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Genetics in Film and TV, 1912–2020

Ethan Gibbons,

Isaac Stovall,

Jay Clayton

Dramatic events such as the cloning of Dolly the sheep, the mapping of the human genome, the proliferation of direct-to-consumer genetic testing services, and the promise of genetic science to alleviate suffering and disease have generated much public attention over the past several decades. Although the recent explosion of genetics research has captured the public imagination, the attention to genetics-related issues is hardly a new phenomenon. From the eugenics movement of the early twentieth century to the birth of two gene-edited babies in China in 2019, genetics has long been the subject of intense debate in the public sphere. As the science on the subject of genetics has developed, these debates have played out on screens both big and small.

In this article, we seek to explore the various factors which shape the ways in which genetic science and technology are presented on screen. Our investigation was driven by three initial assumptions: first, that the portrayal of genetics in film and television would vary over time in parallel with highly publicized advances in genetic science as well as with broader historical developments. Second, that variations in the constraints and opportunities presented by the different media – film vs. television – would also create variation in the representation of genetics. Finally, that different genre conventions would play a role in shaping the ways in which genetics is portrayed on screen and that it would be possible to distinguish these differences from those resulting from medium and release date.

The portrayal of genetic science in film and television is important not because it determines the attitudes of the public, but because it furnishes the public debate about genetics with shared images, narratives, and possibilities for the future of genetic science. Research has shown that people do not blindly consume media narratives, but rather use media to make sense of highly technical topics (Condit 175–176; Conrad & Gabe 508–510; Bates 47; Wilson-Kovacs et al. 289–291). Although descriptive projects on the depictions of science and genetics in popular media have been conducted (e.g., Weingart et al., “Power”; Kirby, “Devil”; Flores, “Scientists”), less work has been done to analyze quantitatively the variation in depictions of genetics in both television and film. Using a unique data set of 238 films and 537 television episodes, this article tracks the depictions of genetics in these forms of popular culture over more than a century.

While it is impossible to be certain that we have collected data on every movie and television episode that deals with genetics, we have assembled the most comprehensive

data set in this domain to date. These unique data allow us to observe how attitudes toward genetics in film and TV have changed over time and how genre and medium affect the portrayal of genetics. As genetic scientists continue to find more applications for their research and as more of the population has their genetic data analyzed by direct-to-consumer firms, it will be valuable to understand what messages viewers are receiving about genetic science from popular media. By mapping the representation of genetics in film and television in the most comprehensive manner undertaken to date, this study provides an understanding of how two prominent entertainment industries have presented the promise and perils of genetics to the public from the dawn of cinema to the twenty-first century.

Background

New scientific knowledge has long been a theme of popular media. In order to attract audiences, film and television producers must strike a balance between following conventions in order to be understood by their desired audiences and evincing novelty in order to be intriguing. In this pursuit, scientific advances provide rich material for film and television producers to exploit.[1] In the process, depictions of science in popular media both reflect and influence public attitudes toward scientific endeavors. By playing out scenarios that have the potential to arise from current or future scientific knowledge, popular media provides a platform for society to think through the implications of our growing understanding of the world. Of the myriad scientific fields, genetics in particular raises intriguing question about fundamental aspects of human existence including individual identity, our sense of belonging, and our place among our fellow species. The manner in which film and television have portrayed science, and to a lesser extent genetics, has been studied by scholars in a variety of fields across the social sciences and humanities.

In this area of scholarship, there have been two principal schools of thought. The first, mainly within the social sciences, has focused on the geneticization thesis put forward by Lippman, who defines geneticization as the tendency to equate individuals with their genes, which in turn come to be seen as the main drivers of traits and behaviors (15). One critique of geneticization is that it can divert attention and resources away from social-environmental factors that contribute to disease, a problem that may have a disproportionate impact on marginalized communities (Nelkin and Lindee 160). Importantly, while concerns about geneticization have included some work on popular media such as film and fictional television, they were mainly based on analyses of the presentation of genetic research in print and television news. This research has demonstrated that such journalistic accounts often focus on potential benefits and promotes patriotic sentiments of national dominance in the field of genetic science while minimizing ambiguity in the findings and the potential pitfalls of genetic research (Petersen 1264; Väliverronen 233; Hjörleifsson 377). On occasion, this celebratory rhetoric about genetics can be encouraged by scientists working with public relations firms in order to garner attention in the news media and to encourage public excitement on topics such as the Human Genome Project (Henderson & Kitzinger 70). Often, though, the news media simply highlights breakthroughs in genetic research,

[1]. Producers are often more concerned with capturing audiences than with representing scientific advances accurately – a point of contention for many scientists (Kirby 2003).

depicting geneticists as heroes, while failing to ask critical questions about uncertainty and ethical challenges or to cover disconfirmations and negative findings (Hjörleifsson et al. 381).

The geneticization thesis has been criticized from several perspectives. For example, some scholars point out that geneticization is not a new phenomenon, since the belief in heritability long preceded the discovery of DNA (Kevles 3; Freese and Shostak 116). In addition, despite the generally positive attitude toward genetics research in the news media, Condit argues that geneticists and other scientists often worry that the image of their work that is portrayed to the public is inaccurate ("Public" 177). Rather than seeking to amplify their research, scientists and scientific institutions often seek to manage news coverage and work against the sensationalized stories desired by journalists to retain the attention of readers (Anderson 333). For example, geneticists interviewed by Condit worried that an overemphasis on the power of genes could lead to a rise in beliefs in genetic determinism and the discriminatory attitudes that often follow ("Public" 169). Especially in the case of cloning, scientists fought to distinguish between "therapeutic cloning" and "reproductive cloning." Whereas the former involves the multiplication of potentially useful cells outside of the body, the latter includes the reproduction of human beings and other animals in a laboratory setting. In pushing the concept of therapeutic cloning in the news media, scientists battled to overcome the nearly universal condemnation of reproductive cloning (Petersen 1265).

Although proponents and critics of the geneticization thesis disagree on the extent to which society has been geneticized, both perspectives share two assumptions. The first is that depictions of science influence the public's perceptions about scientific issues. Although the direct connection between the content of popular media and perceptions of the public is difficult to track – and in the case of fictional genres, often depends on simplistic notions of how imaginary stories are processed by audiences – the influence of popular media in the cultural imaginary has been demonstrated in a variety of capacities outside of the realm of genetics. Carpenter shows that films are an essential tool for the ways in which people make meaning out of their experiences of virginity loss (806). Among scientific issues, a variety of scholars have pointed to the importance of both news media and films about climate change for influencing public opinion on the issue (Boykoff and Boykoff 125; Sakellari 827). Furthermore, scholars have demonstrated the importance of depictions of scientists in the media for children's understandings of the types of people who can become scientists (Tan et al. 520). Finally, although advocates for science are often uneasy about the extent to which popular media narratives influence the public's perception of genetic science, Roberts et al. argue that people combine media narratives with their own knowledge to come to conclusions about the moral and ethical implications of genetics research (369).

The attention paid to popular media by scientists and proponents of the geneticization thesis rests on the assumption that discoveries in the scientific realm influence the content of popular media. As Nadel shows in the case of cold war anxieties manifesting in cinema through a variety of containment narratives, the general historical context of the production of media has great influence on its content (1–10). This point is taken further by Bould, who argues that Science Fiction in particular is a forum for reflecting upon contemporary

issues through allegorical references (59). Likewise, Platts argues that the development of a diachronic understanding of the fictional depiction of a particular subject (in his case zombies) allows for the tracking of a wide range of cultural, political, and economic anxieties within the culture (551).

In this area of research, scholars debate the extent to which depictions of genetics in media from journalism to cinema have resulted in the geneticization of society. While proponents argue that we are increasingly moving toward a world in which our genes define every aspect of our lives, critics argue that scientists and others have worked to temper expectations for genetic science. While this line of research has been popular in the social sciences, some scholars in the humanities have taken a second approach to exploring the meanings of science as depicted in film and television.

Scholars in this second school of thought argue that contemporary media draw on long-standing cultural myths to define perspectives on genetics and science. For example, Weingart et al. analyze a variety of films to show that depictions of science in film are often linked to the myths of Frankenstein and Prometheus in order to contest the ability of science to produce beneficial knowledge (281). In the Prometheus and Frankenstein myths, new knowledge, especially when it results in the creation of artificial life or the alteration of human life, is treated as a violation of nature and thus as the most alarming aspect of scientific inquiry. Weingart et al. argue that movies such as *GATTACA*, *The Raiders of the Lost Ark*, and *The Manhattan Project* draw on these myths to manifest a fundamental cultural ambivalence toward scientific knowledge (282). Likewise, Nagy et al. argue that the deep embedding of the Frankenstein myth in popular culture results in a general stigmatization of scientists, potentially threatening the epistemic validity of science itself (1114).

More directly focusing on genetics, Kirby uses a careful selection of films to analyze cinematic depictions of genetics from the early 20th century to 2004. In these films, the scientists almost always have their experiments go awry as they attempt to make superhumans. Kirby argues that the films question the desirability of the scientific production of “perfection” in humans, particularly if sought through technological means. Like the Frankenstein myth, scientists in these films, including adaptations of Robert Louis Stevenson’s 1886 novel *The Strange Case of Dr. Jekyll and Mr. Hyde*, the 1965 film *Blood Beast from Outer Space* and the 1997 *Batman & Robin* film (with Arnold Schwarzenegger’s Mr. Freeze) are overconfident of their ability to improve humanity through science and are ultimately punished for their hubris (Kirby, “Devil” 86–97). Although the genetic scientists in Kirby’s analysis vary in their motivations, their confidence in their ability to improve humanity through genetic science is ultimately depicted as a major flaw, often leading to catastrophic consequences.

Whereas the critical literature in the second strand of research on genetics in cinema demonstrates that films often depict genetic science by drawing on deeply-embedded cultural myths that portray science and scientists as dangerous and threatening, scholars have drawn divergent conclusions in studies of television about medical doctors. For example, Dudo et al. found that in prime-time television from 2000 to 2008, scientists are

most often presented as white men who are either good or mixed rather than “evil” (762). In physician Glenn Flores’ analysis of films, he found that medical doctors in 131 movies were almost all white men in their thirties or forties, embodying the doctor character as deeply knowledgeable and paternalistic (637). Flores did find however, that negative portrayals of physicians became more common in the 1990s (642). These findings complicate the work of scholars such as Kirby and Weingart by demonstrating that the form (genre, medium, etc.) and context of media play a major role in the way science and scientists are depicted on screen.

Whereas the social science literature debating the geneticization thesis focuses on how the representations of genetics has changed over time, the humanities scholarship in this area highlights the through-lines of common myths and themes. Both lines of thought lend credence to the importance of mediated representations of genetic science. Still other scholars have analyzed the ways in which representations of science have changed both over time and based on genre conventions.

In the early films of the 20th century, scientists are often depicted as helpless and incompetent, whereas the films of the 1920s and 1930s were the heyday of the mad scientist (Kirby, “Cinematic” 45). Later in the 1930s and into the 1940s, the scientist was increasingly seen as heroic, with the endeavor of science being linked to the production power of capitalism (Böhnke and Machura 321). In the 1950s and 1960s, fear of the Manhattan Project and the growing potential of science to create either a post-war utopia or end life itself resulted in scientists being portrayed as either amoral rationalists who deny responsibility for their research or as absent-minded professors, blissfully unaware of the potential dangers of their ground-breaking work (Kirby, “Science Consultants” 243). In the 1970s and 1980s, environmental issues, overpopulation and resource use became important cinematic themes, with individual scientists often struggling against the dangerous ineptitude of government agencies (Kirby, “Cinematic Science” 47). Advances in computer science and digital technology in the 1990s led to the ascendance of the heroic scientist, which continued into the 2000s. Little comprehensive research has been done on science in films of the last decade.

In addition to being influenced by contemporary issues, science on screen is shaped by the conventions of the form itself. Haynes found that there are six scientist stereotypes in film: the alchemist/mad scientist; the absent-minded professor; the inhuman rationalist; the heroic adventurer; the helpless scientist; and the social idealist (“Alchemy” 243). These stereotypes are cinematic shorthand, used to communicate quickly to the audience what they should expect from a character. As such, they are used differently in different genres. For example, Horror films often feature the mad scientist, whose schemes go awry to spark the horrific events of the film, often using science as a type of monstrous threat. Similarly, whereas Comedies often utilize the stereotype of the absent-minded professor for humorous effect, Dramas feature the social idealist, bent on solving a major scientific problem for the benefit of humanity. Finally, while Action films and Science Fiction often utilize similar characters, Haynes argues that the heroic adventurer is particularly common in Action movies, while SF embraces both ends of the stereotype spectrum – inhuman rationalists using science for

whatever benefit they see as reasonable, and helpless scientists wreaking unintentional havoc with over-powered scientific tools (137).

Terzian and Grunzke build on Hofstadter's distinction between "intelligence," which is seen as quantifiable and instrumental, and "intellect," which is the contemplative and critical side of the mind. Terzian and Grunzke argue that Cold War preference for the practical intelligence over the potentially subversive intellect of scientists manifested in a variety of Comedy films in the 1960s (408). For example, whereas in family films and slapstick Comedies, scientists commit social transgressions and become the object of mockery, political satire films such as *Dr. Strangelove* present the scientist as an object of fear and real threat in the context of nuclear annihilation. However, recent work in this area has found that particularly in the twenty-first century, traditional depictions of scientists as either "mad" or unethical have transitioned toward more empathetic portrayals, partly as a result of an increasing general familiarity with science and scientists (Haynes, "Whatever Happened" 35).

Genetic science has the potential to be one of the most revolutionary areas of contemporary scientific research. Whereas cinematic depictions of new areas of knowledge have historically drawn on cultural myths to critique the hubris of scientists, depictions of medical scientists in television have been more empathetic to scientists and more enthusiastic about the potential of genetic science in particular (Furman and Clayton). As genetic science continues to develop, the public will lean on popular depictions in order to make sense of the implications of this expanding area of knowledge. In order to better understand the history of portrayals of genetics in film and television, this article asks the following research questions:

1. How has the presentation of genetic science in film and television changed over time?
2. How does genre affect the portrayal of genetic science?
3. How does medium considered separately from genre and time period affect the portrayal of genetics?

Data and Methods

For this article an interdisciplinary team of researchers conducted a systematic analysis of as many films and television shows that address genetics as we could discover. Staff in the Evidence-Based Practice Center at Vanderbilt's Institute for Medicine and Public Health performed the initial search, which was then supplemented by additional searches by scholars of film and television.[2] Scholars from the departments of English, Cinema and Media Arts, and Communication Studies defined the relevant genres within the dataset and assisted with the coding;[3] researchers from the fields of Genetics, Medicine, and Bioethics helped refine the genetic categories used in the coding;[4] and researchers from Sociology helped code the data and performed the analyses.[5]

[2]·Nila A. Sathe, MA, MLAS; Jay Clayton, PhD; Claire Sisco King, PhD.
[3]·Jay Clayton, PhD; Claire Sisco King, PhD; Lauren Furman, BA.

The body of films and television episodes was obtained from a variety of sources. Using a combination of controlled vocabulary and key terms, we searched summaries of films and television found in IMDB, Wikipedia, the Film and Television Archive at UCLA, and British Film Institute's National Film and Television Archive for the following: "bioterrorism," "biowarfare," "chimeras," "cloning," "DNA," "evolution," "GMOs," "genetics," "genomics," "mutants," and "nature vs. nurture." We supplemented this initial search with inquiries to the Library of Congress and Cold Spring Harbor Laboratories. In addition, we hand-searched the reference lists of articles discussed in the prior section and drew upon our collective media-viewing histories. This hand-searching process continued until August 2020. Inclusion criteria for television episodes included primetime shows released prior to January of 2020 with wide English language distribution in North America, including episodes from streaming services with the exclusion of non-fiction shows about genetics. Inclusion criteria for films included fictional films with wide English language distribution in North American, with the exclusion of non-fiction films about genetics. Our final database yielded 238 films and 539 television episodes. The database is available upon request and will eventually be hosted for public access. This is the most comprehensive database of popular media on the topic of genetics to date and our results give us the best existing indication of the patterns of the treatment of genetics in film and television. The raw data will be made available to the public on a website to coincide with the publication of this article.

In order to conduct quantitative analysis on as many films and television shows as possible, content analysis was conducted on crowd-sourced summaries and reviews archived in the target databases listed above. Since the information on these sites is largely user-generated, we argue that this improves the validity of our data because it moves us one step closer to the public reaction to the film or episode rather than a single analyst's perspective. Wikipedia entries, where available, were given preference because of that source's reliance on crowd-sourced corrections of plot summaries, resulting in a consensus account of a given film or TV show from interested viewers. The remaining sites constitute major sources of information on movies and television shows for both academics and casual viewers. Given our reliance on distant reading methods (in comparison to the close readings of our colleagues elsewhere in this special issue), these sources provide rich information for our analysis. Although having watched many but not all films and episodes in the database constitutes a limitation of the study, we are primarily interested in the reception of them by the general public. This novel method of data collection made it feasible to conduct content analysis for a large body of film and television episodes within a reasonable timeframe and budget.

Each review was coded by two independent investigators for 109 unique attributes ranging from the portrayal of the risk or benefit of genetics to genetic motifs (e.g., cloning, chimeras, and mutations) to bioethical issues (e.g., eugenics, genetic screening, and informed consent) to a range of perspectives on genetic privacy. After being independently analyzed, the variables for each item were reconciled by the pair of analysts through one-on-one

[4]·Ellen Wright Clayton, MD, JD; Bradley Malin, PhD; Lea Davis, PhD.
[5]·Ethan Gibbons, MA; Isaac Stovall, BA; Ariana Shirvani, MA; Ethan Reilly, BA; Andréa Becker, MA.

reconciliation meetings. For this paper, we analyze data on date of release, medium, genre, and the overall attitude toward genetics exhibited by each film or television show. Data were also collected for directors, producers, distributors, cinematic techniques, and plot motifs; the type of genetic risks portrayed; privacy and surveillance themes; box office receipts, critical reception, and awards; and several other variables not included in the present analysis but reserved for future publications.

To study changes in the representation of genetics over time (the "release date variable"), we grouped the films and TV shows into smaller periods, based on clear divisions in the data. The initial period covered by our dataset is 1912–1949. This period had too few films to make analyses by smaller temporal units statistically meaningful. In addition, revelations in the post-World War II period of Nazi medical atrocities catalyzed a shift in how genetics was viewed in cinema and television. Our next two temporal units cover 20 years each. Both the 1950s-1960s and the 1970s-1980s had more works with genetic themes, but still not enough to make analysis by individual decades useful. The 1950s-1960s also form a logical unit in terms of the public's awareness of genetic research. This period saw the landmark publication of Watson and Crick's study of the double-helix structure of DNA (1953), an event that fired the public's imagination, but other significant developments in genetics, such as Marshall Nirenberg's mapping of messenger-RNA to their amino acids in the mid-1960s, did not get nearly as much public attention (Judson). The same pattern holds in the next two-decade unit. In the early 1970s, the era of genetic engineering can be dated to Paul Berg and others' work on recombinant DNA, a breakthrough that once again galvanized public attention and led to the highly publicized Asilomar Conference in 1976. These events were followed in the 1980s by the success of gene-hunters in tracking down the markers for Huntington's Disease and BRCA 1. But it was not until the announcement of the Human Genome Project in the late 1980s that the general public once again became rivetted by developments in genetic science (Cook-Deegan). The increase in genetic-themed films and TV shows in the 1990s reflects the renewed attention to genetics following the inauguration of the Human Genome Project. Because of this growth, we have chosen to analyze the data by decade for the remainder of the years covered by our dataset.

The "genre variable" was broken into six categories selected by the film and television researchers in our project: Action,[6] Comedy, Drama, Horror, Mystery/Thriller, and Science Fiction. The "attitudes toward genetics" variable was broken into three categories: Beneficial, Risky, or Mixed. The goal of this variable was to capture the attitude that the entire movie conveyed to viewers, as it was reflected in the summaries. Items with Risky attitudes toward genetics generally portrayed genetic science in a negative light or as dangerous, while items with Beneficial attitudes dramatized the benefits of genetics for humanity. In summaries that described both beneficial and risky attitudes toward genetics, items were coded as mixed.

In order to address the research questions listed above, we present a series of analyses in the next section. In a preliminary table, the univariate statistics are tabulated to lay out

[6]We included Superhero movies in the Action genre rather than Science Fiction despite the prominence of futuristic technology in many Superhero films, following the lead of many scholars of Science Fiction who do not include comic-book narratives in the genre.

general trends in the data. We then address the first research question about changes in the representation of genetics over time by using bivariate analyses of release date and attitude toward genetics. The second research question about how the genre of a film or TV show affected the portrayal of genetics is similarly assessed using bivariate analyses of genre and attitude toward genetics. The third research question regarding differences between film and TV is addressed throughout these analyses, as each is conducted separately for film and television.

These bivariate analyses only reveal correlational relationships between the variables. As a final step, we use logistic regression to assess whether the genre and release date might be independently related to a work's attitude toward genetics. Because the majority of the films and televisions shows in our dataset present Risky attitudes toward genetics, our logistic regression will predict Risky attitudes vs. non-Risky attitudes (Beneficial combined with Mixed). Does the genre variable alone allow us to predict a higher level of Risky attitudes toward genetics rather than non-Risky, regardless of what time period the work appeared in? Similarly, does the release date of a work allow us to predict the same thing? Here is an example: Given the high frequency of movies that view genetics as Risky in the Horror genre, one might be able to determine or predict the level of probability that any Horror movie ever made would portray genetics as Risky. To make these kinds of assessments, we need to weigh the genre and release date variables independently by controlling for the effect of each variable on the other. Our logistic regression also allows us to measure the impact of a work's medium (film vs. television) on other variables. Thus we can assess several things using logistic regression that could not be measured using bivariate analysis alone: whether the effect of the genre variable holds across time, whether increases in Risky attitudes in certain time periods are the result of the popularity in that time period of a genre (like Horror) that is unusually prone to viewing genetics as Risky, or whether differences between the mediums of film and television are due strictly to differences in the prevalence of particular genres, or to the time periods in which television came onto the scene. To be clear, any relationships between the variables of interest do not indicate causal relations between them. Rather, we investigate whether genre and release date are associated with changes in the treatment of genetics in film and television.

To perform a regression analysis using categorical variables[7] as independent variables, the researcher chooses one level of each variable as the "reference category" and assesses the other levels of each variable in relation to those categories. We selected television as the reference category because it is the larger of the two media in the database. We chose the genre of Action as the reference category for the genre variable because this genre was the closest to having an equal number of Risky vs. non-Risky attitudes toward genetics. Thus, if another genre had either a more or a less Risky attitude toward genetics than Action films, we could calculate the significance of that deviation. The same reasoning governed our choice of the 2010s decade as the reference category against which the other time periods were assessed – it came the closest to having an even number of Risky vs. non-Risky items in the dataset.

[7]·In statistics, categorical variables are qualitative rather than quantitative, by which we mean that the variable describes a quality like the Horror genre, not a number.

The results are presented as odds ratios with 95% confidence intervals. Odds ratios assist in the interpretation of regression coefficients by exponentializing them. Estimated odds ratios above 1 indicate that the variable of interest increases the odds of the outcome variable (in this case, Risky attitudes toward genetics) relative to the reference category by the amount of the result above 1 (i.e., an odds ratio of 1.5 for film would indicate that cinema has a 50% higher likelihood of presenting Risky attitudes toward genetics compared to television). Likewise, estimated odds ratios below 1 indicate that the variable of interest decreases the odds of the outcome variable relative to the reference category by the value of the result below 1 (i.e., a result of 0.5 for the Action genre would indicate that Action films have a 50% lower likelihood of presenting Risky attitudes toward genetics compared to Mystery/Thrillers).

Results & Discussion

Perhaps the most consistent finding is shown in Table A. For films, over 70% of our dataset depicted genetics as Risky, with over 24% of the remaining films exhibiting a Mixed attitude. Somewhat differently, the largest category in television was the Mixed category (44.3%), with Risky attitudes making up another 42.8% of the items; television also had more than twice as high a percentage of shows in the Beneficial category than film (5% film to 12.8% TV). These differences between television and film are relevant to our third research question and will be explored in more detail below. It is worth noting, however, that the data on fictional portrayals of genetics in either media paint a more negative picture than the largely positive vision of genetics found in print and television news in studies by Petersen, Väliverronen, and Hjörleifsson et al..

Our first research question asked how attitudes toward genetics in film and television have changed over time. The initial finding to note is the general increase in the number of both films and television shows about genetics over time, as seen in Table B. More than 50% of films in our dataset came from the 2000s and 2010s, and over 75% of the television episodes came from the same period. Although we cannot definitively argue that this is the result of increasing attention paid to genetics in film and television rather than a result of a general increase in film and television output during this period, this finding does imply that the body of available media content that addresses genetic science is growing over time.

Results analyzing research question 1 appear in Table C and in Figure 1. Of note is the apparent increasing proportion of Mixed attitudes toward genetics in both film and television in the 2000s and 2010s, as well as the rise in Beneficial attitudes in television in the same period. In television, this phenomenon is likely explained by the multiplication and popularity of Medical Dramas such as *House* and *Grey's Anatomy*, as well as police thrillers such as *Law and Order: Special Victims Unit*, *Bones*, and *CSI*. Because police thrillers often depict the use of DNA evidence to solve heinous crimes, many of them exhibit generally Beneficial attitudes toward genetics. Many of the television Medical Dramas, however, depict both positive and negative aspects of genetic science, such as when patients and doctors are shown weighing the benefits of genetic medicine against possible risks. Films during this period did not have the same level of increase in Beneficial attitudes toward genetics but did see a rise in Mixed attitudes. Exemplary films in this category are the series

of *X-Men* comic book adaptations, many of which celebrate genetic difference within the mutant X-Men while portraying other mutants as menaces to society.

Whereas the bivariate analysis indicates that the 20 years between 2000 and 2020 emphasized the Beneficial aspects of genetic science for advances in medical care and criminal justice while often recognizing many of the potential drawbacks, the earliest period (1912–1948) had the highest percentage of Beneficial attitudes toward genetics of any period (25%). All four of the films that viewed genetics as Beneficial had eugenics as a theme, suggesting that during this period, enthusiasm largely centered on understandings of genetics perceived in terms of progress and linked to racialized notions of social stratification. One example of this type of film is *Man's Genesis* by D.W. Griffith. Released in 1912, *Man's Genesis* is the oldest film in our archive. It depicts a grandfather telling his grandsons the prehistoric story of the struggle and eventual success of the clever character "Weakhands" over the strong character "Bruteforce." The physically outmatched Weakhands uses his superior cognitive ability to overpower Bruteforce by attacking him with a club (a weapon of which Bruteforce was presumably unable to conceive), allowing Weakhands to pass on his superior genes by mating with the female character, tellingly named "Lillywhite." The story implies the genetic superiority of brain over brawn, particularly when combined with whiteness, and the purported benefits of eugenics for selecting such Beneficial traits. Enthusiasm for such themes in the early period suggest the general approbation with which racialized eugenics was viewed in the period.

This pattern changes in the 1950s through the 1980s. During these periods, there were no films which had Beneficial attitudes toward genetics. In fact, in the 1950s and 1960s, television had strictly Risky attitudes toward genetics. The revelations of Nazi atrocities had much to do with the decline in enthusiasm for eugenics in the post-war period (Kevles 118). The small bump in Beneficial attitudes toward genetics in the 1970s and 1980s television is due in part to the rise of Medical Dramas such as *Marcus Welby, M.D.* and *St. Elsewhere*. This type of televised depictions of genetic science often emphasizes physicians' ability to use genetics for the benefit of his or her patients.

We will now turn to our second research question: how do genre and medium affect the portrayal of genetic science? Depictions of the risk or benefits of genetics were highly dependent on both medium and genre, as demonstrated in Table D and Figure 2. In the four action-oriented film genres (Action, Horror, Mystery/Thriller, and Science Fiction), Risky attitudes toward genetics predominate, and there are virtually no films in which genetics is depicted as Beneficial. The Action genre, however, is an outlier in one respect. Whereas 95% of Horror films and over 75% of Mystery/Thriller and Science Fiction films present Risky attitudes toward genetics, Action films present a substantial number of Mixed attitudes (44%) alongside the 56% Risky.

It is easy to account for predominance of Risky depictions of genetics in all the action-oriented genres by noting the need for something – a genetically created monster, an evil scientist, or an enhanced supervillain – to set a fast-paced plot in motion. In Action films such as *The Sixth Day* and *Judge Dredd*, which serve respectively as vehicles for the Action stars Arnold Schwarzenegger and Sylvester Stallone, genetic science is used as a plot device

to stimulate the frenetic violence within the film. The Action heroes at the focal point of these films must often battle to overcome the evil unleashed by genetic science. In *The Sixth Day*, this battle is given explicitly biblical references, as Schwarzenegger's character deals with the breaking of so-called "Sixth Day Laws"[8] against the cloning of human beings. Such films often avoid digging deeply into the ethical implications of genetics, instead utilizing the commonly-understood dangers of cloning or gene editing to facilitate a future-oriented Hollywood blockbuster. The large percentage of Mixed attitudes toward genetics in the Action genre can be explained by the popularity of superhero films in recent decades, which often include genetically enhanced protagonists fighting evil mutants, aliens, or the genetic creations of mad scientists bent on world domination. The end result is that the Action genre in film is more balanced relative to Horror, Mystery/Thriller, and Science Fiction.

Perhaps unsurprisingly, the future-facing genre of Science Fiction is the largest in our dataset, with nearly 50% of all films (N=116) and television episodes (N=247). In both film and television, Risky attitudes toward genetics make up over 2/3rd of SF items. The *Jurassic Park* franchise, along with films such as *Star Wars: Episode II – Attack of the Clones* are textbook examples of the use of Science Fiction to convey a message of the Risky potential of genetic science. As classics within the genre itself, these films demonstrate the melding of the genre conventions of contemporary SF with the warnings of the myths of Prometheus and Frankenstein. One of the few SF items that presents a Beneficial attitude toward genetics is *The Last Mimzy*, which tells the story of how the last time-traveling mimzy is able to carry untainted DNA from current-day humans to the future, where environmental pollution has damaged the human genetic code and human's ability to care for one another. Despite having a generally positive view of genetics, *The Last Mimzy* remains critical of the technological hubris of humanity which may lead to environmental destruction and decrease in social cohesion, thereby in some ways echoing the warnings of *Frankenstein*. This pattern is complicated by films that present a Mixed attitude toward genetics such as *Interstellar*, which suggests that genetic engineering of corn is the last, and ultimately futile, hope for humanity to save itself from blight and dust storms, and that a biobank of frozen embryos could be used to seed the human species on another planet. Although *Interstellar* uses a host of SF themes and is set in an apocalyptic future, it contains less of a warning about the dangers of advancing scientific knowledge and manifests a more measured take on the potential for genetic science.

In cases where both films and TV shows in the four action-oriented genres (SF, Action, Horror, and Mystery/Thrillers) presented a Mixed view of genetics, it generally was not because of a balanced assessment of risks vs. benefits but rather because of plots that featured a dedicated scientist struggling to undo the harm caused by scientific overreaching or by a malevolent villain using genetics to wreak havoc on the world. TV shows in the *Star Trek, Doctor Who*, and *Orphan Black* franchises, which together make up a large segment of television SF about genetics (123 of the 200 episodes or about 62%), were dominated by this plot-pattern. TV mysteries and thrillers are the outliers in this dataset, being the only action-oriented genre in which Beneficial and Mixed characterizations exceeded Risky

8. The Sixth Day Laws refer to the Genesis story, in which God creates humankind on the Sixth Day.

assessments of genetics. This anomaly stems from the frequency of forensic plot motifs, in which the protagonist uses genetic testing of crime samples to help solve a crime. These findings demonstrate the importance of considering the influence of medium and genre variables both independently and in conjunction with one another, as the multiple formal elements of these popular media combine to favor particular content.

By contrast, films and TV shows in the Comedy genre and Drama genre had generally higher percentages of Beneficial and Mixed attitudes toward genetics than did the action-oriented genres (in Comedies, 50% of films and 65% of television episodes had either Beneficial or Mixed attitudes; in Dramas, 62% of films and 83% of television episodes were Beneficial or Mixed). In Dramas, a Mixed characterization was more likely to occur because of a serious attempt to weigh the pros and cons of medical genetics. For TV Dramas, this reason for a Mixed view of genetics was overwhelmingly the case. One will notice that TV Dramas – a category dominated by medical shows – was the only genre with a majority of Mixed characterizations. In addition to the weighing of the positive and negative aspects of medical genetics, some Medical Dramas present a Mixed perspective due to fundamentally flawed characters such as the eponymous character of *House*. Dr. House's success in his endeavors to diagnose and treat difficult patients often comes with the drawback of breaking moral, ethical, and legal imperatives. In instances where House's medical interventions are connected to genetics, the audience is presented with this powerful science in the hands of a person who is both extraordinarily effective and dangerously unethical.

Table E displays the results of the logistic regression using medium (television as the reference category), genre (using Action as the reference category) and release period (2010s as reference category) to predict the likelihood of works in the other categories presenting a Risky attitude toward genetics. Results indicate that holding the effect of the date and genre variables constant, the medium of film itself (OR = 2.016, 95% CI = 1.330, 3.080) increases the odds of a Risky attitude toward genetics by 101.6% compared to television. These findings build upon the results from the bivariate analysis, demonstrating that the impact of the medium is additional to any influence stemming from the time period or genre of a film. By holding the effect of the genre and period variables constant, we can discern that films are more likely to present a Risky attitude toward genetics than television shows. Some of the likely reasons for this finding are explored in Furman and Clayton (2021), but we suspect that the dramatic conventions of action-oriented genres, coupled with big-budget special effects, favour a more Risky presentation of genetics whereas the more intimate viewing experience of television encourages a more balanced perspective.

Turning to the genre variable, we find similarly interesting effects that are independent of those of medium or time period. Science Fiction (OR = 2.798, 95% CI = 1.451, 5.798) and Horror (OR = 15.790, 95% CI = 3.673, 115.374) both significantly increased the odds of an item presenting a Risky attitude toward genetics. The extraordinarily large odds ratio for Horror is a result of only a single Horror film (and no television episodes) having a non-Risky attitude toward genetics. Although Science Fiction has a fair number of movies rated as non-Risky, it still increased the odds of Risky attitudes by 179% compared to the reference category (Action). Conversely, the Drama genre significantly decreased the likelihood of Risky attitudes (OR = 0.311, 95% CI = 0.140, 0.682). This finding indicates

that although the influence of Medical Dramas on TV is strong, the effect of Drama as a genre is not limited to television, as an item falling into the category of Drama has 69% lower odds of having a Risky attitude relative to the reference category. Of the two genres that did not differ from the reference category to a statistically significant degree – Mystery/Thriller and Comedy – the former is anomalous among action-oriented genres because of large number of TV shows featuring forensic genetics.[9] Because forensic plotlines emphasize the value of genetics to bring serial killers and other criminals to justice, almost all TV shows that focus on forensic genetics are rated Beneficial or Mixed.

Broadly, we can think of attitudes toward genetics as falling into three groups. Films and television shows in the Science Fiction and Horror genres present genetics as Risky, using scenarios of scientific advances to incite the action of the plot, either as a monstrous threat as Haynes ("Alchemy" 244) asserted, or as a case of human knowledge gone too far, as in the myths of Frankenstein and Prometheus (Weingart et al. 281). Conversely, in films and television shows which fall into the Action, Mystery/Thriller, and Comedy genres, genetics are as likely to be perceived as Risky as they are to be perceived as either Beneficial or Mixed. This complexity is due to variation within these genres. If one excludes Superhero movies from the Action genre and forensic plotlines from the Mystery/Thriller genre, these genres also generally present genetics as Risky (if one includes Superhero and forensic TV shows, the result is still mainly an increase in Mixed views of genetics, not Beneficial). Comedies are perhaps more directly balanced, with genetic science as likely to be treated as a harmless object of humor as it is to be treated as dangerous knowledge which is satirically ridiculed. Finally, the Drama genre does not portray genetics as Risky. Rather, Dramas significantly lower the likelihood of genetics being seen as a troubling scientific development. Instead, the Drama genre (and particularly medical shows) presents genetics as a tool that has benefits and dangers, that can be the source of conversation, excitement, or trepidation, and that must exist within the various other dramatic and mysterious aspects of life.

The results of the period variables are striking. The reference category for this variable is the 2010s, which is the decade closest to a 50/50% split of Risky attitude vs. Beneficial or Mixed. The 2000s is the only period with significant negative effects on the likelihood of presenting Risky attitudes toward genetics. In the 2000s, films and television episodes were less likely to present Risky attitudes toward genetics relative to the 2010s (OR = 0.671, 95% CI = 0.451, 0.994). This result demonstrates that while holding the effect of the genre and medium variables constant, items in the 2000s were approximately 33% less likely to present Risky attitudes toward genetics relative to the 2010s. Conversely, the 1970s and 1980s was the only period to have a significantly positive effect on the likelihood of presenting Risky attitudes toward genetics. Films and television in the 1970s and 1980s were approximately 90% more likely (OR=1.903, 95%CI =1.065, 3.472) to present Risky attitudes toward genetics relative to the 2010s. These results suggest that the 2000s is anomalous in its positive treatment of genetic science in film and television. Enthusiasm for genetic advances at the end of the 20th century and beginning of the 21st may have increased

9.There are no films in our dataset that featured forensic genetics.

the rate at which producers made films and television episodes which presented non-Risky attitudes toward genetics. In contrast, the films and television shows of the 1970s and 1980s reflect the concern with which media producers understood contemporary developments in genetics science.

Conclusion

Over the past 120 years, genetics has become one of the premier areas of science. The depiction of genetics in film and television has both mirrored and influenced the excitement and anxiety around this new area of knowledge. While many of the depictions of this cutting-edge field reflect the tradition in popular media of portraying ambivalence and skepticism toward new areas of knowledge, the manner in which these portrayals manifest is contingent upon both formal factors (such as medium, genre, conventions, and tropes) and historical contexts. Whereas some work has been done by literary and film scholars on individual works featuring genetic science, our analysis allows for a sense of broad patterns in film and television to become visible.

The period in which a film or television show is produced clearly affects the way in which genetics is treated. In the earliest period of our dataset, eugenics is one of the most frequent themes and is generally treated positively. At the time, eugenics was fashionable among many in the educated classes and its popularity is reflected and promoted in the popular media of the day. The subsequent decline of eugenic ideas after the revelations of Nazi atrocities is likewise mirrored in the dearth of eugenics in our dataset after World War II until recent years. In the 2010s, eugenics reemerges as a theme in film and television, suggesting that media producers have once again found this issue to be important, primarily in response to the possibility of genetically enhancing children, athletes, and soldiers. As in the case of *Frankenstein* and the Prometheus myth, film and television connecting the atrocities of the Third Reich to eugenics warn the audience of the overreach of humanity's search for knowledge and power. As the promise of genetic science grows concurrently with movements in the last decade seeking to reaffirm national and racial identities, film and television has taken up the mantle of much older tales warning us about the dangers of manipulating human life through technological means. Further analysis of our dataset that looks for correlations between Frankenstein or Prometheus tropes, as well as Nazi motifs, and the time period in which a work was produced is warranted.

One explanation for the difference of the 2000s relative to all other decades might be that this decade saw the completion of the rough draft of the Human Genome Sequence in year 2000 and of the final sequence in 2003. Extraordinary claims were being made at this period about the medical breakthroughs that sequencing the genetic code would bring. President Clinton proclaimed that "Today, we are learning the language in which God created life." People were predicting fabulous new cures for existing diseases. President Clinton joined the chorus: "it is now conceivable that our children's children will know the term 'cancer' only as a constellation of stars" (US Cong. House. Comm on Sci, 395). That these discoveries came with such fanfare and excitement may be the difference between the first decade of the twenty-first century and the period between 1970 and 1989. The 1970s and 1980s likewise saw great leaps forward in genetic science including the creation of recombinant DNA

molecules, ushering in the first age of genetic engineering. Further study of the production and reception data we have collected on the media in our dataset might shed light on such historical shifts.

The form of a media item also has a clear influence. In our dataset, the importance of genre is clearly shown. Dominated by the Science Fiction genre, our dataset is largely constituted by imaginings of future worlds in which genetic science plays a major role in the workings of society. The dominant picture of genetics in this context is negative, as many extrapolations of future worlds in action-oriented plots imagine genetics to be used for evil purposes. Although this may present a picture of genetics to the public that is more perilous than scientists would like, it also allows for an exploration of the possible downsides of continued developments in genetic science and technology.

By contrast, the more immediate possibilities for the use of genetic science in medicine and law enforcement are more likely to be depicted in a positive manner by the media which take up those issues. Combined, these results suggest that the public may be (perhaps rightfully) concerned about the long-term possibilities for genetic science to threaten the future of the species, their children's identity, and their own privacy, while more immediate applications of advances in genetic medicine and law enforcement are (also perhaps rightfully) understood more positively. This distinction complicates the critical literature on this topic which demonstrates that whereas fictional media often highlight the dangers of new technology, news media and journalism may overplay its positive benefits. In addition, the historical context of the media matters, both in terms of the medium itself (film vs. television) and the conventionalized forms within which these narratives are told (genres, motifs, etc.). That is, scientific developments and ideological concerns seem to interact in distinguishable ways with different genres and different media. Other articles in this special issue explore this finding via close readings of representative films and television shows from the dataset (Casey and Clayton; Feldman and Clayton; Furman and Clayton; Oliver, et al.; Porter; Taylor and King).

Much scholarship has demonstrated that popular media both reflects and influences the ways in which the public perceives scientific issues (e.g., Boykoff & Boykoff; Sakellari; Haynes, "Whatever Happened"). In the context of genetics, this has likely been true since the beginning of our dataset, when *Man's Genesis* argued for the evolutionary advantage of the cleverness of a (white) cave man over the brute force of a darker-hued antagonist. Of course, it is also the case that advances in cutting-edge genetics influences the content of popular media itself, as science opens up new possibilities for cinema and television to explore. As genetic science continues to develop, it will be important to continue to track the relationship between its advances and their subsequent portrayals in popular media.

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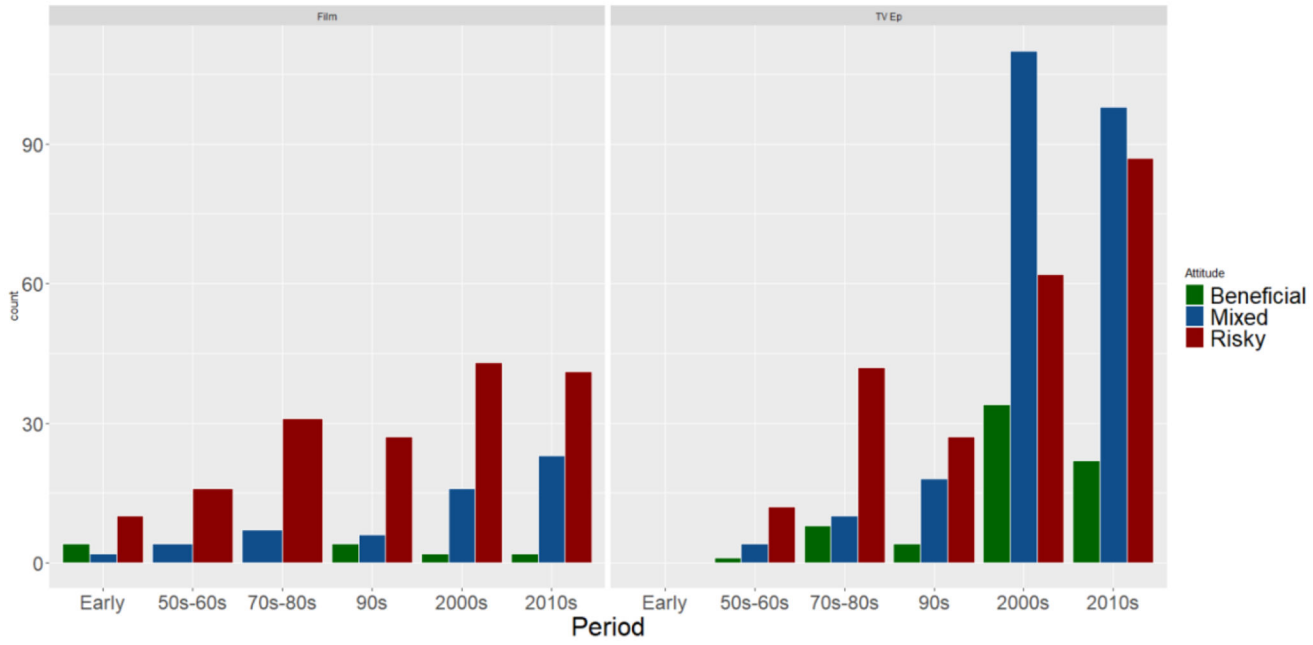

Figure 1.
Changes in Attitudes over Time

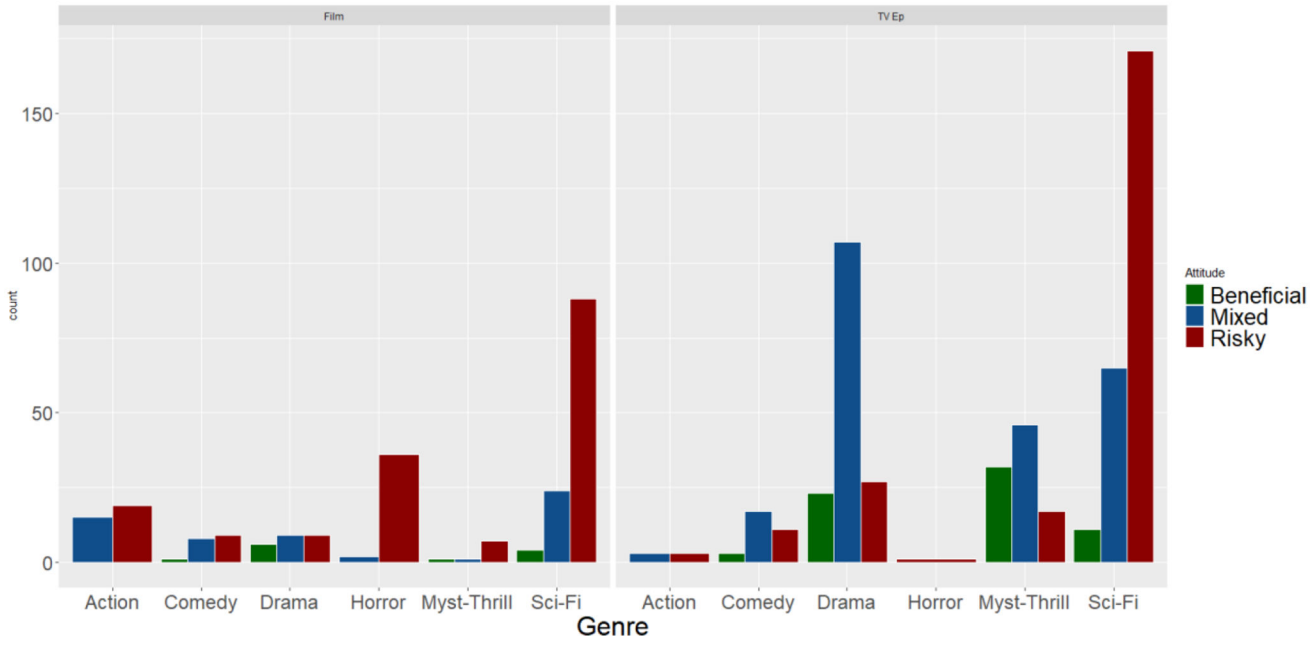

Figure 2:
Differences in Attitude by Genre

Table A:

Attitudes Toward Genetics

Attitudes Toward Genetics	Film (N=238)		TV (N=539)	
Beneficial	12	5.0%	69	12.8%
Mixed	58	24.4%	240	44.5%
Risky	168	70.6%	230	42.7%

Table B:

Genetics in Film & TV over Time

Period	Film (N=238)		TV (N=539)	
1912–1949	16	6.7%	0	0.0%
1950s & 1960s	20	8.4%	17	3.2%
1970s & 1980s	38	16.0%	60	11.1%
1990s	37	15.5%	49	9.1%
2000s	61	25.6%	206	38.2%
2010s	66	27.7%	207	38.4%

Table C:

Attitudes toward Genetics over Time

	Attitude toward Genetics					
	Film (N=238)			Television (N=539)		
Period	Beneficial	Mixed	Risky	Beneficial	Mixed	Risky
1912–1949	4 (25%)	2 (12%)	10 (63%)	0	0	0
1950s & 1960s	0	4 (20%)	16 (80%)	1 (6%)	4 (24%)	12 (71%)
1970s & 1980s	0	7 (18%)	31 (82%)	8 (13%)	10 (17%)	42 (70%)
1990s	4 (11%)	6 (16%)	27 (71%)	4 (8%)	18 (37%)	27 (55%)
2000s	2 (3%)	16 (26%)	43 (71%)	34 (17%)	110 (53%)	62 (30%)
2010s	2 (3%)	23 (35%)	41 (62%)	22 (11%)	98 (47%)	87 (42%)

Table D:

Attitudes toward Genetics in Different Genres

	Attitude toward Genetics					
	Film (N=238)			Television (N=539)		
Genre	**Beneficial**	**Mixed**	**Risky**	**Beneficial**	**Mixed**	**Risky**
Action	0	15 (44%)	19 (56%)	0	3 (50%)	3 (50%)
Comedy	1 (6%)	8 (44%)	9 (50%)	3 (9%)	18 (56%)	11 (34%)
Drama	6 (25%)	9 (37%)	9 (37%)	23 (15%)	108 (68%)	27 (17%)
Horror	0	2 (5%)	36 (95%)	0	0	1 (100%)
Mystery/Thriller	1 (11%)	1 (11%)	7 (78%)	32 (34%)	46 (48%)	17 (18%)
Sci-Fi	4 (3%)	23 (20%)	88 (77%)	11 (4%)	65 (26%)	171 (69%)

*Percentages indicate the proportion of movies from that period and genre which fall into each attitude category. 0s are not marked for visual clarity.

Table E:

Likelihood of Risky Attitudes toward Genetics Predictor Coefficients Using Logistic Regression

		95% Confidence Interval	
Variables	**Odds Ratio**	**Lower**	**Upper**
Medium [a]			
Film	2.016**	1.330	3.080
Genre Variables [b]			
Comedy	0.744	0.304	1.796
Drama	0.311**	0.140	0.682
Horror	15.790**	3.673	115.374
Mystery/Thriller	0.455	0.140	1.050
Science Fiction	2.798**	1.345	5.798
Period of Release [c]			
Early	0.368	0.079	1.593
50s-60s	1.448	0.616	3.681
70s-80s	1.903*	1.065	3.472
90s	0.854	0.484	1.514
2000s	0.671*	0.451	0.994
Constant	0.765		
Pseudo R^2 (Cragg-Uhler)	0.36		
N	777		

*p<.05;

**p<.01;

***p<.001;

[a]Television is the reference category

[b]The reference category for the genre variable is Action

[c]The reference category for the time period variable is the 2010s