalism is associated with a more negative attitudes at higher levels of attention to science fiction. Both results merit future investigation but consider how liberalism is associated with less positive attitudes at high levels of attention to science fiction. Liberalism is a consistent predictor of positive views toward science. Future research could look at other forms of content that change this relationship.

Finally, scientists, ethicists, and other stakeholders have called for active public involvement with the issue of gene editing [National Academies of Sciences, Engineering, and Medicine, 2017]. Science fiction was associated with risk and benefit perceptions, meaning that science fiction content — like the kind that includes fictional clones — matters when it comes to public opinion. And, while it is too much to expect that attention to science fiction would cultivate a shared sense of the risks of HGE among partisans, there is value in using science fiction to engage citizens with the complexities of emerging technologies.

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