Moral Judgments About Genetically Modified Humans (GMHs)

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Declaration

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Abstract

Advances in human gene-editing technologies are outpacing policy and legislation. The development of gene-editing techniques such as CRISPR-Cas9 has simplified the process of gene-editing drastically, enabling scientists to insert, edit and remove sections of DNA more easily than before. The advances in human gene-editing create both hope for the treatment of many diseases and disorders as well as many novel ethical challenges. The ultimate impact of gene-editing technology is contingent on whether and how people are willing to use it. Yet, despite these major leaps forward in gene-editing technology, little research has been devoted to understanding the factors that influence people's moral judgments about human gene-editing.

In the present thesis I employ the psychological literature on attitudes to genetically modified organisms (GMOs) to examine different factors that play a role in people's moral judgments about human gene-editing. Across seven studies, utilizing correlational and experimental methods, I examine moral judgments about human gene-editing. In Chapter 2, Studies 1 (*n* = 447) and 2 (*n* = 348) provide preliminary evidence for the role of perceived harm in support for human gene-editing. Specifically, perceived harm was negatively associated with support for human gene-editing, and perceived benefits positively associated with support, while purity concerns and disgust were unrelated to support for these technologies.

I then turn to the effect of gene-editing *purpose* on judgments about human gene-editing. Three studies were the first to employ a carefully matched experimental design to examine the effect of treatment vs. enhancement purpose of human gene-editing on suppor. These studies also examined the role of different moral considerations such as the perceived moral rule violation and outcomes in terms of harms and benefits (Ch. 3). In Studies 3 (*n* = 369) and 4 (*n* = 394; Ch. 3), participants were significantly more supportive of human gene-

editing for treatment purpose (e.g., to improve the physical functioning of people *with* physical disabilities) compared to for enhancement (e.g., to improve the physical functioning of people *without* physical disabilities). Further, the lower support afforded to enhancement vs. treatment purpose was mediated by endorsement of both outcome-based and rule-based moral considerations. Specifically, participants viewed enhancement (vs. treatment) as producing less benefits for people and as more of a moral rule violation. These perceptions partially accounted for the lower support afforded to enhancement (vs. treatment). The aim of Study 5 was to test whether the influence of *purpose* is specific to human gene-editing rather than GMOs more broadly, thus I experimentally manipulated whether the target of gene-editing was people or farm animals in a between-participants design (Ch. 3; n = 355). Study 5 also included a measure of the perception of unfair advantage from gene-editing. Enhancement (vs. treatment) purpose was viewed as more unfair and was afforded less support when the target of gene-editing was people, but not when the target was farm animals. Additionally, unfairness mediated the effect of purpose when the target of gene-editing was people, but not when the target was farm animals.

In Chapter 4, the final study sought to replicate the findings across a wider range of domains than just physical functioning. Study 6 (Ch. 4; n = 329). Utilizing a mixed design, Study 6 was the first to show that the lower support for genetic modification for enhancement (vs. treatment) purpose replicates in other domains aside from physical functioning, including longevity, mobility, intelligence and disease resistance. Additionally, the results of Study 6 demonstrated that although participants in general showed a preference for conventional methods over genetic modification, the lower support afforded to enhancement (vs. treatment) was explained by reduced perceptions of social benefit and increased perceived unfairness for both methods.

Together the findings suggest that the purpose is central to the level of support afforded to human gene-editing, with enhancement (vs. treatment) consistently receiving less support, even when the function that is targeted is identical (e.g., physical functioning). Further, endorsement of both outcome- and rule-based moral considerations account for the different levels of support afforded to human gene-editing for enhancement (vs. treatment). Importantly, human gene-editing evoke different moral considerations compared to GMOs, for instance regarding fairness concerns, which explain the effect of purpose on support when people are gene-edited, but not when farm animals are. In concert, these findings demonstrate that the purpose, outcome- and rule-based moral considerations all play a role in people's moral judgments about human gene-editing. A final chapter (Ch. 5) discusses implications for the literature on opposition to GMOs, and harm- and rule-based moral considerations in moral judgments. The final chapter also outlines some avenues for future research in moral judgments about human gene-editing and potential significance for regulatory frameworks of human gene-editing.

Chapter 1: Literature Review

In 2015 a group of Chinese scientists used a technique called CRISPR-Cas9 (CRISPR) to edit the genomes of human embryos for the first time in history (Cyranoski & Readon, 2015). This technique has simplified the process of gene-editing, allowing scientists to insert, remove, and modify sections of DNA more easily and with more precision than ever before (Landphier et al., 2015). The news coverage ranged from optimistic portrayals of CRISPR's potential to cure a wide range of diseases including blood disorders, HIV, and Huntington's disease (Fernández, 2018), to dystopian visions of a future with 'designer babies' edited to be more attractive and have greater intelligence, reserved only for those with sufficient funds (Reddy, 2017).

These rapid developments in human gene-editing technologies pose many acute ethical questions and by extension a pressing need for policy makers to understand people's moral judgments about it (Lunshof, 2017). Yet, very little research has been done to examine what underpins people's moral judgments about these technologies and how people deal with the potential ethical and practical implications of their use. To date, research suggests that people harbour quite favourable views towards human gene-editing for treatment purposes but are more sceptical towards gene-editing for enhancement purposes (PEW Research Center, 2018a; Rainie et al., 2016). In medical ethics the distinction is commonly used to differentiate between medical interventions that are necessary to maintain health (treatment) and interventions aimed to improve functioning beyond this (enhancement; Daniels, 2000). These are typically thought to differ in their utility such that treatment yields more benefits than enhancement (Buchanan et al., 2001). It is not clear what specific moral considerations underlie people's preference for treatment over enhancement. Further, the studies that have examined the treatment vs. enhancement distinction in attitudes to human gene-editing have confounded this distinction with other aspects, for instance by comparing enhancements of intelligence and attractiveness with the treatment of disease (e.g., PEW Research Center, 2018a; 2018b). Consequently, it is impossible to say whether the previous results show a treatment (vs. enhancement) preference, or whether they are merely the product of design confounds.

This thesis offers the first systematic, experimental investigation of the enhancement vs. treatment distinction in moral judgments about human gene-editing. The current investigation provides the first evidence that participants are consistently more supportive of human gene-editing for treatment compared to enhancement. Further, the current investigation is the first to show the moral considerations that underlines this preference. Specifically, participants prefer human gene-editing for treatment over enhancement both because treatment is seen to produce greater benefits for people and is viewed as less of a moral rule violation compared to enhancement. The present investigation reveals little support for the view that opposition to human gene-editing is rooted in specific emotions such as disgust or purity-based concerns. Rather participants in the present studies tended to be somewhat nuanced in their evaluations of human gene-editing. Consequently, the extent to which the intervention was seen to improve the wellbeing of people as well as the extent to which it was perceived to violate moral rules were both associated with support for gene-editing.

In the present chapter I first offer an overview of what human gene-editing is, its potential applications and the current state of legislation and policy surrounding human gene-editing. I then provide a summary of different theoretical accounts of attitudes toward science, including cognitive constraints, religiosity and ideology, before considering why these may not suffice when it comes to attitudes to human gene-editing. Next, I employ the literature on attitudes to science and GMOs as a starting point to understanding moral judgments about human gene-editing. I argue that although judgments about GMOs and human gene-editing share some central features, they differ in a fundamental way. Namely, whether the target of gene-editing is a human or non-human organism. This distinction leads to some important differences in terms of the harm and rule-based moral considerations that shape people's attitudes. I further argue that past research has failed to examine the treatment (vs. enhancement) distinction in the application of human gene-editing in a systematic way, instead relying on survey designs comparing enhancement and treatment in different health domains. Thus, it is unclear whether people do in fact reliably distinguish between human gene-editing for treatment vs. enhancement.

What is Human Gene-editing?

Although gene-editing tools have been available for decades, the CRISPR technology represents a major leap forward due to the ease, precision and availability with which it allows scientists to edit DNA (National Human Genome Research Institute, 2019). Because CRISPR relies on a protein called Cas9, which operates like a pair of molecular scissors that can target and cut specific regions of DNA, scientists are able to add and remove genes with much greater precision than earlier techniques permitted (Hamzelou, 2017; Symons, 2019). The increased precision originates in the way the CRISPR system stores fragments of viral DNA sequences that protects bacteria from viruses and targets sequences that match the specific fragment (Esvelt, 2014). This fragment can be changed so that any given gene can be targeted (Esvelt, 2014). In other words, CRISPR allows scientists to cut the DNA and trick the cell's natural repair mechanisms to make the desired changes (Vidyasagar, 2018). The gene-editing can be done in somatic cells, where only the genes of the specific organism is changed, or in germline cells (e.g., egg or sperm cells), where the genome change becomes heritable to future offspring of the specific organism (Vidyasagar, 2018).

The application of CRISPR could potentially eliminate a range of diseases, advance food production, enhance human health and alter the course of evolution (Funnell, 2016;

Park, 2016; Doudna & Sternberg, 2017). Compared to older gene-editing techniques which are less precise, much more time-consuming and expensive (New Scientist, 2021), CRISPR has simplified the process drastically, enabling scientists to insert, replace and delete sections of DNA in any living organism, including humans.

The list of potential applications of CRISPR is seemingly endless and range from medical research and medicine to agriculture and ecosystem management (Blakemore, 2017). Most attention has been devoted to the potential for gene-editing to cure genetic conditions (Hockemeyer & Jaenisch, 2016), with hopes that it can one day be applied to treat a host of diseases such as blood disorders, HIV, and Huntington's disease (Fernández, 2017). Older gene-editing techniques have already been applied in clinical trials of humans, with the aim of treating Huntington's disease (an inherited disease that causes degeneration of nerve cells in the brain; Ledford, 2018). Previous research has already demonstrated that CRISPR has been successful in treating genetic disorders in animals as well as human embryos (Barrangou & Doudna, 2016). For instance, CRISPR has been successfully applied to edit a genetic mutation that leads to a heart defect in human embryos (Ghose, 2017). Further, in March 2020, a person with Leber's congenital amaurosis, a genetic condition that causes blindness for which there is currently no cure, became the first to undergo CRISPR gene treatment (Ledford, 2020).

Beyond genetic disorders, there is also hope that gene-editing can be applied to treat diseases. Older gene-editing techniques have already been used to treat leukaemia in children (Le Page, 2016) and clinical trials using CRISPR to treat cancer are already underway (Le Page, 2016). For instance, in 2016 CRISPR gene-editing was for the first time employed in a person to treat lung cancer by a team of Chinese scientists (Cyranoski, 2016). In terms of germ line editing, where the DNA in germ cells or embryos is altered and the genetic change becomes hereditary, CRISPR has also been applied successfully in non-viable human embryos (embryos that cannot result in live birth; Fogarty et al., 2017; Liang et al., 2015; Kang et al., 2016; Tang et al., 2017). The use of CRISPR in germline editing has still not been applied clinically (Hendriks et al., 2018).

The hopes for the application of CRISPR is not limited only to the treatment of disease – scientists are also researching the possibility for CRISPR to aid in organ transplants. Specifically, scientists have used CRISPR in experiments to create human-pig *chimeras* (organisms whose cells originate from two or more species), and human-sheep chimeras with the aim to eventually enable scientists to grow organs in the lab (Blakemore, 2017; Davis, 2009). Lab grown organs would not only represent a major scientific advancement, but also create new hope for the many that are currently on the waiting list for donor organs.

Alongside medical treatment, CRISPR is also proving crucial to basic medical research. For instance, in the UK researchers have successfully applied CRISPR to edit the genes of human embryos and subsequently been able to identify the role of a specific gene in the development of embryos (Gyngell & Savulescu, 2017). The research was conducted using human embryos that were donated by couples following their in vitro fertilization treatment, a technique used to treat couples struggling to conceive where the egg is combined with the sperm outside the body and later transferred to the uterus; The Mayoclinic, 2020). The research findings can be applied to understand why one in three embryos formed naturally miscarry. The study represented a regulatory milestone too, as the first gene-editing study officially sanctioned by a regulatory body in the UK.

In addition to basic medical research, gene-editing using CRISPR can also be employed in agriculture to improve nutrient content and resistance against pest and drought (Gil-Humanes & Voytas, 2014; Wang et al., 2019). The US Department of Agriculture has already approved certain crops that have been modified through CRISPR (Waltz, 2016).

Similarly, CRISPR has also been applied to edit the genes of yoghurt cultures to vaccinate against viruses (Waltz, 2018). The potential application of CRISPR is not limited to agriculture: scientists have proposed that the technology could be revolutionary in ecosystem management (Esvelt et al., 2014). The argument is that with a precise gene-editing tool like CRISPR, scientists could eventually be capable of altering traits or population size of non-domesticated species. For instance, scientists could potentially use gene-editing to change the genes of mosquitoes that transmit malaria to prevent them transmitting it. If this gene change was heritable, this could spread through the mosquito population and create resistance to malaria (Esvelt et al., 2014). Further, CRISPR can be used to create so-called gene drives that enhance the likelihood of certain traits being inherited from parent to offspring (Vidyasagar, 2018). These gene drives could also be applied to eliminate resistance to pesticides and invasive species (Vidyasagar, 2018).

Despite its enormous potential, the application of CRISPR in human gene-editing is still very much in its early stages, and there are concerns about unintended changes to the genome, where the DNA is cut at other locations than intended. In one study, scientists found that attempts to repair a gene that causes hereditary blindness in human embryos led to unintended changes and even eliminated parts of the chromosome (Marcus, 2020). The scientists emphasised caution in human trials, arguing that we do not yet know how to make precise changes without creating unintended and potentially dangerous consequences. Similarly, scientists who have applied CRISPR to rice found that the proportion of gene-edited cells varied from as low as 50% to as high as 80%, with higher percentages of changed cells reflecting greater efficiency. Thus, it is clear that a lot of research remains to be done before gene-editing can be safely and efficiently applied.

Although human gene-editing is still in its infancy gene-edited animals are already commercially available. Take the aquarium fish genetically modified to glow in the dark.

Originally meant for scientific purposes, the fish were created using fluorescent proteins from marine jellyfish inserted into the genome (PetMD, 2016). Similarly, some companies now offer cloning services to farmers that wish to extend the legacy of their prize animals. As Transova Genetics put it: “Cloning livestock empowers you to leverage the value of your most profitable animals” (Trans Ova Genetics, 2020). These services are not limited only to farmers. Even pet owners with sufficient funds can avail of such services. For example, the singer Barbara Streisand cloned her dog, twice, using cells collected before the dog died (BBC, 2018).

Policy and Legislation

Human gene-editing has sparked both legal and ethical concerns. This became especially apparent following a case in 2014 where a Chinese scientist edited the genes of 86 non-viable human embryos (Liang et al., 2015). The scientist used germline editing, wherein the changes to the DNA are passed down to future generations. The event eventually led members of the scientific community to call for a moratorium on the editing of human germlines (Cyranoski & Reardon, 2015). Similarly, in 2018, the Chinese scientist He Jianku became the first to have used CRISPR to edit the genes of human embryos to reduce their susceptibility to HIV (Cyranoski, 2020). The human embryos were later transferred into two women, one of which gave birth to twins with the edited change. The research was met by outrage in the scientific community worldwide, and many deemed it highly unethical, unnecessary, and premature (Cyranoski, 2020). Jianku and the two other lead scientists on the project were later sentenced to serve a three year prison sentence and pay a fine of $430,000 (Cyranoski, 2020).

These rapid advances in human gene-editing have been met with concern. For instance, ethicists have voiced worries over human gene-editing for enhancement purposes in healthy individuals and germline editing where changes to the DNA become hereditary

(Rabino, 2003). More generally, others have expressed fears of a dystopian future with cloned humans, designer babies and eugenics (Nuffield Council on Bioethics, 2018). Thus, there is a growing need for policy and legislation to deal with the myriad uses of gene-editing technology.

Yet, developments in human gene-editing are rapidly outpacing legislative frameworks. As of October 2020, heritable gene-editing is prohibited in most countries (Center for Genetics and Society, 2020). Nonetheless, there are massive variations between countries. For instance, the gene-editing of human embryos (regardless of funding source) would lead to a prison sentence in Australia, while no legislation covers privately funded research conducted in the US (Gyngell & Savulescu, 2017). Similarly, China has no national legislation covering embryo research. Somatic gene-editing on the other hand, where the gene change is not heritable, is not as strictly regulated (Gyngell & Savulescu, 2017). For instance, in the UK, ethical approval for scientific projects is granted by the Human Fertilisation and Embryology Authority (HFEA; Gyngell & Savulescu, 2017).

There are continuous debates over the legal and ethical implications of human gene-editing both within and outside the scientific community (Baltimore et al., 2015; Lanphier et al., 2015). The general public has also voiced the need to be consulted before any clinical trials become a reality (Scheufele et al., 2017). Researchers of public opinion emphasise the importance of including the general public in debates and policy making on issues pertaining to human gene-editing. They argue that the inclusion of the public may support greater trust in science (Hendriks et al., 2018). Nonetheless, very little is known about the psychological processes that underpin people's moral judgments about human gene-editing.

The potential for gene-editing to deal with many of the world's most pressing challenges including everything ranging from genetically heritable disease to the effects of global warming on crops means the technology is here to stay. However, the ethical and legal implications are profound. Policymakers and legislators are struggling to keep up with the fast paced technological advancements (Cyranoski & Reardon, 2015). Indeed, one of the pioneering scientists responsible for developing the CRISPR technology Dr. Jennifer Doudna (Doudna & Sternberg, 2017), wrote the following about the implications of her discovery:

“Armed with the complete CRISPR toolkit, scientists can now exert nearly complete control over both the composition of the genome and its output.”

Thus, it is imperative that we gain a deeper understanding of the kinds of moral considerations that influence people’s attitudes to human gene-editing – for scientists and policy makers alike.

Theoretical Accounts of Attitudes to Science and GMOs

Research on public support for, and trust in, science and scientific innovation suggests that people’s attitudes are often driven by lack of knowledge, taboos, and religiosity (Rutjens et al., 2018a). On one hand human gene-editing might merely represent yet another scientific innovation wherein people’s attitudes are in part rooted in the usual suspects such as the lack of knowledge, taboos, religiosity, emotion and the like (e.g., Rutjens et al., 2018a; see also Rutjens et al., 2018b). On the other, hand attitudes to human gene-editing may be informed by other factors such as moral concerns about the potential harms and benefits of the technology. Although there has been a dearth of research into the psychological underpinnings of attitudes to human gene-editing, there is a rich literature on psychological predictors of attitudes to science more generally. This literature provides a useful starting point for the examination of attitudes to human gene-editing specifically. The present thesis will employ the different theoretical frameworks used to understand moral judgments about GMOs to examine the psychological factors that underpin moral judgments about human gene-editing. GMOs share a central feature with human gene-editing in that it is the genetic material that is being modified for different purposes, through the same technological innovations. Only the target differs – GMOs involve the genetic modification of plants and animals, while human gene-editing naturally entails modifying the genome of people. Nonetheless, the moral considerations which underpin judgments about GMOs might be similar for judgments about human gene-editing. Below I outline some of the factors that have been found to play a role in attitudes to science in general, including cognitive constraints, religiosity, ideology and emotion, and discuss how these might also relate to attitudes to human gene-editing.

The Role of Cognitive Constraints

A wealth of research has documented the role of various cognitive constraints in science attitudes (Blancke et al., 2012; Rutjens et al., 2018a; Shtulman & Harrington, 2016). The theorising on cognitive constraints is mainly centred around how many narratives supported by science play against cognitive biases that religious explanations align with (Rutjens et al., 2018a; Shtulman, 2017). Blancke et al. (2012) offered a review of some of the common cognitive biases that impede the comprehension and acceptance of evolutionary theory: the tendency to infer agency and intentionality in observed changes to the environment, teleology (i.e., the belief that the manner in which organisms and natural phenomenon operate serve a purpose) and essentialism (i.e., the belief that the natural world emerges from immutable, categorizable essences). I now will discuss empirical research regarding the influence of each in turn.

The tendency for people to infer agency and intentionality is well documented and is especially evident when people interpret changes in the natural world (Guthrie, 1993; van Elk et al., 2016). This entails perceiving changes in the natural world as the product of intent or an agent. For example, the belief that the world has been created by God (Blancke et al., 2012). While this tendency is argued to have had evolutionary advantages in the ancestral environment, it is at odds with the absence of agency and intent that underpins scientific theories like evolutionary theory (Blancke et al., 2012). Evolutionary theory has little to offer in terms of intent and agency when juxtaposed with creationist accounts where the natural world is the result of intentional acts by superhuman agents (Blancke et al., 2012).

Another bias that influences people's understanding of science is teleology – the intuition that the manner in which the natural world functions is guided by underlying purposes (Kelemen et al., 2013). Students have been found to prefer teleological explanations over causal explanations (Kelemen & Di Yanni, 2005; Trommler et al., 2018). For instance, participants in one study reported believing that organisms develop new traits because they need them to survive (Bishop & Anderson, 1990). Teleological bias has also been found in educated adults (Kelemen et al., 2013).

Science understanding can also be impeded by essentialist bias – the tendency for people to perceive the natural world as originating in invisible and immutable essences, which form homogenous and discrete categories (Gelman, 2003). For instance, essentialist bias makes it difficult for people to ascertain an accurate understanding of evolutionary theory due to the perception of species as homogeneous and discrete categories (Shtulman & Schulz, 2008). Beyond evolutionary theory, essentialist bias has been found to be particularly relevant in people's comprehension of genetic concepts (Dar-Nimrod & Heine, 2011). In particular, Dar-Nimrod and Heine (2011) argue that when people are presented with the suggestion that genes play a role for instance in a behaviour, a condition or even a social group, they become viewed in a specific manner. Specifically, they propose four outcomes from learning about the relevance of genes to a behaviour or trait: they become seen as immutable and determined, as dividing people into homogeneous and discrete groups, as originating in a specific etiology, and natural – leaving people prone to the naturalistic fallacy. This particular way of (mis)understanding genetics is not only associated with support for eugenics, but could also affect people's attitudes toward genetic modification

(Heine et al., 2017). For instance, Heine et al. (2017) argue that part of the reason why many people are opposed to GMOs is because of this kind of essentialist bias.

Ideology

Furthermore, research shows that the acceptance of science is influenced by ideological and motivational factors (See Rutjens et al., 2018a for a review). Of particular importance is political ideology. Although early work primarily highlighted political conservatism in opposition to science, recent investigations show a more complicated picture (Rutjens et al., 2018b). Specifically, across three studies Rutjens et al. (2018b) found that conservatism was positively associated with opposition to climate change but was unrelated to attitudes to GMOs and vaccine scepticism. The authors argue that this reflects how political ideology shape motivations that in turn differentially affect science attitudes. Specifically, for political conservatives climate change present economic and political consequences that are at odds with conservative ideology (i.e., belief in climate change is seen as inextricably linked with restrictions to economic development). This is in line with other research findings on the motivated rejection of science (Campbell & Kay, 2014; Lewandowsky & Oberauer, 2016).

Religiosity

Research has, perhaps unsurprisingly, identified religiosity as another important individual difference factor in opposition to science. Some have argued that science and religion are incompatible because they offer fundamentally different explanatory frameworks of reality (Dawkins & Ward, 2006; Preston & Epley, 2009; see also Rutjens et al., 2018a; McPhetres & Nguyen, 2019). The psychological literature offers support for this notion. For instance, across two experiments, Preston and Epley (2009) found that scientific and religious explanations were automatically opposed such that when scientific theories of how the world came to be were described as poor explanations, this resulted in lower evaluations of science and simultaneously higher evaluations of God. In a second experiment they found that using God as an explanation led to higher evaluations of God and simultaneously decreased evaluations of science. Similarly, in a large scale survey of 9205 US participants McPhetres and Zuckerman (2018) found that higher levels of religiosity is associated with opposition to science. Religious beliefs have also been found to correlate positively with opposition to technological innovations (Brossard et al., 2009) as well as climate change (Morrison et al., 2015). Thus, it is clear that religiosity plays an important role in science acceptance.

Beyond science acceptance more generally, religiosity has also been found to correlate with attitudes to gene-editing. For instance, a recent investigation has linked opposition to human gene-editing to religiosity (Scheufele et al., 2017) and the perception that it interferes with nature (Dragojlovic & Einsiedel, 2013a; 2013b). Other studies have also found this association (Singer et al., 1999). For instance, McCaughey et al. (2016) found in a social media survey of 12,000 people that religious affiliation was negatively correlated with support for human genome editing. Similarly, Singer et al. (1999) reported that church attendance was negatively associated with support for genetic technologies used for prenatal testing. A recent investigation has also linked opposition to gene-editing to religiosity (Scheufele et al., 2017). Religiosity has also been linked to opposition to related research such as using stem cells (Nielsen et al., 2009).

The development and use of these technologies go against deeply held religious values, such as the respect for God as the creator (Rutjens et al., 2018a). By extension, individuals with religious fundamentalist beliefs (e.g., a literal interpretation of the bible as God's word; Evans, 2002), are likely to be even more opposed to these technologies due to an even stricter adherence to scripture. Although, it should be noted that there are also secular grounds for deontological opposition to genetic modification such as principles relating to human dignity and freedom (Kalfoglou et al., 2005; see Ch. 2). This is in line with previous research showing that traditional religious beliefs were associated with opposition to stem cell research, while individuals with more open-ended religious beliefs, that is greater acceptance of the complexity of existential questions and viewing religion as a search for truth, were more supportive than those with a more literal religious beliefs (Nielsen et al., 2009). Because of this, it is expected that religiosity and religious fundamentalism will be negatively associated with support for human gene-editing.

Moral Foundations

A lot of the research on attitudes to GMOs has conceptualised people's objections to GMOs as rooted in certain moral values. For instance, the moral values outlined in Moral Foundations Theory (Haidt, 2007; Haidth & Graham, 2007). According to Moral Foundations Theory there are five (or six; Haidt, 2012) foundations which form the basis for peoples' moral intuitions, these are: harm/care, fairness/reciprocity, ingroup/loyalty, authority/respect, and purity/sanctity. The harm/care foundation encapsulates the approval of virtues that seek to alleviate or prevent harm, including kindness and compassion. The fairness/justice foundation entails the approval of reciprocal interactions and values virtues such as fairness and justice. The ingroup/loyalty foundation include the approval of virtues related to facilitation of ingroup cooperation, such as loyalty and patriotism. The authority/respect foundation involves the approval of virtues associated with subordination to authority such as respect and obedience. The purity/sanctity foundation encapsulates virtues such as sanctity and the suppression of carnal instincts (e.g., lust, greed, selfishness) and are central in religious laws (Graham et al., 2009). Although the proposed nature of these intuitions (i.e., as innate psychological systems) as well as the measures used have been criticised (Sinn & Hayes, 2017; Suhler & Churchland, 2011), they nonetheless provide a useful taxonomical framework to articulate certain moral concerns that people have when it comes to genetic technologies.

For instance, the moral values outlined in the purity foundation have been argued to be related to opposition to GMOs (Jarudi, 2009; Swiney, 2020), due to the emphasis placed on sanctity, adherence to religious values and purity of the body (Haidt, 2007). GMOs involve both a violation of what is sacred (i.e., scientists using these technologies are often seen as playing God) and a violation of species' purity, because it entails artificially altering the genome (Liu et al., 2019). Further, due to the purity foundation's emphasis on maintaining bodily purity and the theorised role of disgust as underpinning purity concerns (Graham et al., 2009; Haidt & Graham, 2007; Rozin et al., 1999), these reservations should be particularly salient in the case of GMOs.

Consistent with this proposed role of purity, in a correlational design Jarudi (2009) found that endorsement of the purity foundation was moderately associated with the perception that eating genetically modified foods is morally wrong. Similarly, across three studies Swiney et al. (2020) found that purity concerns were associated with the perception that it is morally wrong to genetically modify plants and animals. The endorsement of purity concerns was also associated with the perceived harmfulness of consuming genetically modified organisms. Similarly, previous research has also linked purity concerns with opposition to related technologies or treatments including stem cell research and animal cloning (Koleva et al., 2012).

Moral Values in Judgments About Human Gene-editing

In respect of the present thesis, I expect a subset of moral foundations, namely, purity/sanctity, harm/care and fairness/reciprocity, to be relevant in people's attitudes toward human gene-editing, and for simplicity they will be referred to as purity, harm and fairness respectively. When it comes to the sort of concerns people express regarding the development and use of gene-editing technologies, these anecdotally coincide with purity, harm and fairness. For example, newspaper headlines about human gene-editing commonly mention concerns about fairness: “Gene editing could make social inequalities worse if misused, warns author” (CBC Canada, 2021), violations of purity, “God Playing God: Why the future may be genetically modified” (Hughes, 2019) or the potential to reduce harm “CRISPR-Based Therapy Shows Early Promise for Cancer” (Goodman, 2020) or cause it “Gene-edited babies: Current techniques not safe, say experts” (British Broadcasting Corporation, 2020). Next I will discuss indirect support of my proposed links between purity, harm, and fairness with support of human gene-editing.

Purity

Akin to the research showing that purity is related to opposition to GMOs, purity concerns might be central in opposition to human gene-editing. Human gene-editing is often accused of violating of what is sacred (i.e., scientists using these technologies are often seen as playing God; Kalfoglou et al., 2005; Nisbet & Markowitz, 2014; Sadler & Zeidler, 2004) and bodily purity, because it entails artificially altering the human genome. In contrast, it is difficult to see how virtues related to the ingroup/loyalty (e.g., patriotism) and authority/respect foundations (e.g., obedience) would be associated with peoples’ moral judgments about human gene-editing. Although they might be relevant in specific contexts where the associated virtues are particularly salient (e.g., obedience to medical experts), they are unlikely to be consistently relevant in peoples’ general judgments about human gene-editing.

Research on the perceived naturalness of genetically modified organisms lend indirect support to the role of purity concerns in attitudes to human gene-editing. Rozin (2004) theorised that people have a preference for “natural” entities over “unnatural” ones. Specifically, Rozin distinguishes between two bases for people’s preference for naturalness: instrumental and ideational (Rozin et al., 2004). Instrumental reasons for the preference of natural entities include the belief that natural entities are healthier and kinder to the environment than non-natural entities. Ideational reasons for the preference for the natural originate in the view that natural entities are inherently better because they are more moral or more aesthetically pleasing. These reasons overlap somewhat with the purity concerns outlined in the purity foundation. Importantly, research shows that the preference for the natural remains even in cases where the chemical structures of natural and non-natural products are identical (Rozin et al., 2004). Across two studies Rozin et al. (2004) asked participants to rate the naturalness of a range of entities including genetically-engineered plants and animals. The results demonstrated that genetically modified entities in the study (either a pig or a plant) saw a 54.1% drop in perceived naturalness, compared to the entities that did not receive the genetic modification.

Rozin et al. (2004) theorised that the results reflect the importance of the process over content when it comes to evaluations of naturalness. Specifically, both chemical manipulations (e.g., boiling, small additions or subtractions of natural or unnatural entities) and genetic modification led to stark reductions in perceived naturalness. In comparison, physical transformations such as grinding peanuts to make peanut butter or using oranges to make orange juice had small effects on perceived naturalness. The results further showed that domestication of wild animals led to greater reductions in perceived naturalness compared to genetic engineering, despite the former involving a massive amount of genes across hundreds of generations while the latter typically only involves the insertion of a single gene (Rozin et al., 2004). Rozin argues that this apparent contradiction is the result of the level at which humans intervene, with perhaps the idea of humans "playing God" becoming more salient in the genetic engineering scenarios. For this reason, Rozin argues that the objections to genetic engineering are primarily ideational.

An unpublished study by Herzhog and Roush (2015) has also indicated that genetically modifying animals leads to a perceived loss of naturalness. Herzhog and Roush

(2015) examined the ratings of naturalness of animals in different situations. The researchers created a scale designed to assess the naturalness of animals across 28 different scenarios, such as “A dairy cow” versus “A cloned dairy cow”. Results showed that cloning an animal reduced its perceived naturalness by 80% compared a non-cloned animal. Similarly, the results showed that a genetically engineered lab rat was rated as 77% less natural than a garbage dumpster rat. Overall, any animal created through biomedical means was rated as 85% less natural than their domesticated or wild counterparts. Although these results suggest a clear reduction in perceived naturalness, Herzhog argues that this does not make sense rationally since genetic engineering focuses on altering a single gene or a few, while domestication amends a large number of genes. Overall, domestication, captivity and biotechnology were all associated with lower perceived ratings of naturalness. Together these findings suggest that concerns about purity might also be important in people’s moral judgments about human gene-editing because it can be seen as violating the core tenets of the purity foundation in terms of naturalness and bodily purity.

Harm and Fairness

Beyond purity, harm considerations are likely also important in moral judgments about human gene-editing. Indeed, survey research shows that people report concerns that the use of these technologies could be harmful to people and society (Robillard, et al., 2014), while others emphasise the potential of these technologies to reduce harm of certain diseases (Kalfoglou et al., 2005). The harm foundation involves virtues such as protecting and caring for those that are vulnerable, and avoiding causing harm (Haidt, 2007). Gene-editing technologies can be construed both in terms of their potential to reduce harm, for instance by treating diseases, as well as their potential to cause harm such as causing harm to vulnerable groups in society such as people with disabilities. Indirect harm can also be done to people through unfairness. For instance, people express fairness concerns when it comes to the potential for economic differences to manifest in the access to gene-editing technologies (Kalfoglou et al., 2005). The fairness foundation entails valuing peoples' right to certain resources or kinds of treatment (Haidt, 2007). Gene-editing technologies could be used in a way that could entrench socio economic inequalities.

The Role of Emotion in Moral Judgments: Disgust

Moral judgments are not only shaped by different moral concerns, but also emotional responses. One emotion that may be of particular importance in terms of attitudes toward gene-editing is the emotion of disgust. Opposition to GMOs has been examined through the lens of disgust (Clifford & Wendell, 2015). Disgust describes a feeling of revulsion in response to an aversive stimulus, leading to avoidance of that stimulus (Rozin & Fallon, 1987). Disgust is thought to have initially evolved to protect against disease and other contaminants, and later co-opted as a response to socio moral elicitors (e.g., immoral behaviours) to facilitate social control in human cultures (Rozin et al., 2008; Russell & Giner-Sorolla, 2013). Researchers commonly differentiate between state disgust, the momentarily emotional reaction in response to a specific stimulus (Reynolds et al., 2014), and trait disgust or disgust sensitivity, which refers to an individual's general, stable inclination to feel disgust easily or intensely in response to aversive stimuli (Haidt et al., 1994).

Although the exact role of disgust in moral condemnation is debated (see Russell & Giner-Sorolla, 2013), I sidestep this discussion for the purposes of the present research and employ the perspective of Graham et al. (2009; see also Haidt & Graham, 2007; Horberg et al., 2009) that disgust serves to protect the body and soul from contamination. It should be noted that although disgust has been conceptually linked to purity in what started out as a mechanism to avoid consumption of contaminants, later extended to the socio-moral domain (Horberg et al., 2009), they are distinct concepts. Purity encapsulates the particular concerns people have, while disgust sensitivity entail how inclined people are to feel disgust in response to various aversive stimuli (Graham et al., 2009; Haidt et al., 1993). For instance, across five studies Wagermans et al. (2018) found that disgust sensitivity was more strongly related to moral condemnation of purity transgressions (e.g., “you see a story about a remote tribe eating the flesh of their deceased members”) compared to other types of moral transgressions related to harm (e.g., “you see a woman clearly avoiding sitting next to an obese woman on the bus”) or fairness. Importantly, the meta-analytic correlation across the five studies was moderate, r = .40. Similarly, in other studies disgust sensitivity has demonstrated moderate positive correlations with the purity foundation (e.g., Graham et al., 2011; Van Leeuwen et al., 2017). Together, these findings suggest that there is not a complete conceptual overlap between moral condemnation of purity transgressions and the stable inclination to experience disgust.

Previous research has linked disgust sensitivity (i.e., the stable tendency to experience disgust) with opposition to GMOs. Clifford and Wendell (2015) theorised that disgust sensitivity plays a role in the opposition to these technologies since they are commonly seen as containing toxic chemicals or likened with “Frankenfood”. They argued that disgust’s role in protecting the body and soul from contamination should lead people who are high in measures of disgust sensitivity to be more opposed to GMOs. Studies 1 and 3 were experimental, while Study 2 was correlational. In Study 1 the researchers experimentally manipulated state disgust using an autobiographical writing task, while in Study 3 disgust was experimentally manipulated through the display of disgust-eliciting pictures. Across all three studies attitudes to GMO crops and livestock, vaccines, organic foods and a range of other attitude objects such as drug and obesity policies were measured, as was disgust sensitivity.

The results demonstrated that disgust sensitivity was positively associated with opposition to genetically modified foods, anti-vaccination beliefs and support for organic foods. However, the state disgust manipulations had no statistically significant effects on subsequent ratings of GMOs and vaccines in either Study 1 or 3. The authors argue that the relation between disgust sensitivity and these attitudes is of primary importance because it provides information about how individuals may choose to expose themselves to specific types of information about GMOs that impact their attitudes for instance by endorsing stricter regulation of these technologies.

The role of disgust in opposition to GMOs has been corroborated in another study by Scott et al. (2016). The authors theorised that because GMOs are typically viewed as unnatural, they are seen as contaminating the people who ingest it as well as parts of the natural environment that come into contact with it. This perception in turn contributes to absolutist opposition to GMOs, wherein opposition to GMOs remains irrespective of the potential benefits. In a large scale survey of 1022 U.S. participants were presented with scenarios describing either the intentional or unintentional consumption of four types of GMOs: tomatoes, apples, tuna and milk. Following this, participants were asked to select either the word “disgust” or “anger” to describe their response. They also had to choose between the image of an angry or disgusted face. Additionally, participants reported their disgust and anger on Likert-scales. Further, participants were classified as moral absolutist if they agreed that GMOs should be prohibited regardless of how great the benefits and minor the risks. Trait disgust sensitivity was also measured. The results showed that moral absolutist reported greater levels of disgust across all scenarios and scored higher on the disgust sensitivity measure, compared to non-absolutists. Further, participants were more likely to choose a disgusted (vs. angry) face in response to the GMO scenarios. Finally, results also showed that disgust was positively associated with the support for government restrictions on GMOs.

These findings provide compelling evidence for the role of disgust in opposition to GMO and furthermore the absolutist nature of this conviction. The authors argue that the results underscore the role of disgust in shaping attitudes to novel technologies. They further state that in certain cases affective evaluations can lead people to disregard risks and benefits entirely. Although they do acknowledge other factors that may influence people's opposition to GMOs (e.g., anticorporatism; concerns about increased inequality), they argue that these concerns about fairness and inequality do not provide a full account. Instead, they contend that opposition to GMOs is uniquely driven by intuitions about physical contamination and the perception that nature is being violated.

A more recent study by Liu et al. (2019) investigated how physical and social components of disgust may relate to GMO opposition differently. Specifically, their study examined the role of disgust sensitivity and moral disgust in opposition to GMOs. The researchers theorised that GMOs elicit physical disgust due to the violation of species purity, while at the same time triggering moral disgust due to their potential to undermine domains of autonomy. The researchers argue that the latter is the result of the prevalence of conspiracy theories surrounding GMOs and that the violation especially concerns the public's right to know. They conducted two experiments with the aim of differentiating the physical and social dimensions of state and trait disgust for GMOs. In Study 1 participants were randomly allocated to one of three conditions: core disgust elicitation, sociomoral disgust elicitation or no disgust elicitation (control). In the core disgust condition participants were asked to describe a physically disgusting event, in the sociomoral disgust condition they were asked to describe a morally disgusting event, and in the control condition participants described a typical everyday event. Results revelated that both disgust manipulations led to higher levels of opposition to GMOs, but that elicited state disgust did so through both pathogen and moral disgust sensitivity.

In Study 2 the researchers further introduced an emotion reappraisal variable, wherein participants were asked to either describe their thinking process when completing the questionnaire or not (control). Further, participants' moral preference between deontology, virtue ethics and consequentialism was measured. Results showed that in the core disgust condition, emotion reappraisal led to higher levels of perceived morality of GMO among deontologists and consequentialists but not for virtue ethicists. In the sociomoral disgust condition, emotion reappraisal led to increased levels of perceived morality of GMOs for consequentialists, deontologists, and virtue ethicists. Together these results demonstrate the causal effects of both state and trait disgust on moral evaluations of GMOs. The results further show how disgust interacts with individual difference factors including emotion reappraisal and moral preference.

It is possible that disgust plays a similar role in moral judgments about human gene-editing. Changing the human genome through human gene-editing might be perceived by some as a form of contamination of the body, thus leading those with higher levels of disgust response or sensitivity to be less supportive of human gene-editing. Another possibility is that human gene-editing is different from GMOs in some important ways. Some research seems to indicate that the relationship between disgust and attitudes to human gene-editing may differ compared to that of disgust and GMO.

In one study Kahan and Hilgard (2016) recruited 2473 Americans, to examine the association between disgust sensitivity and a range of fears including the concerns about GMOs, vaccines, flying in commercial airlines, elevator crashes, and children drowning in swimming pools. The results showed that disgust sensitivity was positively correlated not only with the perceived risks of GMOs and vaccines, but also other fears, such as flying in commercial airlines and elevator crashes. The authors argue that this suggests that rather than the disgust sensitivity scale reflecting an aversion to bodily contamination, it captures a generalised fear of risks. These findings call into question the conclusion that opposition to GMOs is associated with pathogen avoidance.

Relatedly, although limited research has been devoted to human gene-editing specifically, findings from one recent investigation by Halstead and Lewis (2020) also questions the link between disgust and human gene-editing. Their study examined the role of pathogen disgust sensitivity in opposition to human gene-editing (Halstead & Lewis, 2020). The authors theorised that due to the perception that gene-editing involves something artificial and unnatural, higher levels of disgust sensitivity would be associated with opposition to not only GMOs but also human gene-editing. In a correlational study with 347 UK participants, the researchers measured participants' disgust sensitivity along with their attitudes to GMOs, gene-editing in embryos, adults, and animals. For the items focused on embryos and adults they further included four different purposes of gene-editing: physical strength, cognitive ability/intelligence, lifespan and attractiveness/looks. The researchers found that while disgust sensitivity was positively correlated with opposition to GMOs, contrary to their predictions, it was modestly *negatively* correlated with opposition to human gene-editing. Specifically, higher levels of disgust sensitivity were associated with greater support of human gene-editing. The researchers propose that this might be due to the aversion to physical imperfections occasionally observed among high scorers in disgust sensitivity and viewing gene-editing as a means to amend this (e.g., Lieberman et al., 2012). However, this is currently unclear from their investigation.

Given these contradictory research findings, at present it is not clear what the relation between disgust and moral judgments about human gene-editing is. A systematic examination of the relation with disgust and attitudes to human gene-editing is needed.

Further, there may be some reason to suspect that attitudes to GMOs and human gene-editing differ in some important ways. I outline some potential reasons for this difference in the following section.

Human Gene-editing is Different

Although there are similarities between GMOs and human gene-editing, a central difference is that GMOs involve the genetic modification of foods and animals for consumption, not the genetic modification of humans themselves. This difference constitutes a major shift in the moral concerns that arise when considering the ethicality of gene-editing technologies. Furthermore, as mentioned previously, human gene-editing can involve the genetic modification of the germ line, somatic cells or genetic modification in embryos, all of which present a unique set of moral considerations (Barrangou & Doudna, 2016). While the purpose of GMOs is focused on boosting the food yields from plants and animals, the hypothetical purposes of human gene-editing are much more varied. They range from improvements in intelligence and appearance to the prevention of congenital disease), and also have implications for social inequality and organisation (Gyngell et al., 2017).

Related, another major difference in the genetic modification of humans and other organisms is that compared to animals and plants, humans are afforded much greater moral standing (Caviola et al., 2019; 2020a). People ascribe fewer mental capabilities and lower moral worth to animals typically categorized as food, in particular (Bilewicz et al., 2011; Bratanova et al., 2011; Loughnan, et al., 2010). More generally, people show a tendency to view animals more instrumentally (Caviola et al., 2020b) than members of their own species. Thus, I theorise that people have more regard for the potential harms and benefits for humans (compared to other organisms) who may be genetically modified.

Beyond differences in the *degree* of moral concern, I further propose that there are important differences in the *kinds* of moral considerations that arise in response to the gene-editing of humans vís a vís animals. Previous research has demonstrated that people display greater *deontological constraints* against instrumental harm in moral judgments about humans compared to those about animals. In other words, participants have stronger principled objections towards harming humans compared to animals for the greater good (Caviola et al., 2020b). Consistent with this perspective, I would expect people to report qualitatively different moral concerns about human gene-editing, that do not apply to the gene-editing of plants and animals. These could for instance include moral concerns about social organisation such as equality, discrimination and human dignity (e.g., Kalfoglou et al., 2005). Thus, I propose that moral judgments about human gene-editing are different from those about GMOs both in the *kinds* of moral concerns as well as the *degree* to which they apply to humans compared to animals.

The Enhancement vs. Treatment Distinction

Another factor that may differentiate moral considerations about human gene-editing from those about GMOs is how people respond to the ultimate purpose of genetic modification. A key distinction within human gene-editing is the purpose for which it is applied, that is treatment (e.g., treating cancer) versus enhancement (e.g., enhancing intelligence). This distinction is theoretically important because it is intertwined with people's moral considerations – such as the potential of gene-editing to both cause and reduce harm. Several researchers have argued that lay people distinguish between human gene-editing for enhancement versus treatment purposes. For instance, in a qualitative study examining discussions about human gene-editing, Sadler and Zeidler (2004) found that participants expressed support for gene-editing for disease, but not other traits such as intelligence and eye colour. Participants sometimes argued that the former had the potential to reduce harm, whilst the latter did not. Relatedly, a survey of Americans on the topic of human gene-editing showed that participants reported greater support for gene-editing in babies to “treat a serious disease” than “to make the baby more intelligent” (PEW Research Center, 2018a). However, it should be noted that these investigations did not employ a controlled comparison of treatment and enhancement on the same trait, instead comparing very different domains such as eye colour and disease (Sadler & Zeidler, 2004), or disease and intelligence (PEW Research Center, 2018a). Consequently, it is not entirely clear whether the lower support reflects lower endorsement of enhancement per se, or rather lower importance afforded to certain traits such as eye colour and intelligence vis a vis disease.

The level of support afforded to human gene-editing seems contingent on the severity of the ailment it is applied for. In one study, Robillard et al. (2014) surveyed 467 American participants about gene therapy and its applications. Participants were allocated to read different vignettes about both actual and hypothetical applications of gene-editing. They were also asked to report the perceived harms and benefits of gene-editing. The scenarios involved: the treatment of Alzheimer disease, treatment of attention deficit hyperactivity disorder (ADHD) or the enhancement of normal memory. Most participants were supportive of human gene therapy for severe illnesses, with 65% stating they would definitely support it. In contrast, support was lower for the less severe ADHD, with only 45% in support. Gene-editing to enhance normal memory received the lowest support, with only 35% in support. The majority of participants (80%) agreed that genetic treatments for disease would have an overall positive impact on society because of the reduction of suffering. Half of participants reported that they agreed that the benefits of gene therapy would be greater than the harm it could cause. The majority of participants disagreed that gene therapy should not be allowed because it goes against nature. Participants also reported concerns regarding disparities in resource allocation and discrimination in response to scenarios involving gene-editing for enhancement purposes. This pattern has been found both in other large scale surveys (e.g., PEW Research Center, 2018a) and qualitative studies (Kalfoglou et al., 2015). Participants were also worried that these technologies could exacerbate inequality and reduce genetic diversity, especially in the case of enhancement (Kalfoglou et al., 2015).

Concerns about fairness and inequality have been identified in attitudes toward other medical innovations. For instance, in one study by Rudski (2014) participants indicated the acceptability of and moral concerns relating to the use of a hypothetical drug to improve concentration under either competitive or non-competitive circumstances. Participants were less accepting of drug use for enhancement compared to when it was prescribed as treatment. Further, in the competitive scenario, acceptance of enhancement was even lower, while the acceptance of treatment did not differ between the competitive and non-competitive scenarios. Importantly, participants also reported concerns about fairness in response to enhancement, but not treatment. Similarly, in a review of 40 empirical studies on the topic, Schelle et al. (2014) found that concerns about fairness was a central consideration in public attitudes toward pharmaceutically based cognitive enhancements. The researchers further classified the concerns about fairness into three subthemes: equality of opportunity, honesty and authenticity.

Together these findings suggest that people might be sensitive to the purpose for which human gene-editing is applied. Further, the findings suggest that they report different moral considerations related to the potential positive and negative outcomes in terms of reductions in harm, disparities in resource allocation and discrimination. However, these studies still fail to provide a controlled comparison of the enhancement vs. treatment distinction on the gene-editing of the same trait or disease, instead comparing applications on different traits ranging from disease to attention deficit disorders. This leaves open the possibility that the different moral considerations that arise are at least in part the product of the traits selected for comparison for the specific studies. Thus, it is difficult to make more general inferences about the different moral considerations that underlie support of human gene-editing for treatment vs. enhancement.

The lack of a controlled comparison between enhancement vs. treatment purpose has been commonplace in previous research investigating attitudes to human gene-editing. In another large scale survey recruiting across 185 countries, McCaughey et al. (2016) surveyed 12,562 participants on the extent to which they agreed or disagreed with five different questions on human gene-editing. The questions asked about gene-editing in children or adults to cure a life-threatening or debilitating disease, as well as gene-editing in embryos to prevent these. Finally, one question also asked about gene-editing of embryos to alter non-disease characteristics. The results showed that the majority of survey respondents supported human gene-editing to cure life-threatening disease (59%) and debilitating disease (59.4%). In contrast, only a minority supported human gene-editing for non-disease characteristics (27%), with most participants being opposed to this application (43%). Again, the results suggests that participants' level of support varies depending on the application of the technology. However, the results do not provide clear evidence that the differential level of support is the product of the distinction between treatment and enhancement purpose. It is possible that the difference in levels of support is the product of the specific health domains compared, as these were not held constant across treatment and enhancement purpose.

A similar pattern of results was observed in a survey of 1013 Dutch citizens, where participants reported their willingness to alter the human genome through gene-editing (Hendriks et al., 2018). The results showed that 85% of participants reported that they would be willing to use somatic cell gene modification to treat a neuromuscular disease, while 66% were willing to use germline modification to prevent passing on a neuromuscular disease. In contrast, 83.9% were against editing the genes of an embryo to increase intelligence and 69% were against editing the genes of an embryo to increase HIV resistance. One of the most common reasons participants cited in favour of human gene-editing was the potential to improve the quality of life of those affected. While the possible health risks were the most common reason cited against human gene-editing (See also Xiang et al., 2015; Howell et al., 2020). Nevertheless, also this study failed to offer a controlled comparison of the enhancement vs. treatment distinction.

A recent psychological investigation also offers evidence that the level of support afforded to human gene-editing depends on the application. Halstead and Lewis (2020) found that support of human gene-editing for treatment and enhancement loaded on separate factors in a sample of UK adults. Although the results suggest that people differentiate between enhancement and treatment purpose and that this affects their support of gene-editing. Again the lack of a controlled comparison between treatment and enhancement purpose leaves open the question of whether the effects observed on the moral considerations are the product of the enhancement vs. treatment distinction, or rather the result of the specific health domains chosen by the researchers.

The researchers of all of these studies argue that the results provide evidence that people distinguish between treatment and enhancement purposes of human gene-editing and that this in turn affects the endorsement of different moral considerations and support of the technology. However, as noted, there is an important limitation to these studies. Specifically, the treatment vs. enhancement distinction employed in the previous investigations, be it surveys, qualitative interviews or psychological investigations, the comparison of treatment and enhancement purpose vary in other important ways (i.e., one involves physical functioning, the other cognitive functioning; one involves a serious disease, the other assumes a neutral baseline etc.; PEW Research Center, 2018a). Thus, it is not clear whether the results reflect the distinction between enhancement and treatment, or other contextual factors. This makes it difficult to assess what considerations underlie participants’ judgments.

Consequently, the results could at least in part be the product of the different traits chosen to represent treatment and enhancement purposes.

The division between treatment and enhancement is not straightforward. For instance, one could conceivably edit the genes of someone with reduced life expectancy vs. a normal life expectancy, and this would constitute a treatment, not an enhancement. Similarly, editing genes to improve physical strength could be done either on people with average levels of functioning or on people with reduced levels of functioning, thus making it a treatment. In short, previous research shows that people are sensitive to the application of human gene-editing, but not that they *differentiate* treatment and enhancement. Nor do previous studies elucidate *why* some purposes are afforded more support than others. Consequently, little is known about the psychological underpinnings of people's attitudes to human gene-editing. In the next section I propose that moral judgments about human gene-editing can be understood from the perspective of moral considerations about harm and rules.

Harm and Rule-based Moral Considerations. Some indirect support for the notion that people are attuned to the potential harms that can arise or be reduced by human gene-editing come from the literature on harm considerations in moral judgments. Perceived harm is key in the moral condemnation of a range of acts including assault, murder, and theft (Haidt et al., 1993; Mikhail, 2007). Further, harm considerations are central in both rationalist and social intuitionist accounts of moral judgment, either through the conscious deliberation of issues related to harm in the case of rationalist approaches (e.g., Gray et al., 2014; Kohlberg, 1969), or as justifications conjured post-hoc to rationalize a moral stance according to social intuitionists (Greene & Haidt, 2002; Haidt, 2001). In a similar vein, I propose that harm concerns are essential when people consider the ethicality of human gene-editing.

Harm concerns can be expressed not only about the direct recipient of an action, such as an organism being genetically modified, but abstract, conceptual entities such as society and nature (Schein & Gray, 2018; Gray et al., 2014). The moral objections to human gene-editing for the purpose of enhancement often entail harms to society, including concerns that the benefits of the technology would be distributed unequally, exacerbating social inequalities (e.g., Gyngell et al., 2017; Kalfoglou et al., 2005). Importantly, these kinds of concerns, are unlikely to be relevant in moral objections to GMOs, because the distribution of gene editing among plant and animal populations has no obvious direct impact on inequality in human societies. Further, harms toward nature, including disruptions of the natural order appear less specifically as an objection to enhancement. Whether a gene is edited to enhance a desired trait or treat a health condition, the natural genetic code of a person is being modified either way, thus the threat toward nature remains the same.

Research on attitudes to related technological innovations like stem cell research show that harm considerations are particularly important when people consider the ethicality of new technologies. In a content analysis of the coverage of the stem cell debate in the New York Times spanning 12 years using the moral foundations as reference framework for moral language, Clifford and Jerit (2013) found that those in favour of stem cell research employed a greater proportion of harm words than those who were against it. Further, those in favour especially emphasised the potential for stem cell research to reduce harm and suffering. In contrast, those against stem cell research employed a greater proportion of purity words. However, purity words were still quite uncommon in the debate, and those against stem cell research primarily employed harm words when arguing against stem cell research. These results provide preliminary support for the role of harm considerations in moral judgments about one type of novel technology.

Harm in Respect of Human Gene-editing. The endorsement of harm considerations have also been identified in moral judgments about human gene-editing. In a qualitative interview study of 20 college students, Sadler and Zeidler (2004) presented participants with different genetic engineering dilemmas. The researchers found that participants demonstrated endorsement of different moral considerations. Participants considered the potential consequences of the technology, evaluating the extent to which it could reduce and cause harm. For instance, participants were more supportive of gene-editing for treatment, reporting the potential for the technology to relieve harm. In contrast, participants indicated lower support for cosmetic and convenience reasons, reporting concerns that this could lead to social stratification and reduced diversity. Participants also endorsed rule-based considerations against gene-editing, disclosing concerns that it alters the natural process, with humans playing God. Some participants also reported the status of an embryo as a human life. The results also showed other considerations such as emotion-based choices (e.g., participants reporting empathic concern for a mother who lost a child when considering reproductive cloning) and intuition based-choices where no explicit consideration was reported (e.g., something is just morally wrong or right). However, considerations relating to consequences or outcomes as well as references to moral rules or principles were the most frequent.

Other research has also shown that participants tend to evoke moral considerations about the potential harms and benefits when considering the ethicality of human gene-editing. Kalfoglou et al. (2005) recruited 181 Americans in 21 focus groups to examine opinions about a range of new reproductive genetic technologies. These technologies included preimplantation genetic diagnosis (PGD; where embryos are screened prior to implantation), hypothetical genetic modification and sperm sorting for sex selection. The scenarios presented to participants concerning genetic modification pertained to the treatment of life-threatening childhood disease, adult-onset disease, obesity, depression, and for intelligence. Further, participants were asked to especially consider the following six factors: 1) the possible destruction of embryos, 2) the nature of the disease or trait being avoided or sought, 3) technological control over "natural" reproduction, 4) the value of suffering, disability, and difference, 5) the importance of having genetically related children and 6) the kind of future people desire or fear.

Although participants were never in unanimous agreement, the majority reported support of genetic modification in cases where the application could prevent life-threatening disease, but not for trait selection, less severe disorders such as depression or obesity, or disorders with no symptoms present until adulthood. Further, participants reported a range of different outcome centred moral concerns including the potential of these technologies leading to increased inequality, disparities in access, overpopulation and genetic diversity. However, participants also commonly made reference to rule-based moral considerations about people playing God, and violating God's plan, with the use of these technologies. Relatedly, participants mentioned concerns about the unnaturalness of modifying genes. These results are in line with the proposition that people employ both outcome – and rule-based considerations when making moral judgments about human gene-editing. These results also indirectly mirror the enhancement vs. treatment distinction, in the greater support afforded to therapeutic uses of genetic modification vs. trait selection and less severe disorders.

It should be noted that rule- and outcome-based considerations are employed at different rates depending on the moral foundation that is being referenced. Wheeler and Laham (2016) conducted two experiments to examine differences in moral considerations. In the first study participants were presented with moral vignettes and selected from three predesigned appeals either referencing deontological, consequentialist or emotive justifications. In the second study participants' free responses were recorded in response to 15 moral vignettes. Across both studies, rule-based moral justifications were preferred for the sanctity foundation, while consequentialist outcome-based moral justifications were preferred in violations of the harm and fairness foundations.

Beyond qualitative investigations, some quantitative surveys have also identified harm considerations as especially important when it comes to the treatment vs. enhancement distinction in the purpose of human gene-editing. Gaskell et al. (2017) conducted a large scale survey comparing gene-editing for treatment and enhancement purposes. In a sample of 11,716 participants across 11 different countries the researchers surveyed participants on whether they thought it would be morally acceptable to use gene-editing to cure a disease (treatment) and improve memory and learning capacity (enhancement). The survey also compared the moral acceptance of these interventions in adults and prenatally. The results showed that greater support for treatment vs. enhancement overall. Further, altering genes of adults was viewed as more morally acceptable than prenatally. Importantly, 75% of the free-text comments were positive. In the comments participants made frequent references to the improvements to quality of life gene-editing could facilitate, the potential for it to cure disease and how benefits outweigh potential risks. These kinds of considerations clearly align with harm concerns – wherein the morally acceptability of human gene-editing is evaluated in terms of the extent to which it is seen as a potential means to reduce harm.

This pattern was also evident in a recent investigation by Critchley et al. 2019. A sample of 1004 Australians were recruited to take part in a survey. Results showed that participants reported higher levels of support for gene-editing for improving health, and for human and animal research, while support for enhancement purposes was significantly lower. Further, participants were more supportive of gene-editing of germline cells than embryos.

Finally, there was no difference in the support of gene-editing germ and somatic cells, suggesting that hereditary concerns do not influence support for gene-editing in general. However, there was a significant interaction effect such that participants reported higher levels of support for gene-editing somatic (vs. germline) cells when the purpose was improvement of human health and human research, but not in cases when the purpose was enhancement, animal research or animals for food.

Note that I am not making a claim about the extent to which these moral considerations accurately represent the ethical challenges of gene-editing technologies. Research suggests that moral evaluations shape factual beliefs (e.g Kahan et al., 2010; Kunda, 1990; Liu & Ditto, 2012). Thus the extent to which participants view human gene-editing as morally wrong or right likely affects their reported moral considerations. In all likelihood the effect is probably bi-directional, such that the moral intuitions people harbour about human gene-editing shape their evaluation of the technology. Similarly, the extent to which they endorse outcome- and rule-based considerations also affect the extent to which they view human gene-editing as morally right or wrong.

The Present Research

Despite the rapid advances in human gene-editing technologies, limited research has been devoted to examine people's moral judgments about the application of this emerging technology. The present thesis aimed to provide the first systematic, social psychological examination of the moral considerations that play a role in moral judgments about human gene-editing. Drawing on the research on attitudes to GMOs and science, as well as the literature on moral judgments, the present thesis provides the first theoretical account of moral considerations associated with support of GMHs utilizing perspectives from social psychology. Note that I use the term GMHs to refer to any kind of modification to the human genome, whether it be somatic cells, the germline or in embryos – the term itself does not have an agreed upon definition by bio-scientists, who typically use human genome editing more generally or refer to the specific applications of the technology (World Health Organisation, 2021). Addressing the paucity of research into moral reasoning about GMHs, the present thesis employs a combination of correlational and experimental designs.

I propose that although both GMOs and GMHs involve the modification of genetic material, moral reasoning about GMHs can be expected to differ in both degree and kind. I argue that this is due to both the greater moral standing afforded humans compared to animals (Caviola et al., 2019), as well as the differences in the kinds of moral considerations that apply to humans compared to animals (Caviola et al., 2020a). I also include previously identified predictors of attitudes to GMOs that may also underlie opposition to GMHs, including purity, disgust, religiosity.

Beyond the target of genetic modification, moral concerns about GMHs are likely to also depend on whether human genes are altered for treatment or enhancement purposes. I expect that people will differentiate between the purpose of gene-editing, perceiving enhancement to be lower utility enhancement, compared to treatment. Based on the centrality of harm considerations in moral judgments (e.g., Schein & Gray, 2018; Haidt & Graham, 2007), I propose that moral considerations about harm and benefits are important in the support of GMHs. I also propose that wider moral concerns referring to principles such as fairness and harms to society will be applied more strongly in judgements about the genetic modification of humans, compared to animals. Further, based on theorising that people invoke rule-based moral considerations about human gene-editing (Sadler & Zeidler, 2004), I argue that human gene-editing for enhancement (vs. treatment) will be seen as a moral rule violation. I did not specify the moral rule, as previous qualitative investigations have shown that there are many different rule-based objections to human gene-editing including violation of fairness, violation of nature, and violation of sanctity (e.g., Kalfoglou et al., 2005).

Outline of the Following Chapters

Chapter 2 offers a preliminary, correlational investigation of different predictors of support for genetic and gene-editing technologies. Study 1 showed that perceived harm was the strongest positive predictor of support for genetic technologies, while the perceived disease reduction and religiosity were the only other significant predictors. Purity and disgust sensitivity did not significantly predict support for genetic technologies. Study 2 demonstrated that viewing human gene-editing as morally right on the basis of the potential social benefits it can produce is positively associated with support. Further, a more proximal measure of sanctity concerns about human gene-editing, was negatively associated with support for human gene-editing.

Chapter 3 provided the first systematic examination of the enhancement vs. treatment distinction on support of human gene-editing. Studies 3 and 4 were the first to show, in a carefully matched experimental design, that participants do not demonstrate a blanket opposition to human gene-editing, but instead are sensitive to the application of the technology, consistently preferring treatment over enhancement. Further, the effect of purpose on support of gene-editing was mediated both by outcome and rule based moral considerations. The results of Study 5 further showed that moral judgments about human gene-editing are distinct from those about GMOs in that enhancement (vs. treatment) received lower support ratings and was seen as more unfair when the target was people (vs. farm animals) and unfairness mediated this effect when people were the target, but not farm animals.

Finally, Chapter 4 sought to replicate the effect of purpose on support across different domains in addition to physical functioning. Further, Chapter 4 examined how genetic modification compares to other, conventional methods of intervention such as vaccination and drugs. Study 6 utilised a mixed design and was the first to demonstrate that the lower support for genetic modification for enhancement (vs. treatment) purpose replicates in other domains including longevity, mobility, intelligence and disease resistance. Additionally, the results of Study 6 showed that although participants preferred conventional methods over genetic modification, the lower support afforded to enhancement (vs. treatment) was explained by reduced perceptions of social benefit and increased perceived unfairness for both methods.

Chapter 2: Human Gene-Editing: Moral Values, Religiosity and Perceived Harm

The present investigation aims to use different strands of social psychological theory to provide a preliminary understanding of peoples' attitudes to genetic and gene-editing technologies. The studies utilised correlational designs to provide a preliminary examination of how each of the major theoretical perspectives reviewed in Chapter 1 might be relevant in people's attitudes to human gene-editing.

First, I will outline how attitudes to human gene-editing were conceptualised. Then, I summarize some different theoretical perspectives covered in Chapter 1 that can aid the understanding of people's moral objections to and support of human gene-editing. I begin with a brief outline of Moral Foundations Theory (Haidt & Graham, 2007), move on to the role of disgust sensitivity, religiosity and finally harm considerations. The predictions derived from these theoretical perspectives where then tested using a correlational design.

Conceptualising Attitudes to Human Gene-editing

The current study builds on public opinion research on human gene-editing PEW Reseach Center 2018a; 2018b). First, it was important to distinguish technologies that edit the human genome, from other genetic or reproductive technologies which involve a broad range of interventions including in-vitro fertilization (where an egg is fertilized outside the uterus and then the embryo is inserted to the uterus), pre-implantation genetic screening (where an embryo is screened prior to being inserted to the uterus) and the genetic modification of non-human organisms such as animals. This differentiation is important because I theorise that the direct modification of the human genome pose unique moral considerations that may be different not only from the genetic modification of non-human organisms, but also other genetic technologies more generally. Thus, the present investigation differentiates human gene-editing from other genetic technologies.

Moral values

Moral Foundations Theory posits that people rely on distinct moral foundations to evaluate the morality of an action (Haidt, 2007; Haidt & Graham, 2007). The foundations include considering the extent to which someone is harmed, treated unfairly, shown loyalty, or obedience. A central moral foundation is Purity. Purity concerns have been identified in the opposition to GMOs (Scott et al., 2016). Purity incorporates concerns regarding the sanctity of the body and divinity (Jarudi, 2009; Swiney, 2020). Purity concerns might also be important in opposition to human gene-editing. Human gene-editing is often accused of violating of what is sacred (i.e., scientists using these technologies are often seen as playing God; Kalfoglou et al., 2005; Nisbet & Markowitz, 2014; Sadler & Zeidler, 2004) and bodily purity, because it entails artificially altering the human genome.

The concerns people express regarding human gene-editing anecdotally coincide with purity, harm and fairness in the Moral Foundations Theory (Haidt & Graham, 2007). For instance, people report concerns that the use of human gene-editing could be harmful to people and society (Robillard et al., 2014), while others highlight the potential of gene-editing to reduce harm of certain diseases (Kalfoglou et al., 2005). Relatedly, people express fairness concerns when it comes to the potential for economic differences to manifest in the access to these technologies (Kalfoglou et al., 2005). Finally, purity seems to be of particular relevance, due to its emphasis on sanctity, adherence to religious values and purity of the body.

The harm foundation involves virtues such as protecting and caring for those that are vulnerable, and avoiding causing harm (Haidt, 2007). Human gene-editing can be construed both in terms of their potential to reduce harm (e.g., treating diseases) as well as their potential to cause harm (e.g., unintended side-effects). In comparison, the fairness foundation entails valuing people’s right to certain resources or kinds of treatment (Haidt, 2007). Gene-editing technologies could be used in a way that lead to greater inequalities for instance between rich and poor.

Disgust

Conceptually related to purity concerns, disgust is another factor associated with opposition to GMOs (Clifford & Wendell, 2015). Further, the opposition to technologies similar to gene-editing such as stem cell research also correlate with disgust (Terrizzi et al., 2010). It is possible that disgust plays a similar role in moral judgments about human gene-editing. The focus of the present investigation is on trait disgust or disgust sensitivity (See Chapter 3 & 4 for disgust responses; Haidt et al., 1994). Changing the human genome through human gene-editing might be perceived by some as a form of contamination of the body, thus leading those with higher levels of disgust response or sensitivity to be less supportive of gene-editing. According to this perspective, human gene-editing could represent a form of contamination of the body.

Religiosity

The literature reviewed in Chapter 1 showed that in terms of attitudes towards genetic technologies, religion has been devoted the most attention. Previous research has documented a consistent link between religiosity and opposition to genetic technologies (McCaughey et al., 2016; Scheufele et al., 2017; Singer et al., 1999). The development and use of these technologies could be viewed as going against deeply held religious values, such as the respect for God as the creator (Rutjens et al., 2018). Certain moral values, also outlined in the Purity foundation (e.g., the sanctity of life), are likely central in religious opposition to human gene-editing. By extension, individuals with religious fundamentalist beliefs (e.g., a literal interpretation of the bible as God's word), are likely even more opposed to these technologies due to an even stricter adherence to scripture. This is consistent with research showing that traditional religious beliefs are associated with opposition to stem cell research, while individuals with more open ended religious beliefs were more supportive (Nielsen et al., 2009).

Harm

Beyond dispositional factors, the literature on harm considerations in moral judgments suggests that people are may be attuned to the potential harms that can arise or be reduced by human gene-editing. That is, harm considerations are central in both rationalist and social intuitionist accounts of moral judgment, either through the conscious deliberation of issues related to harm in rationalist approaches (e.g., Kohlberg, 1969), or as justifications conjured post-hoc to rationalize a moral stance according (in social intuitionist approaches, e.g., Greene & Haidt, 2002; Haidt, 2001). Harm concerns can be expressed not only about the direct recipient of an action, such as an organism being genetically modified, but abstract, conceptual entities such as society and nature (Schein & Gray, 2018; Gray et al., 2014).

Moral Rules

Beyond harm considerations, qualitative investigations have revealed that people utilise rule-based moral considerations when considering the ethicality of human gene-editing (Sadler & Zeidler, 2004). Scenarios involving human gene-editing evoke different moral rules about fairness, violation of nature, violation of sanctity in response to scenarios involving human gene-editing (e.g., Kalfoglou et al., 2005). For example, in one qualitative study participants commonly equated gene-editing with humans playing God and the disruption of the natural order and deemed it morally wrong on this basis (Sadler & Zeidler, 2004). This finding indicates that when people consider human gene-editing they do not only do so with reference to potential harms or benefits, but in part also with reference to whether the technology violates certain moral rules that are important to them. Thus far no quantitative work has investigated the role of moral rules in moral judgments about human gene-editing.

The Current Research

Past research on psychological predictors of gene-editing has focused mainly on GMOs, and there have been few investigations into the psychological underpinnings of people's attitudes towards human gene-editing. Incorporating existing psychological theorising on GMOs and the role of harm considerations in moral judgments, the present study provide the first examination of people's moral considerations in their judgments about human gene-editing.

It is expected that Purity, Disgust Sensitivity, Religiosity and Religious Fundamentalism all will be negatively associated with support for human gene-editing and support for genetic technologies. No specific predictions were made about the relations between the harm and fairness foundations and attitudes towards human gene-editing, as these variables were included as control variables in the examination of the association between purity and support for human gene-editing. It was further expected that the perceived harm of human gene-editing will be negatively related to support. It was also expected that the perceived benefits of human gene-editing in terms of the estimates of disease reduction will be positively associated with support for human gene-editing.

Study 1: The Role of Perceived Harm and Benefits in Attitudes to GMHs

Method

Participants and Design

Participants were 447 British undergraduate psychology students who took part in exchange for course credit. Of the 447 participants, 21 failed the attention checks, leaving 426 in the final sample (Women = 356, Men = 69, Other = 1; M_{age}= 19.70, *SD* = 4.03, 18-55). Participants reported their ethnicity: White = 280 (65.8%), Black = 60 (14%), Other = 86 (20.1%).

Materials

Attitude Measures

Support of Human Gene-editing. To measure support for human gene-editing a new measure was constructed. Following an exploration of existing and planned technologies, three items were adapted from public opinion surveys (PEW Research Center, 2018a; 2018b). Before responding, participants read a brief description detailing the use of the different technologies: "All of the technologies described below have been proposed or are being used for medical benefits, including helping childless couples conceive, reduce or eliminate congenial diseases (i.e., medical conditions present at or before birth) or to improve health outcomes for people"). Then, participants indicated their support (1 = *Strongly oppose*, 6 = *Strongly support*) on three items: "Editing the genome of an individual in such a way that the change is heritable and present in future generations"; "Using gene-editing techniques on babies with genetic diseases to treat the illness."; "Using gene-editing on healthy babies to improve the immune system, allowing people to live with dramatically reduced risk of disease and illness" ($\alpha = .71$).

Support of Genetic Technologies. We included a measure of support for other genetic technologies that do not involve directly modifying the human genome. The items addressed a range of technologies including in-vitro fertilization and pre-implantation genetic diagnosis. Participants read the same a brief description as for gene-editing technologies, detailing the use of the different technologies. Then, participants indicated their support (1 = *Strongly oppose*, 6 = *Strongly support*) on seven items such as "Genotyping an embryo to provide expecting parents with information about its genetic traits" and "Using an artificial uterus to grow an embryo" ($\alpha = .82$; See Appendix A).

Harm. The perceived harm of human gene-editing was assessed with two measures constructed for the present study. The items were inspired by qualitative research showing that people express concerns that human gene-editing could be harmful or beneficial to different entities including people, society and medicine (Kalfoglou et al., 2014; Sadler & Zeidler, 2004). The first comprised of three items on a seven-point bipolar scales. In response to the question “If the use of technologies designed to edit human genes were widely applied, this would most likely:”,– be a bad thing for medicine, be a good thing for society – be a bad thing for society, be a good thing for people – be a bad thing for people (-3 = *good thing*, 3 = *bad thing*). Then participants were asked to report percentages in response to two items: “Please indicate how likely it you think it is that genetic technologies will be misused” and “Please indicate how likely you think it is that gene-editing in humans will lead to harmful gene mutations”), participants reported the percentage on a sliding scale (0-100%). We transformed the scores of all items into z-scores and included them in one measure of harm (α = .78).

Reduce Disease Estimate. Participants were also asked to indicate the percentage estimate of how much they thought human gene-editing would reduce diseases on one item: “Please indicate by how much you think gene-editing technologies will reduce genetic diseases.” (*0-100%*). This item was created based on previous investigations identifying perceived benefits to health as important in attitudes to human gene-editing (e.g., Howell et al., 2020).

Dispositional Measures

Disgust Sensitivity. An eight-item short version of the Disgust Scale was used (Inbar, Pizarro & Bloom, 2009). First, participants responded to “Please indicate how much you agree with each of the following statements, or how true it is about you…” on four items (e.g., “I might be willing to try eating monkey meat, under some circumstances.”; 1 = *False*, 4 = *True*). In the second part, participants were asked to rate how disgusting four scenarios are (e.g., “You see maggots on a piece of meat in an outdoor garbage pail; 0 = *Not disgusting*, 3 = *Very disgusting*). The scores on each item were transformed into z-scores and then a mean sum score of the responses was calculated, where higher values reflect greater disgust sensitivity (α = .65).

Religiosity. Religiosity was measured with a four-item scale from Sullivan (2001). Participants responded to items such as “In general, would you say you are a religious person?” (1 = *Not at all*, 5 = *A great deal*; α = .94).

Religious Fundamentalism. To examine potential differences in the relations between religiosity and religious fundamentalism and support for human gene-editing, one item assessing religious fundamentalism was also included: “The Bible is the actual word of God, and is to be taken literally word for word.” (Jones, 2011); 1 = *Strongly Disagree*, 6 = *Strongly Agree*).

Moral Foundations. Participants endorsement of the Harm, Fairness and Purity foundations were measured with 18 items (six per foundation), from the Moral Foundations Questionnaire (Graham et al., 2009). Although the variable of focal interest was Purity, measures of the Harm and Fairness foundations were included as control variables. Participants were first asked “When you decide whether something is right or wrong, to what extent are the following considerations relevant to your thinking?”, and then rated the relevance (1 = *Not at all relevant*, 6 = *Extremely relevant*) of items such as “Whether or not someone suffered emotionally” (Harm), “Whether or not someone acted in a way God would approve of” (Purity) or “Whether or not someone was acted unfairly” (Fairness). Then, participants indicated their agreement (1 = *Strongly Disagree*, 6 = *Strongly Agree*) on items such as “Compassion for those who are suffering is the most crucial virtue” (Harm), “People should not do things that are disgusting, even if no one is harmed.” (Purity) and “Justice is the most important requirement for a society” (Fairness). A mean score of the two parts were computed for each foundation, Purity (α = .65), Harm (α = .64) and Fairness (α = .64) respectively.

Demographic information and other measures. Participants also reported demographic information, including political orientation (1 = *Very left-wing*, 7 = *Very right-wing*), gender, ethnicity, religious affiliation and age. Further, participants also completed some additional measures for purposes unrelated to the present study (Appendix B).

Procedure

The study received ethical approval from the Ethics Committee. On the Research Participation Scheme website, participants select studies they wish to participate in from a list of projects. Participants were invited to take part in a study on “Moral Reasoning, Emotion and Society” that would take 15 minutes. The measures were presented in randomized order.

Results

See Table 1 for bivariate correlations and descriptive statistics. Using a two-step hierarchical multiple regression analysis, I first examined the predictions that Harm, Reduce Disease, Purity, Disgust Sensitivity, Religiosity, Harm Foundation and Fairness Foundation would predict Support of Human Gene-Editing. In the first step more distal variables were entered: Disgust Sensitivity, Purity, Religiosity, Religious Fundamentalism, Harm Foundation and Fairness Foundation, with Support of Human Gene-Editing as the outcome variable. The overall model was significant, $F(6, 419) = 2.75$, $p = .012$, $\Delta R^2 = .02$. However, only Religiosity and Disgust Sensitivity were marginally significant predictors of support (See Table 2). In the second step we entered the more proximal predictor variables Harm and Reduce Disease, that explicitly measured perceptions about the potential harms and benefits of human gene-editing. The overall model was significant, $F(8, 417) = 23.80$, $p < .001$, $\Delta R^2 = .30$. Consistent with the predictions, both Harm and Disease Reduction were significant predictors of Support of Human Gene-Editing. Harm was the strongest, negative predictor of support, while Disease Reduction was positively associated with support (See Table 2).

When these variables were included, none of the other variables were statistically significant.[1]

I then conducted a simultaneous multiple regression analysis to examine whether Purity, Disgust Sensitivity, Religiosity, Harm Foundation and Fairness Foundation would be significant predictors of Support of Genetic Technologies. This analysis did not include a second step with Harm or Reduce Disease as predictors since these measures were specific to human gene-editing. The overall model was significant, $F(6, 419) = 7.02$, $p < .001$, $\Delta R^2 = .08$. The results showed that Religiosity and Religious Fundamentalism were the only significant predictors of support (See Table 3), while all the other variables were non-significant.

[1] Note that when either Religiosity or Religious Fundamentalism were entered as a predictor of support, without controlling for the other, Religiosity was negatively associated with support in the first step, ($\beta = -.13$, $p = .02$), but not in the second ($\beta = -.08$, $p = .100$), while Religious Fundamentalism was unrelated to support both in the first step ($\beta = -.09$, $p = .113$) and second step ($\beta = -.01$, $p = .772$).

Table 1.

Bivariate Correlations and Descriptive Statistics (Study 1)

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Support for Gene-editing										
2. Support for Genetic Tech	.74***									
3. Harm	-.51***	-.52***								
4. Reduce Disease	.33***	.28***	-.24***							
5. Disgust Sensitivity	-.09†	-.08†	.20***	-.11*						
6. Purity Foundation	-.09†	-.18***	.20***	-.06	.27***					
7. Religiosity	-.14**	-.25***	.16**	-.09†	.12*	.51***				
8. Religious Fundamentalism	-.13**	-.27***	.18***	-.17***	.13**	.49***	.61***			
9. Harm Foundation	.03	.01	.02	.05	.27***	.32***	.10*	-.01		
10. Fairness Foundation	.07	.04	.03	.11*	.21***	.32***	.13*	-.01	.69***	
M	3.96	3.89	-0.02	68.20	-0.04	3.46	2.26	1.98	4.64	4.57
SD	1.01	0.92	0.72	20.64	4.29	0.83	1.22	1.27	0.71	0.65

Note. $N = 426$. Support for Gentech = Support of Genetic Technologies. *$p < .05$. **$p < .01$. ***$p < .001$. † $p < .10$.

Table 2.

Multiple Regression Analysis Predicting Support for Human Gene-Editing (Study 1)

	Support of Human Gene-Editing		
	β	t	sr^2
Step 1			
Disgust Sensitivity	-.09	-1.79†	.01
Purity Foundation	-.03	-0.39	.00
Religiosity	-.11	-1.74†	.01
Religious Fundamentalism	-.04	-0.55	.00
Harm Foundation	.01	0.11	.00
Fairness Foundation	.10	1.52	.00
Step 2			
Disgust Sensitivity	.01	0.32	.00
Purity Foundation	.03	0.57	.00
Religiosity	-.09	-1.72	.00
Religious Fundamentalism	.03	0.57	.00
Harm Foundation	-.02	-0.37	.00
Fairness Foundation	.07	1.21	.00
Harm	-.46	-.10.60***	.18
Reduce Disease	.22	5.09***	.04

Note. $N = 425$. *$p < .05$. **$p < .01$. ***$p < .001$. † $p < .10$.

Table 3.

Multiple Regression Analysis Predicting Support for Genetic Technologies (Study 1)

	Support of Genetic Technologies		
	β	t	sr^2
Disgust Sensitivity	-.05	-0.91	.00
Purity Foundation	-.05	0.42	.00
Religiosity	-.14	-2.28*	.01
Religious Fundamentalism	-.15	-2.39*	.01
Harm Foundation	-.01	-0.10	.00
Fairness Foundation	.03	1.24	.00

Note. $N = 425$. $^*p < .001$.

Discussion

The results of Study 1 are consistent with the theoretical perspective that people's attitudes towards human gene-editing are related to perceived harm and benefits. Specifically, the present findings suggest that when people consider these technologies they do so primarily by assessing the potential consequences this could have in terms of causing and reducing harm. Religiosity and Disgust Sensitivity was only marginally negatively related to support of human gene-editing, and became non-significant when Harm and Reduce Disease were included. This could suggest that Religiosity, Purity and Disgust Sensitivity may be of secondary importance in people's attitudes towards human gene-editing. Similarly, when considering support for other genetic technologies, only Religiosity and Religious Fundamentalism were significant negative predictors of support. Disgust Sensitivity, Purity, Harm Foundation and Fairness Foundation were all unrelated to support for genetic technologies.

Study 2: Harm, Benefits and Sanctity Considerations in the Support of GMHs

Study 1 suggests that perceived harms and benefits are both relevant in attitudes to human gene-editing. However, only a few items each were used to measure different perceived harms and benefits. Specifically, perceived benefit was conceptualised by asking participants the extent to which GMHs have the potential to reduce disease, while harm was conceptualised by asking whether GMHs would be bad for society, people or lead to harmful gene mutations. Study 2 sought to address this limitation by including a wider range of specific moral considerations assessing the extent to which human gene-editing is seen as *morally right* or *morally wrong* on the basis of different considerations, and examine whether these are related to support of GMHs.

Since genetic modification can be viewed as causing a wide range of potential benefits and harms for different entities (e.g., Schein & Gray, 2018), I wanted to capture a broader range of potential outcome-based considerations in the present study. Study 2 therefore included more granular measures of social benefit and social harm. These measures were constructed based on the typical concerns expressed about human gene-editing. When people consider human gene-editing they often report concerns that human gene-editing for enhancement purposes could exacerbate societal inequality (e.g., Gyngell et al., 2017; Harris, 2010; Kalfoglou et al., 2015). Simultaneously they also express hopes that human gene-editing can be beneficial to people and society, for instance by eradicating disease and improving population health (e.g., Kalfoglou et al., 2015; Sadler & Zeidler, 2004). Study 2 also included a measure of Faith in Science, to ensure that the measure of benefits in Study 1 was not merely capturing positive views of science.

Further, in Study 1 the measures of Purity, Harm and Fairness from MFT (Graham et al., 2009) were all unrelated to support of human gene-editing. The measures have been criticised for including only a limited set of moral values per foundation (e.g., McNease and

Sinn, 2018) as well as showing low reliability (Harper & Rhodes, 2021). Thus, I wanted to examine whether more proximal measures of the perceived sanctity violation and dignity and individuality concerns would be associated with support of human gene-editing. I also included a measure to capture endorsement of the belief that people should be free to decide over their own genes (e.g., Harris, 2010), termed Free Will Consideration. The items for each of these measures were constructed based on concerns expressed in qualitative investigations as well as philosophy writing on the topic of human gene-editing. Additionally, the present study controlled for endorsement of religiosity and spirituality, to tease apart general religious belief and spirituality from specific moral concerns about sanctity and purity.

Finally, the items measuring support of human gene-editing in Study 1 were quite general and did not really capture the wide range of potential applications of gene-editing technology. Thus, Study 2 expanded the measure of support, and in addition to an item of support for gene-editing in general, participants were asked the extent to which they support human gene-editing for the purpose of enhancing intelligence, longevity, mobility and disease resistance. This also allowed for an examination of whether the endorsement of different moral considerations would be differentially related to support in the different domains. I expected that the perceived social benefit of human gene-editing would be positively associated with support of gene-editing, while the perceived social harm, sanctity violation and dignity and individuality violation would be negatively associated with support. I did not make any specific predictions about the relations between the predictor variables and support across, instead examining this on an exploratory basis.

Method

Participants and Design

Participants were 379 UK Prolific Academic workers, wherein 31 failed the attention check, leaving 348 in the final sample (Women = 225, Men = 123; M_{age}= 31.77, *SD* = 11.97, 18-70). Most participants reported their ethnicity as White (*N* = 303), while the rest reported other ethnicities (*N* = 45). The study employed a within-subjects design, where participants read about one general scenario of gene-editing and then gene-editing for enhancement purposes across four different domains. The outcome variable was support for human gene-editing. The study also measured different moral considerations about GMHs detailed below.

Materials and Procedure

Gene-editing General. Participants were first asked to read a brief explanation of human gene-editing: “Genome editing (also called gene-editing) is a group of technologies that give scientists the ability to change an organism's DNA. These technologies allow genetic material to be added, removed, or altered at particular locations in the genome. Human gene-editing refers to the application of this technology to human genes.” Then participants were asked to indicate their support of human gene-editing in general in response to one question: “Editing the human genome (i.e., human gene-editing)” (1 = *Strongly oppose*, 7 = *Strongly support*).

Domains. Following the general questions, participants were then randomly presented with four scenarios describing gene-editing for the purpose of *enhancement* only across four different domains (Intelligence, Longevity, Mobility & Disease Resistance). For instance, participants were presented with: “Please indicate the extent to which you would support or oppose the following: Editing the human genome to improve the disease resistance of people with normal immune systems.” (See Appendix C for domains). Following each of the four scenarios participants completed various measures described below.

Support. Support for gene-editing was measured with five items, one for the general scenario and one per domain described above: “Please indicate the extent to which you would support or oppose the following:” (1 = *Strongly oppose*, 7 = *Strongly support*; α = .83).

Social Benefit. Following qualitative research showing that perceived benefits are important in moral judgments about human gene-editing (e.g., Kalfoglou et al., 2005; see also Sadler & Zeidler, 2004). Eight items were created to provide a more granular measure of different kinds of social benefit of human gene-editing. Participants were asked to indicate the extent to which they agreed or disagreed with the statement "Human gene-editing is morally right because:" on eight items: "...it will reduce harm for people with genetic diseases.", "…it will save lives", "...it will improve the quality of life for many people.", "...it will eradicate deadly diseases.", "...it will improve population health.", "...it will change humans for the better.", "...it will produce more good outcomes than bad." "…it will allow people to improve their physical functioning." (1 = *Strongly disagree*, 7 = *Strongly agree*; α = .92).

Social Harm. Similarly, since past qualitative research has identified perceptions of social harm as relevant in attitudes to human gene-editing (e.g., Kalfoglou et al., 2014; Sadler & Zeidler, 2004), seven items were created to capture more details about different kinds of social harms of human gene-editing. In response to the statement "Human gene-editing is morally wrong because:" participants indicated their agreement or disagreement on seven items: "…people will create designer babies.", "…it discriminates against people with disabilities.", "…it will lead to eugenics.", "…it will cause greater societal inequality.", "it will reduce genetic diversity in humans.", "…future generations cannot consent to it.", "…it poses risks to individual health." (1 = *Strongly disagree,* 7 = *Strongly agree;* α = .84).

Sanctity Violation. A more detailed measure of different moral considerations relating to sanctity was created, adapted from concerns participants have expressed in qualitative interview studies on attitudes to human gene-editing (Kalfoglou et al., 2014). In response to the statement "Human gene-editing is morally wrong because:" participants indicated their agreement or disagreement with eight items: "…it is unnatural.", "...it undermines the destiny of the individual.", "...it undermines the destiny of the human species.", "..the human genome is sacred and should not be altered.", "...humans should not play God.", "...it fundamentally changes what it means to be human.", "…it changes human nature.", "…it will be used to indulge people's vanity." (1 = *Strongly disagree*, 7 = *Strongly agree*; α = .93).

Dignity and Individuality Violation. In previous research participants have expressed the view that human gene-editing is morally wrong because it undermines human dignity and individuality, for instance by leading to discrimination (Sadler & Zeidler, 2004). Thus, for the purpose of the present study a measure of the perceived dignity violation of human gene-editing was constructed. In response to the statement "Human gene-editing is morally wrong because:" participants recorded their agreement or disagreement with four items: "…it is a violation of human dignity.", "…it will undermine people's individuality.", "…it undermines free will", "…it undermines individual autonomy." (1 = *Strongly disagree*, 7 = *Strongly agree*; α =.86).

Free Will Consideration. The belief that people should be free to decide over their own genes is occasionally expressed in ethics debates (e.g., Harris, 2010). Similarly, philosophers of this view, typically argue that a technology is not morally wrong on the basis that it can be misused (Harris, 2010). Thus, three items were created to assess participants endorsement of free will arguments for human gene-editing. In response to the statement "Human gene-editing is morally right because" participants recorded their agreement or disagreement with the items: "…it will allow people to improve their genetic make-up.", "…people should be free to decide over their own genes", "...a technology is not morally wrong simply because it could lead to social inequalities." (1 = *Strongly disagree*, 7 = *Strongly agree*; α =.66).

Religiosity. Participants also responded to the same four items as in Study 1 assessing their level of religiosity (1 = *Not at all*, 7 = *A great deal*; α = .93).

Faith in science. To ensure that perceived Social Benefits of GMHs were not merely capturing general Faith in Science, the present study included a measure of Faith in Science, measured with five items: “We believe too often in science, and not enough in feelings and faith.”; “Science tells us everything there is to know about what reality consists of.”; “The scientific method is the only reliable path to knowledge.”; “The only real kind of knowledge we can have is scientific knowledge.” and “Science is the most efficient means of attaining truth.” (1 = *Strongly disagree*, 7 = *Strongly agree*; α = .88; Rutjens et al., 2018b).

Spirituality. Participants’ level of spirituality was also measured using two items “To what extent do you consider yourself to be a spiritual person?” and “To what extent do others consider you to be a spiritual person?” (1 = *Not at all*, 7 = *Very much*; α = .92; Maij & Elk, 2018).

Demographics and Other Measures. For purposes unrelated to this study participants were also asked to consider the amount of people that would have their genes edited in each scenario and report their support for the different proportions (See Appendix D). Finally, participants reported some of their demographic information including gender, political orientation, age, ethnicity and religion. Participants were asked to respond to a free-text question about the challenges human gene-editing pose (See Appendix E).

Results

Support of Human Gene-editing

I first examined whether there were any significant differences in the level of support afforded to human gene-editing across the different domains. A repeated measures ANOVA showed that there was a significant difference in the support of gene-editing across the different domains, $F(3, 344) = 66.12$, $p < .001$. Specifically, pairwise comparisons showed that gene-editing for enhancing intelligence received the lowest support (*M* = 2.76, *SD* = 1.94) compared to gene-editing in General (*M* = 3.59, *SD* = 1.60; $p < .001$; *d* = 0.43), Longevity (*M* = 3.20, *SD* = 1.92; $p < .001$; *d* = -0.24; $p < .001$), Mobility (*M* = 3.23, *SD* = 2.13; *p* = .002; *d* = -0.26), and Disease Resistance (*M* = 4.36, *SD* = 2.04; $p < .001$; *d* = -0.83). Gene-editing for Disease Resistance was afforded more support compared to all other domains (Intelligence: *d* = 0.83; Longevity: *d* = .70; Mobility: *d* = 0.52; all *ps*< .001). Gene-editing in general received greater support than all other domains (Longevity: *d* = 0.21; Mobility: *d* = 0.17) aside from Disease Resistance which received greater support (*d* = -.43). There was no difference in the support of Longevity and Mobility (*d* = .02; *p* = .775).[2]

I then examined whether the proposed predictor variables were associated with support of genetic modification within each of the different domains, conducting five hierarchical multiple regression analyses (see Table 4 for zero-order correlations). In the first step I entered the more distal predictor variables: Faith in Science, Religiosity and Spirituality. In the second step more proximal variables were entered: Social Benefit, Social Harm and Sanctity Violation, while Support (of genetic modification within each domain) was the outcome variable.

See Table 5 for regression statistics for each outcome variable. In the first step, only Faith in Science was significantly positively associated with Support for gene-editing across the different domains. In contrast, neither Religiosity nor Spirituality were significantly negatively associated with support in any of the domains. In the second step and consistent with predictions, Social Benefit was positively associated with Support across all domains, while Sanctity Violation was negatively associated with support for gene-editing in the domains of General, Intelligence and Disease Resistance, but not significantly in the domains

[2] We used Sidak's correction for multiple comparisons for the pairwise comparisons, so the adjusted significance level was $p < .005$.

of Longevity and Mobility. Contrary to predictions, Social Harm was not significantly, negatively related to support in any of the domains. Endorsement of the Free Will Consideration was only positively associated with support in the domain of Intelligence. Contrary to predictions, Dignity and Individuality Violation was unrelated to support across all domains, aside from Longevity, where it was positively associated with support, not negatively as expected.

Table 4.

Bivariate Correlations and Descriptive Statistics (Study 2)

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Support									
2. Social Benefit	.70***								
3. Social Harm	-.50***	-.52***							
4. Sanctity	-.56***	-.58***	.67***						
5.Dignity	-.50***	-.55***	.75***	.83***					
6. Free Will	.55***	.64***	-.44***	-.41***	-.44***				
7. Religiosity	-.02	-.01	-.09†	.10†	.06	.05			
8. Spirituality	-.04	-.05	.00	.15**	.11*	.03	.81***		
9. FiS	.18***	.20***	-.17**	-.31***	-.25***	.10†	-.41***	-.48***	
M	3.43	4.40	5.31	4.88	4.78	3.70	2.38	2.89	4.34
SD	1.49	1.28	1.06	1.43	1.43	1.35	1.63	1.76	1.42

Note. *N* = 348. Sanctity = Sanctity Violation; Dignity = Dignity Violation. FiS = Faith in Science. ***$p < .001$. **$p < .01$. *$p < .05$. † < .10.

Table 5.

Hierarchical Multiple Regression Predicting Support of Human Gene-Editing Within Domains (Study 2)

	Support of Human Gene-Editing														
	General			*Intelligence*			*Longevity*			*Mobility*			*Disease Resistance*		
	β	t	sr^2	β	t	sr^2	β	t	sr^2	β	t	sr^2	β	t	sr^2
Step 1															
Faith in Science	.20	3.37**	.03	.19	3.18**	.03	.14	2.31*	.02	.14	2.24*	.01	.13	2.15*	.01
Religiosity	.06	0.62	.00	.02	0.21	.00	.09	1.00	.00	.02	0.22	.00	.02	0.21	.00
Spirituality	-.07	-0.71	.00	.13	1.37	.01	-03	-0.34	.00	.03	0.35	.00	-.03	-0.30	.00
Step 2															
Faith in Science	-.01	-0.32	.00	.05	0.82	.00	.00	0.05	.00	.01	0.08	.00	-.03	-0.62	.00
Religiosity	-.05	-0.82	.00	-.05	-0.64	.00	-.01	-0.13	.00	-.05	-0.65	.00	-.06	-0.85	.00
Spirituality	-.02	-0.26	.00	.15	1.84†	.01	.00	-0.00	.00	.06	0.68	.00	-.00	-0.03	.00
Social Benefit	.46	8.50***	.10	.21	3.13**	.10	.35	5.19***	.05	.33	4.78***	.05	.49	7.95***	.11
Social Harm	-.10	-1.79	.00	-.05	-0.74	.00	-.21	-2.94**	.01	-.09	-1.21	.00	-.06	-0.87	.00

Sanctity Violation	-.22	-3.29**	.01	-.22	-2.54*	.10	-.16	-1.85†	.01	-.17	-1.84†	.01	-.17	-2.14*	.01
Dignity	-.06	0.76	.00	.04	0.38	.00	.22	2.38*	.01	.12	1.27	.00	.12	1.41	.00
Free Will	.01	0.24	.00	.18	2.93**	.02	.13	2.12*	.01	.11	1.78†	.01	-.10	1.75†	.00

Note. $N = 348$. F-statistics: General (Step 1: $F(3, 347) = 5.72$, $p < .001$, $\Delta R^2 = .04$; Step 2: $F(8, 339) = 60.52$, $p < .001$, $\Delta R^2 = .54$); Intelligence (Step 1: $F(3, 344) = 3.70$, $p = .012$, $\Delta R^2 = .02$; Step 2: $F(8, 339) = 16.87$, $p < .001$, $\Delta R^2 = .25$; Longevity (Step 1: $F(3, 344) = 2.14$, $p = .095$, $\Delta R^2 = .01$; Step 2: $F(8, 339) = 18.39$, $p < .001$, $\Delta R^2 = .29$); Mobility (Step 1: $F(3, 344) = 1.71$, $p = .164$, $\Delta R^2 = .01$; Step 2: $F(8, 339) = 14.19$, $p < .001$, $\Delta R^2 = .23$); Disease Resistance (Step 1: $F(3, 344) = 2.22$, $p = .086$, $\Delta R^2 = .01$; Step 2: $F(8, 339) = 27.91$, $p < .001$, $\Delta R^2 = .38$). *$p < .05$. **$p < .01$. ***$p < .001$.

Discussion

In the present study, participants were the most supportive of genetic modification for the enhancement of disease resistance, while enhancement of intelligence was afforded the least support. After disease resistance, participants were the most supportive of gene-editing in general. Further, Study 2 elaborated on the different moral considerations proposed to be relevant in attitudes to human gene-editing. Using measures detailing different considerations relating to social benefit, social harm, sanctity violation, dignity and individuality violation as well as free will consideration, Study 2 elucidated the associations between these and support.

Specifically, the results showed that perceiving gene-editing to be morally right on the basis that it will lead to social benefits, was positively associated with support of genetic modification in general and across all domains. In contrast, viewing genetic modification as morally wrong on the basis that it constitutes a sanctity violation, was negatively associated with support of gene-editing in general, and in the domains of intelligence and disease resistance, while the relation with support was non-significant in the domains of longevity and mobility. Perceiving human gene-editing as morally wrong on the basis that it violates dignity and individuality was only related to support in the domain of longevity, and contrary to expectations it was positively associated with support. In contrast, viewing gene-editing as morally right based on free will considerations was positively associated with support only in the domain of intelligence. Finally, neither, Religiosity, Spirituality or Faith in Science were significantly associated with support in any of the domains once more proximal moral considerations were included.

General Discussion

The present studies are the first empirical investigations to identify some of the psychological variables that may be important in people's moral judgments about human gene-editing and other genetic technologies. The results of Study 1 show that perceived harm of human gene-editing is negatively associated with support for human gene-editing, while perceived benefits in terms of reduced disease is positively associated with support. Importantly, this pattern of results hold when other variables including religiosity, purity and disgust sensitivity are controlled for. Alongside the perceived harm and benefit of human gene-editing, religiosity, religious fundamentalism, disgust sensitivity, purity, harm foundation and fairness foundation were all non-significant predictors. Study 2 replicated this pattern, showing that viewing human gene-editing as morally right on the basis of the social benefits it is seen to produce was positively associated with support for human gene-editing to *enhance* intelligence, longevity, mobility and disease resistance.

While previous research has demonstrated the role of disgust sensitivity in opposition to genetically modified organisms (GMO) and stem-cell research (Clifford & Wendell, 2016; Royzman et al., 2017; Scott et al., 2016), the present investigation focused on human gene-editing and other genetic technologies. The results of Study 1 could suggest that the association between disgust sensitivity and attitudes towards human gene-editing is different from GMOs. Specifically, contrary to the prediction, disgust sensitivity was not significantly associated with support for human gene-editing or other genetic technologies. This could be consistent with my theorising that human gene-editing constitutes a shift in the kinds of moral concerns that can arise because the target of genetic modification changes from non-human organisms to humans.

Previous research has also linked the five moral concerns outlined by Moral Foundations Theory to attitudes on a range of social issues, where Purity has been found particularly useful in explaining ideological differences (Koleva et al., 2012). The focus of the present studies was on purity concerns, which is argued to be based on the emotion of disgust (Koleva et al., 2012) and is correlated with opposition to scientific developments such as GMO, stem-cells research and cloning (Koleva et al., 2012). Contrary to predictions, there was no significant association between Purity and support for human gene-editing or other genetic technologies in Study 1. Again these findings are consistent with the proposition that moral judgments about human gene-editing may be distinct from those about GMOs.

Study 2 expanded the examination of purity concerns, including a measure specifically capturing moral considerations about purity and sanctity with respect to human gene-editing. Thus, although Study 1 failed to find a significant association between purity concerns as measured in the Moral Foundations Questionnaire (Graham et al., 2009) and support of human gene-editing, the sanctity violation-measure constructed for Study 2, was negatively associated with supports. This finding suggest that although a more general measure of purity concerns was unrelated to support of human gene-editing, people nonetheless endorse moral considerations about sanctity and purity about human gene-editing. Specifically, judging human gene-editing as morally wrong on the basis that it violates sanctity and purity, was negatively associated with support in general as well as for intelligence and disease resistance.

In Study 1, consistent with predictions, religiosity was negatively correlated both with the support for human gene-editing and other genetic technologies. However, in Study 2, neither religiosity nor spirituality were negatively associated with support of human gene-editing in general or within any of the domains. Further, both religiosity and spirituality were also uncorrelated with support at zero-order. It is currently unclear why this is the case. It could be that religiosity is not the most reliable variable in explaining support of human gene-editing. Indeed, some research findings suggest that the association between religiosity and attitudes to science in general is subject to great variability, in part because levels of religiosity has decreased in Western Europe (Rutjens & van der Lee, 2020).

The results of Study 1 is in line with earlier research where those reporting greater religiosity also report lower support for gene editing (Scheufele et al., 2017), and related technologies such as stem cell research (Nielsen et al., 2009) and synthetic biology (Dragojlovic & Einsiedel, 2013a; 2013b). Past research has suggested that it is particular more fundamentalist or orthodox religious beliefs that are negatively associated with opposition to related technological innovations such as stem cells, while more open-ended types of religious affiliation do not show this pattern (Nielsen et al., 2009). However, the present results did not replicate this pattern. Specifically, when both religious fundamentalism and religiosity were accounted for, neither were significant predictors of human gene-editing, while only religiosity was negatively related to support for human gene-editing, if religious fundamentalism was not controlled for. It should be noted that since undergraduate students were recruited for Study 1, while the sample in Study 2 comprised British adults, there may have been important differences both in previous knowledge about human gene-editing as well as levels of religiosity (a point I return to in Chapter 5). These differences could in turn have affected the perception of the different domains.

Although the results of Study 2 are in line with qualitative investigations on attitudes to human gene-editing, it should be noted that since the measures of different moral considerations were constructed for this study and have not been validated in previous research, caution should be exercised in interpreting the findings. The large positive correlation between support and social benefit is of particular concern, and begs the question whether the perception of social benefits is the outcome of greater support for human gene-editing, rather than a predictor. Moral evaluations can influence factual beliefs as well as risk perceptions (Braman et al., 2005; Kahan & Braman, 2006; Ditto & Liu, 2012). Consequently, the present findings only show that endorsing the view that human gene-editing is morally right on the basis of the social benefits it can produce is associated with support, not that participants support is affected by the perceived benefits.

Further, since the measures of different moral considerations were constructed specifically for Study 2, and have not been validated in previous research, some caution should be exercised in interpreting the findings. The lack of validated measures in Psychology in general has been highlighted as a key issue in the failure to replicate research findings (Schimmack, 2021). That said, all the measures were constructed based on moral considerations voiced by lay people in qualitative interviews about human gene-editing (e.g., Sadler & Zeidler, 2004) or voiced by ethicists on the subject of human gene-editing (e.g., Harris, 2010). Thus, the measures do at least mirror common concerns voiced about human gene-editing. Further research should focus on validating the measures of different moral considerations about GMHs. Nonetheless, the findings of Study 2 does go some way in elucidating which moral considerations are associated with support for human gene-editing when other moral considerations are controlled for.

Although the present findings suggest that harm and benefit considerations are important in people's support for human gene-editing, there was no experimental manipulation of the gene-editing purpose, making it difficult to know whether people did in fact consider the potential harms and benefits that the different applications of human gene-editing could produce and that this in turn affected their support. Further, although the current findings indirectly indicate that there may be important differences in the moral judgments about genetic modification of humans and other, non-human organisms, the present investigation did not provide a direct test of this proposition. Specifically, a comparison between moral judgments about human gene-editing and other GMOs is necessary.

In Chapter 3 I addressed these limitations using a carefully matched manipulation to distinguish between treatment and enhancement purpose. In a between-participants design participants were presented with a brief text either describing gene-editing used in people with (or without) physical disabilities to improve strength and functioning. Further, we examined how the purpose of gene-editing affected different kinds of moral considerations, investigating the extent to which participants perceived gene-editing to violate a moral rule (Rule-based consideration) and its potential to improve the quality of life for people (Outcome-Based Consideration). Finally, to examine the proposed differences in the moral considerations underpinning attitudes to human gene-editing and GMOs, I experimentally manipulated whether the target of gene-editing was people or farm animals.

Chapter 3: The Role of Purpose and Target in Moral Judgments About GMHs

Findings from Chapter 2 were consistent with the theoretical perspective that people's attitudes towards human gene-editing are related to perceived harm. Specifically, the findings suggest that considerations about the potential of human gene-editing to cause and reduce harm is associated with levels of support afforded to gene-editing. However, the studies in Chapter 2 did not include an experimental manipulation of the gene-editing purpose, making it difficult to know whether people did in fact consider the potential harm and benefits that different applications of genetic modification could produce and that this was associated with subsequent support.

In Chapter 3 I employed a carefully matched manipulation to distinguish between treatment and enhancement purpose. In a between-participants design participants were presented with a brief text either describing gene-editing used in people with (or without) physical disabilities to improve strength and functioning. Further, I examined how the purpose of gene-editing affected different kinds of moral considerations, investigating the extent to which participants perceived gene-editing to violate a moral rule (Rule-Based Consideration) and its potential to improve the quality of life for people (Outcome-Based Consideration). Finally, to examine my proposition that moral considerations about the genetic modification of humans may be different from those about GMOs, I also included an experimental manipulation of whether the target of genetic modification was people or farm animals.

Why GMHs may be Different From GMOs

As noted in Chapter 1, one reason that moral judgments likely differ between GMOs and GMHs is that compared to plants and animals, humans are given much greater moral standing (Caviola et al., 2019). Thus, I theorise that people show more regard for the potential harms and benefits for humans (compared to other organisms) who may be genetically modified.

This greater moral standing of GMHs may lead to an important difference in moral reasoning processes. People are relatively utilitarian about animals, weighing the consequences of an action for an individual animal against the sum total of harms and benefits to other animals, but relatively deontological about humans, assessing the morality of an action against a set of rules or principles (Caviola et al., 2020b). These principles include the notion that people should be treated fairly and with dignity (e.g., Kalfoglou et al., 2005). This differentiated application of different moral principles is higher among speciesists who extend relatively more moral concern to people and less to animals (Caviola et al., 2020b). Thus, I propose that moral judgments about GMHs are different from those about GMOs both in the *kinds* of moral concerns as well as the *degree* to which they apply to humans compared to animals.

The Enhancement vs. Treatment Distinction

One factor that may distinguish reasoning about human gene-editing from GMOs is how people respond to the ultimate purpose of genetic modifications. To date, some public opinion research suggests that people harbour quite favourable views towards human gene-editing for *treatment* purposes such as the prevention and treatment of disease, but are more sceptical towards gene-editing for *enhancement* purposes such as elevating intelligence, longevity or other desirable traits (PEW Research Center, 2018a; Rainie et al., 2016). However, there is an important limitation to these studies. Specifically, they confound the treatment vs. enhancement with other important differences. For example, the Pew Research Center’s (2018a) questions about treatment referred to physical health or functioning including the prevention of serious disease, while questions about enhancement referred to cognitive functioning. Thus, it is not clear whether the results reflect the distinction between enhancement and treatment, or other factors such as the outcomes including physical health, cognitive performance, or even appearance that are being targeted by genetic interventions. Nor do previous studies elucidate *why* some purposes are afforded more support than others. That is, little is known about the psychological underpinnings of people's attitudes to human gene-editing.

The enhancement versus treatment distinction seems intertwined with the unique moral implications of human gene-editing for society and social organization. In one qualitative interview study participants reported concerns that human gene-editing could increase societal inequality and unfair outcomes (Kalfoglou et al., 2005; see also Sadler & Zeidler, 2004). Philosophers have also noted this entrenchment of inequality as one of the most common objections to human gene-editing (Gyngell et al., 2017; Harris, 2010). Consequently, I argue that this distinction will be of greater importance to subsequent levels of support for gene-editing when the target of gene-editing is people compared to farm animals.

Why Would People Prefer Treatment to Enhancement?

The moral objections to editing human genes for the purpose of enhancement seem to refer to harms to society, including fears that the benefits of the technology would be distributed unequally, exacerbating social inequalities (e.g., Gyngell et al., 2017; Kalfoglou et al., 2005). These concerns, importantly, are unlikely to apply to GMO since the distribution of gene editing among plant and animal populations has no obvious direct impact on inequality in human societies. Harms to nature, such as disruptions of the natural order, seem to appear less specifically as an objection to enhancement. Whether a gene is edited to enhance a desired trait or treat a health condition, the natural genetic code of a person is being modified, presenting a *prima facie* threat to the natural order.

Qualitative research suggests that people also employ rule-based moral considerations about human gene-editing (Sadler & Zeidler, 2004). People draw on a range of different moral rules about fairness, violation of nature, violation of sanctity in response to scenarios involving human gene-editing (e.g., Kalfoglou et al., 2005). For instance, participants in one qualitative study commonly equated gene-editing with humans playing God and the disruption of the natural order and deemed it morally wrong on this basis (Sadler & Zeidler, 2004). This finding indicates that when people consider human gene-editing they do not only do so with reference to potential outcomes, but also with reference to whether the technology violates important moral principles. Thus far, however, no quantitative work has investigated the role of moral rules in moral judgments about human gene-editing.

The Current Research

Although both GMOs and GMHs involve the modification of genetic material and so may be subject to similar moral concerns, moral reasoning about GMHs can be expected to differ in both degree and kind. Unique moral concerns about GMHs are likely to depend on whether human genes are altered for treatment or enhancement purposes. The present studies sought to examine the moral considerations that guide judgments about human gene-editing. Addressing a paucity of controlled research into moral reasoning about GMHs, the present studies employ a carefully matched manipulation of gene-editing for treatment versus enhancement (Studies 3 & 4) as well as the target of gene-editing (humans vs. farm animals; Study 5). I predicted that for GMHs in particular, participants would be less supportive of gene-editing for enhancement (vs. treatment) purposes. I expected this effect, and attitudes to GMH in general, to be associated with the lower utility of enhancement, compared to treatment, for people whose genes are modified. I also expected that wider moral concerns referring to principles such as fairness and harms to society would be applied more strongly in judgements about the genetic modification of humans, compared to animals. Finally, I included previously identified predictors that may underlie opposition to both GMOs and GMHs, including purity, disgust, religiosity.

Study 3: The Enhancement vs. Treatment Distinction in Support of GMHs

Method

Participants and Design

In Study 1, 369 British Prolific Academic users were recruited, wherein 13 failed the attention check, leaving 356 in the final sample (Women = 240, Men = 116; M_{age} = 37.27, *SD* = 12.55, 18-85). Ethnicity was not recorded.

The study employed a between-participants design where participants were randomly allocated to either read about gene-editing for treatment versus enhancement. The dependent variable was support of human gene-editing.

Procedure

The study received ethical approval. On Prolific Academic (an online crowdsourcing site), participants select the studies from a list of projects. The survey was part of a research collaboration data collection and included various other measures. Participants took part in a study on attitudes towards science taking 15 minutes. The measures were presented in randomized order.

Manipulation

Purpose

To address the confounds of previous research on the treatment vs. enhancement distinction in human gene-editing, a carefully matched scenario was created where the particular trait targeted was held constant, but the purpose of the gene editing was either treatment or enhancement. The scenario was adapted from public opinion surveys (PEW, 2018a; 2018b). Instead of comparing for instance the gene-editing for the treatment of disease with gene-editing for enhancement of cognitive functioning as in previous studies, the present scenario varied on whether the people whose genes would be edited were physically disabled or not, thus holding the trait targeted constant. The scenario read: "Medical enhancements that edit the genes of people *with(out)* physical disabilities to improve their strength and movement". Following the manipulation participants completed various measures described below.

Measures of Attitudes to Human Gene-editing

Support. Two items measured support for gene-editing: "To what extent do you support or oppose these therapies?" (1 = *Strongly oppose*, 6 = *Strongly support*) and "To what extent do you see these therapies as ethically right or wrong?" (1 = *Ethically wrong*, 6 = *Ethically right*). They were collapsed to one measure of Support (α = .92).

Rule-based Consideration. Based on previous qualitative research that has identified concerns about moral rules to be important in moral judgments about human gene-editing (e.g., Kalfoglou et al., 2005; Sadler & Zeidler, 2004) I created an item to assess the extent to which participants perceived gene-editing to violate a moral rule: "To what extent do these therapies violate an important moral rule or principle?" (1 = *Not at all*, 6 = *Very much so*).

Outcome-Based Consideration. Following qualitative research showing that concerns about outcomes in terms of the potential benefits (in reducing harm) to be important in moral judgments about human gene-editing (e.g., Kalfoglou et al., 2005; see also Sadler & Zeidler, 2004), I created an item to assess participants' estimates of how much they thought gene-editing could improve the quality of life for recipients: "By how much, if at all, do you think these therapies would improve the quality of life of those who received them?" (*0 – 100%*).

Dispositional Measures

Purity. Three items measured the Purity foundation: "I would call some acts wrong on the grounds that they are unnatural"; "People should not do things that are disgusting, even if no one is harmed" and "Chastity is an important and valuable virtue" on a five-point Likert scale (1 = *Strongly disagree,* 5 = *Strongly agree*; α = .73; Graham et al., 2009).

Belief in God. One item measured belief in God: "Do you believe in God or a higher power?" (Oxhandler & Parrish, 2016; 1 = *Not at all*, 10 = *Very much*).

Religious orthodoxy. Two items measured Religious Orthodoxy: "God has been defined for once and for all and therefore is immutable." and "Religion is the one thing that gives meaning to life in all its aspects."; Duriez et al., 2005; 1 = *Strongly disagree*, 7 = *Strongly agree*; α = .73).

Results

Descriptive statistics and bivariate correlations within each condition are presented in Table 6. I first examined the effect of the purpose of genetic modification. An independent t-test revealed that, as predicted, participants were significantly less supportive of the use of gene-editing for enhancement compared to treatment, $t(298.20) = -5.18$, $p < .001$, $d = 0.58$.[3] To examine whether the lower support afforded to enhancement (vs. treatment) purpose could be explained by the perceived moral rule violation of enhancement as well as the lower utility, I used PROCESS (Model 4; Hayes, 2017) with 95% confidence intervals and 5000 bootstrap resamples to assess significance. Purpose (1 = Enhancement, -1 = Treatment) was entered as the predictor variable (X), Rule-Based Consideration and Outcome-Based Consideration were entered as candidate mediators (M), and Support was the outcome variable (Y). Continuous predictor variables were standardized prior to analysis.

[3] Levene's test was significant, $F = 5.29$, $p = .022$, thus equal variances were not assumed and the corrected t-statistics were reported.

As predicted, there were significant indirect effects of Purpose on Support via Rule-Based Consideration, indirect B = -.10, [-.16, -.04], and Outcome-Based Consideration, indirect B = -.14, [-.22, -.08] (See Figure 1). The direct effect of Purpose was also significant, consistent with partial mediation.

Table 6.

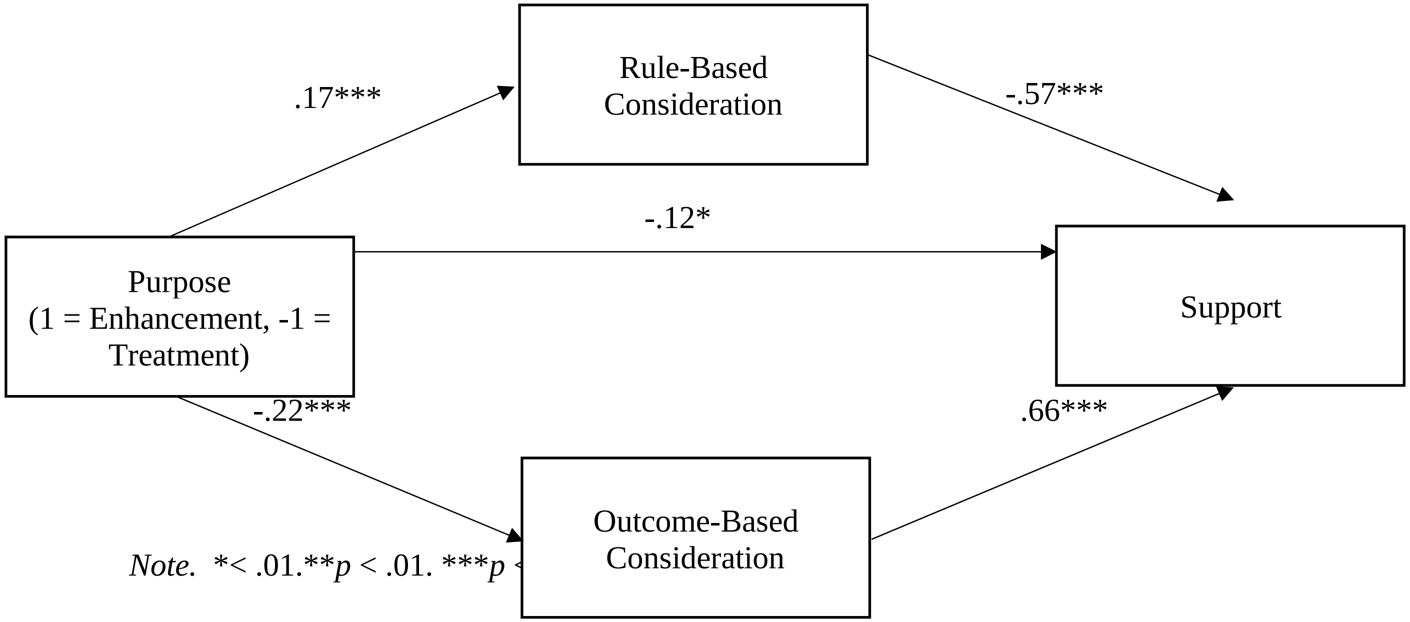
Bivariate Correlations and Descriptive Statistics (Study 3)

	1.	2.	3.	4.	5.	6.
1. Support for Gene-Editing	-	-.64***	.59***	-.23**	-.03	-.10
2. Rule-Based Consideration	-.41***	-	-.29***	.17*	.13†	.26**
3. Outcome-Based Consideration	.57***	-.23**	-	-.13†	.06	-.03
4. Purity	-.08	.24**	.01	-	.40***	.44***
5. Belief in God	-.09	.21**	-.08	.37***	-	.77***
6. Religious Orthodoxy	-.05	.23**	-.05	.54***	.72***	-
Enhancement *M(SD)*	3.58(1.36)	3.09(1.40)	57.26(28.37)	3.12(1.05)	3.79(2.91)	2.62(1.57)
Treatment *M(SD)*	4.32(1.17)	2.58(1.17)	69.11(20.47)	3.22(0.95)	4.21(3.17)	2.59(1.76)

Note. Treatment above the diagonal $N = 173$; Enhancement below the diagonal: $N = 151$. *$p < .05$. **$p < .01$. ***$p < .001$. † $p < .10$.

Figure 1.

Mediation Analysis of the Effect of Purpose, Outcome- and Rule-Based Consideration, and Support (Study 3)



Note. *< .01.***p* < .01. ****p* <

I then examined the role of theoretically relevant individual difference variables in support for human gene-editing. With one exception, detailed below, the effect of these variables did not differ between conditions, so I collapsed across conditions and used a simultaneous multiple regression analysis to test whether Purpose, Outcome-Based Moral Consideration, Rule-Based Moral Consideration, Purity, Religious Orthodoxy and Belief in God would predict Support. These variables were entered as simultaneous predictors and Support as the outcome variable. The overall model was significant, $F(6, 317) = 57.43$ $p < .001$, $\Delta R^2 = .52$. As expected, Purpose (1 = Enhancement, -1 = Treatment) was negatively associated with Support, $\beta = -.10$ ($sr^2 = .01$), $t(317) = -2.47$, $p = .014$. Further, consistent with predictions, endorsement of an Outcome-Based Moral Consideration was positively associated with support, $\beta = .47$ ($sr^2 = .19$), $t(317) = 11.25$, $p < .001$. Similarly, endorsement of the Rule-Based Moral Consideration was negatively associated with support, $\beta = -.39$ ($sr^2 = .13$), $t(317) = -9.11$, $p < .001$. Contrary to predictions, neither Purity[4] $\beta = -.08$ ($sr^2 = 0$), $t(317) = -1.73$, $p = .084$, Religious Orthodoxy, $\beta = .10$ ($sr^2 = 0$), $t(317) = 1.59$, $p = .112$. nor Belief in God, $\beta = -.03$ ($sr^2 = 0$), $t(317) = -0.55$, $p = .582$, were significantly associated with support.

Because the Purpose x Rule-Based Consideration interaction was significant, $\beta = .28$ ($sr^2 = .01$), $t(312) = 2.75$, $p = .006$, I split the sample according to condition and performed two separate simultaneous regression analyses omitting only Purpose as a predictor variable. Rule-Based Consideration was a significantly stronger negative predictor of Support in the treatment condition, $\beta = -.53$ ($sr^2 = .23$), $t(167) = -9.86$, $p < .001$, than it was in the enhancement condition, $\beta = -.30$ ($sr^2 = .08$), $t(145) = -4.33$, $p < .001$.

[4] Purity remained a non-significant predictor of Support when excluding Religious Orthodoxy and Belief in God from analyses, $\beta = -.04$, $p = .268$.

Discussion

This study is the first to employ a carefully matched manipulation of the purpose of human gene-editing to investigate the effect on support. Participants were more supportive of gene-editing to improve strength and functioning of those with (vs. without) physical disabilities. This is important since previous research has not examined the treatment vs. enhancement distinction systematically. The study further demonstrates that when participants evaluate the ethicality of gene-editing they endorse considerations both about the potential good the technology is seen to produce and whether it is violating a moral rule. These considerations are the strongest predictors of participants' support of human gene-editing, and partially mediate the effect of purpose on support. In contrast, purity, religious orthodoxy, and belief in God did not account for any variance in participants' support of gene-editing.

Study 4: Enhancement vs. Treatment Purposes Differ in Perceived Harm, Benefits and Moral Rule Violation

In Study 3 only one item measured outcome-based consideration, specifically perceived benefits in terms of quality of life to recipients of human gene-editing. Since genetic modification can be viewed as causing a wide range of potential benefits and harms for different entities (e.g., Schein & Gray, 2018), I wanted to capture a broader range of potential outcome-based considerations in the present study. To examine whether the reduced support for gene-editing for enhancement (vs. treatment) purpose is not only associated with lower utility for recipients, but with harm towards different entities, I therefore included two new measures of harm, adapted from Sabo (2016).

Given my theorising that GMHs evoke unique moral considerations relating to social organisation vis á vis GMOs (Gyngell et al., 2017), the present study included measures of Social and Natural harm. The enhancement vs. treatment distinction is particularly important in terms of the perception of different kinds of harm. Based on the theorising that medical interventions for treatment purposes are higher in utility (Daniels, 2000), I would expect human gene-editing for treatment to be viewed as beneficial to society (Kalfoglou et al., 2015). In contrast, medical interventions for enhancement purposes are lower in utility (Daniels, 2000). Further, people consistently report concerns that human gene-editing for enhancement purposes could exacerbate societal inequality (e.g., Gyngell et al., 2017; Harris, 2010; Kalfoglou et al., 2015). Thus, I would expect enhancement to be viewed as harmful to society.

The perception of harm towards nature entails concerns about the potential damage the technology will do to nature itself and seem to appear less specifically as an objection to enhancement. Researchers have theorised that because of the bias that what is natural is inherently better, any human intervention for instance through genetic modification, is inevitably seen as causing harm to nature in some way (Rozin et al., 2004). Thus, irrespective of whether human gene-editing is done for the purposes of enhancing a desired trait or treat a health condition, the natural genetic code of a person is being modified, thus the threat to the natural order remains the same. Consequently, I would not expect the perception that human gene-editing is harmful to nature to be sensitive to the enhancement vs. treatment distinction.

As in Study 3, I predicted that people would show less support for enhancement (vs. treatment) purpose, due to the lower perceived benefits of enhancement (vs. treatment), and that enhancement (vs. treatment) would be negatively associated with endorsement of an outcome-based moral consideration for gene-editing, whilst endorsing the outcome-based moral consideration would be positively associated with support. I further expected that gene-editing for enhancement (vs. treatment) purposes would be seen as a moral rule violation, and that this would in turn be negatively associated with support.

Based on the theorising that people's objection to enhancement (vs. treatment) purpose is caused by perceived harm, specifically social harm, I expected that enhancement (vs. treatment) purpose would be rated higher in social harm. I predicted that the effect of gene-editing purpose on support would be mediated by perceived social harm, but not natural harm. Specifically, that enhancement (vs. treatment) would be associated with greater social harm and in turn lower support for gene-editing.

Method

Participants and Design

Participants were 394 British Psychology undergraduate students, wherein only 292 passed the attention checks (284 Women, 25 men; *M*age = 19.49, *SD* = 2.66). Participants' ethnicity: White = 63.4%; Other = 36.6%. The design was identical to Study 1.

Procedure

The study received ethical approval. On the Research Participation Scheme website, participants took part in a study on "Moral Reasoning, Emotion and Society" taking 35 minutes. The survey was part of a research collaboration data collection and included various other measures. The measures were presented to participants in randomized order. To manipulate Purpose, participants were randomly allocated to read one of the scenarios from Study 1, describing gene-editing either for the purpose of treatment or enhancement.

Measures

Support. The same two items from Study 3 were used to measure support for gene-editing (α = .89).

Rule-based Consideration. The item from Study 3 measured the extent to which participants perceived gene-editing to violate a moral rule or principle.

Outcome-based Consideration. As in Study 3, percentage estimates of how much gene-editing could improve the quality of life for recipients were used as a proxy for outcome-based consideration for gene-editing.

Harm. In Study 3, only one item measured outcome-based consideration, specifically benefits to the recipients of human gene-editing. Given that genetic modification can be viewed as leading to benefits or harms for different entities I wanted to capture a broader range of potential outcome-based considerations, thus the present study sought to increase the precision in the measurement of different outcome-based considerations. To examine whether the reduced support for gene-editing for enhancement (vs. treatment) purpose is associated with harm towards different entities, I included two new measures, adapted from Sabo (2016). The first subscale measured the perceived harm towards nature on two items. In response to "Do you think the use of medical enhancements that edit the genes of people *with(out)* physical disabilities to improve their strength and movement…" (1 = *Not at all*, 6 = *Entirely*), participants indicated the extent to which they thought gene-editing: "...cause damage to the natural order of things?" and "…violate any laws of nature? (α = .89). The second subscale measured perceptions of *social harm* towards people and society with three items: "…cause (psychological/physical/emotional) harm to other people?", "…violate the rights of other people?" and "…cause harm to society at large?" (α = .88).

Aversion. To test our predictions concerning disgust, measures of disgust and anger were included (Royzman et al., 2014). The measure employs metaphorical depictions of disgust and anger, to more accurately capture the emotion of disgust (Giner-Sorolla et al., 2018). In response to: "When I think about medical enhancements that edit the genes of people *with(out)* physical disabilities to improve their strength and movement…" participants responded to six items (1 = *Not at all*, 6 = *Entirely*). Three items assessed disgust: "…this makes me want to gag", "...this makes me feel like I will lose my appetite.", and "...this makes me sick to my stomach.”. Three items measured anger: “…this makes my blood boil.”, “...this makes me feel like I will lose my cool.” and “...this makes me see red.”. The Anger and Disgust measures were unusually highly correlated $r = .88$, $p < .001$, and thus collapsed into one measure of Aversion ($\alpha = .96$).

Results

Bivariate correlations and descriptive statistics are presented in Table 7. First, consistent with my predictions and with Study 3, an independent t-test revealed that participants were significantly less supportive of the use of gene-editing for enhancement compared to treatment $t(271) = -8.93$, $p < .001$, $d = 1.08$.

Table 7.

Bivariate Correlations and Descriptive Statistics (Study 4)

	1.	2.	3.	4.	5.	6.
1. Support for Gene-Editing	-	-.43***	-.37***	-.51***	.54***	-.46***
2. Social Harm	-.57***	-	.67***	.43***	-.37***	.38***
3. Natural Harm	-.42***	.64***	-	.41***	-.21*	.29***
4. Rule-Based Consideration	-.30**	.29**	.31***	-	-.38***	.42***
5. Outcome-Based Consideration	.50***	-.19*	-.14	-.06	-	-.39***
6. Aversion	-.22*	.34***	.24**	.20*	-.10	-
Enhancement *M(SD)*	3.08(1.15)	3.30(1.30)	4.10(1.41)	3.50(1.24)	54.33(27.07)	1.75(0.95)
Treatment *M(SD)*	4.27(1.06)	2.21(1.08)	3.07(1.36)	2.71(1.20)	74.98(18.57)	1.36(0.66)

Note. Treatment above the diagonal: $N = 141$; Enhancement below the diagonal: $N = 132$. *$p < .05$. **$p < .01$. ***$p < .001$.

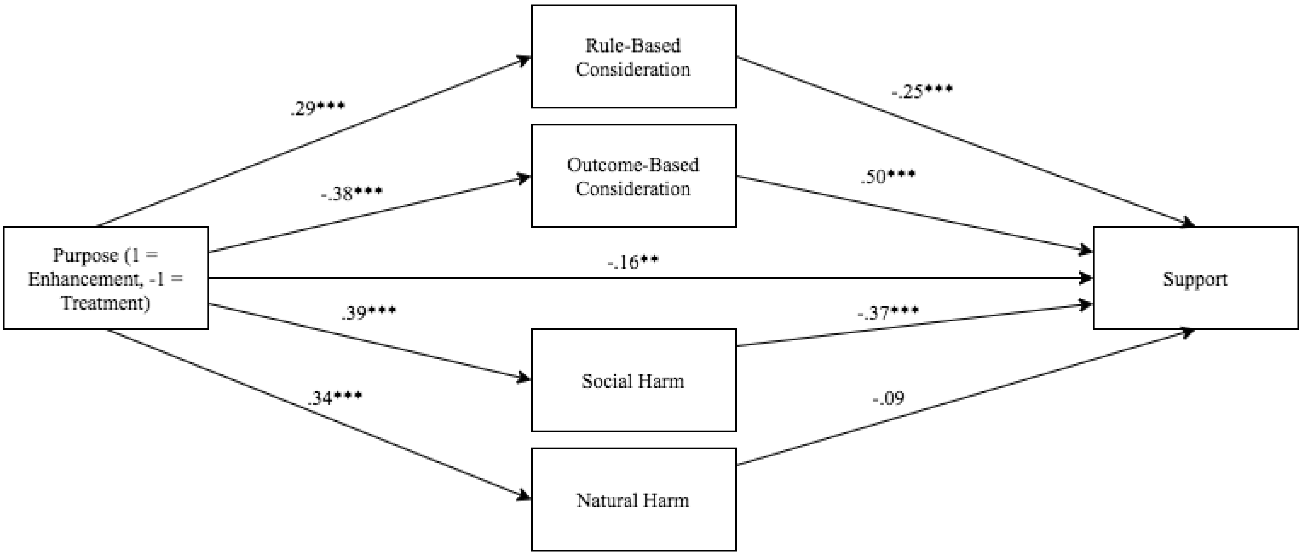
Mediation

To examine whether the lower support afforded to gene-editing for enhancement (vs. treatment) could be explained by the concerns that it represents a moral rule violation, is seen as lower in benefits to the recipient of gene-editing, and as causing to harm toward society, a mediation analysis using PROCESS (Model 4; Hayes, 2017) was conducted. Purpose (1 = Enhancement, -1 = Treatment) was entered as the predictor variable (X), Rule-Based Consideration, Outcome-Based Consideration, Social Harm and Natural Harm were entered as the mediators (M), and Support for Gene-Editing was entered as the outcome variable (Y). Finally, 95% confidence intervals with 5000 bootstrap resamples were used to assess the significance. Continuous predictor variables were standardized prior to the analysis.

As predicted, Rule-Based Consideration, Outcome-Based Consideration and Social Harm mediated the effect of Gene-Editing Purpose on Support for Gene-Editing (See Figure 1). Specifically, Gene-Editing Purpose significantly predicted support through Rule-Based Consideration, indirect *B* = -.07, *SE* = 03, [-0.13, -0.03], Outcome-Based Consideration, *B* = -.19, *SE* = 04, [-0.27, -0.13], and Social Harm, *B* = -.15, *SE* = 04, [-0.23, -0.07]. In contrast, there was no indirect effect through Natural Harm, *B* = -.03, *SE* = 03, [-0.09, 0.02]. The total effect of Purpose of Gene-Editing was significant, *B* = -.60, [-0.73, -0.47]. Further, the direct effect of Purpose of Gene-editing on Support for Gene-Editing was also significant, consistent with partial mediation (See Figure 2).

Figure 2.

Mediation of the Effect of Purpose, Rule-Based Consideration, Outcome-Based Consideration, Social Harm and Natural Harm, and Support (Study 4)



Note. ***p* < .01. ****p* < .001.

Interaction Effects

To examine the predictions concerning interaction effects I conducted a simultaneous multiple regression analysis with the following predictor variables in the first step: Purpose (1 = Enhancement, -1 = Treatment), Aversion, Outcome – and Rule-Based Consideration, Social Harm and Natural Harm, with Support as the outcome variable. In the second step, I added interaction terms for Purpose and each of the other predictor variables. Only two interaction terms were significant: the Purpose x Social Harm interaction, β = -.35 (sr^2 = .01), $t(261)$ = -2.51, p = .013, and the Purpose x Aversion interaction, β = .20 (sr^2 = .01), $t(261)$ = 1.99, p = .048. As predicted, Social Harm was a significant negative predictor of Support in the enhancement condition, β = -.41 (sr^2 = .09), $t(126)$ = -4.81, p < .001, but was not significant in the treatment condition, β = -.07 (sr^2 = .00), $t(135)$ = -0.78, p = .436. Aversion was only a significant predictor of Support in the treatment condition, β = -.18 (sr^2 = .02),

$t(135) = -2.41$, $p = .017$, but not in the enhancement condition, $\beta = .00$ ($sr^2 = .00$), $t(126) = 0.02$, $p = .985$.

I then examined the role of Aversion in support for human gene-editing. Since there were only two significant interactions, I conducted a multiple regression analysis to examine whether Aversion, Outcome – and Rule-Based Considerations, Social Harm and Natural Harm, independent of Gene-Editing Purpose (1 = Enhancement, -1 = Treatment), would significantly predict Support. These were entered as simultaneous predictor variables and Support was entered as the outcome variable. The overall model was significant, $F(6, 266) = 60.98$, $p < .001$. As predicted, Purpose ($\beta = -.13$, $t(266) = -2.75$, $p = .006$, $sr^2 = .01$), Rule-Based Consideration ($\beta = -.18$, $t(266) = -3.77$, $p < .001$, $sr^2 = .02$), and Social Harm ($\beta = -.26$, $t(266) = -4.31$, $p < .001$, $sr^2 = .03$) were negative predictors of Support, while Outcome-Based Consideration ($\beta = .36$, $t(266) = 7.96$, $p < .001$, $sr^2 = .10$) positively predicted Support. Neither Natural Harm ($\beta = -.07$, $t(266) = -1.18$, $p = .240$, $sr^2 = .00$) nor Aversion ($\beta = -.07$, $t(266) = -1.50$, $p = .136$, $sr^2 = .00$) were significant predictors of Support.

Discussion

The results replicated Study 3: participants supported human gene editing for treatment more than enhancement purposes, via indirect effects of rule-based and outcome-based considerations. Extending Study 3, results also showed that participants’ lower support for enhancement (vs. treatment) purpose was mediated by greater ratings in social harm, but not natural harm. GMHs for enhancement (vs. treatment) purpose was seen as harmful toward society, which in turn negatively predicted support. In contrast, natural harm did not mediate the effect of gene-editing purpose on support, suggesting that participants are uniquely sensitive to the potential social harm arising from gene-editing for enhancement. Importantly, aversion was a significant predictor of support only in the treatment condition.

Study 5: Different Moral Considerations About GMHs and GMOs

Studies 3 and 4 show that the enhancement versus treatment distinction is central to people's support of human gene-editing. In Study 5 I sought to test the theorising concerning the differences in moral judgments about GMOs and GMHs. As in the first two studies, I predicted that participants would be less supportive of gene-editing for enhancement (vs. treatment). Further, on the basis that gene-editing for the enhancement of human beings, in particular, may be seen to violate ethical principles, I predicted that this effect would be more pronounced for human than animal targets. I similarly predicted that perceptions that gene editing is a moral rule violation would be stronger for enhancement (vs. treatment). Additionally, due to the greater principled objections to instrumental harm in humans (vs. animals), I predicted that this effect would be stronger for human compared to animal targets.

Given my theorising that GMHs evoke unique moral considerations pertaining to social organisation (Gyngell & Savulescu, 2017), I extended the measures of different kinds of harm used in Study 3, to also include additional measures of different kinds of benefits: social benefit, target of gene-editing benefit and benefit to the natural order. I expected that perceived social benefits would only mediate the effect of purpose on support for human targets. I did not expect benefits to nature to be sensitive to the purpose manipulation.

I also predicted that perceptions that gene editing is unfair would be stronger for enhancement (vs. treatment), and that this effect would be stronger for human rather than animal targets. Further, I expected that perceived unfairness would mediate the effect of purpose on support for gene-editing among human targets, but not farm animal targets. Specifically, enhancement (vs. treatment) purpose of gene-editing would be rated as more unfair when the target is human (vs. farm animals). In turn, this would be associated with lower support for gene-editing. Finally, in line with my theorising that GMOs, but not necessarily GMHs, evoke disgust I predicted that the gene-editing of farm animals (vs humans) would be rated as more disgusting.

Method

Participants and Design

Participants were 355 American Prolific Academic users (182 women, 167 men, 5 other; M_{age} = 34.23, *SD* = 12.76). Participants' ethnicity: White = 69.3%; African American = 10.1%; Other = 20.5%. The study employed a 2 (Target: Human vs. Animal) x 2 (Purpose: Treatment vs. Enhancement) between-subjects factorial design. Support for gene-editing was the dependent variable.

Procedure

The study received ethical approval. The survey was part of a research collaboration data collection and included various other measures. Participants took part in a study on attitudes towards science taking 15 minutes.

Participants read a scenario involving either the gene-editing of human (vs. animal) targets for either treatment (vs. enhancement) purpose. The scenario read as follows (between-subjects manipulations marked in italics):

"A new technological development known as CRISPR allows scientists to edit genes much more easily than before. This technology can be used to modify genes as an enhancement for *people (vs. farm animals)* who *have (vs. do not have)* any disability or disease. For example, it can be used to improve their growth, strength, or mobility."

Measures

Support. Two items measured support and perceived ethicality of gene-editing: "I support it" and "It is ethical" (1 = *Strongly Disagree*, 7 = *Strongly Agree*; α = .87).

Rule-based consideration. Participants responded to the item "It violates an important moral rule or principle", assessing extent to which they perceived gene-editing to violate a moral rule or principle (1 = *Strongly Disagree*, 7 = *Strongly Agree*).

Social Benefit, Target Benefit and Natural Benefit. To increase the granularity in the measure of outcome-based consideration I adapted the harm items from Sabo (2016). In Studies 3 and 4, only one item measuring potential improvement in outcomes for recipients was included. Given that genetic modification can be viewed as leading to benefit or harm to different entities I wanted to capture a broader range of potential outcome-based considerations. Consequently, in each condition, participants were asked to respond to the question "To what extent could this use of CRISPR benefit…". One item measured benefit to nature: "...the natural order of things" (*Natural Benefit*). One item assessed benefit to society: "…society" (*Social Benefit*). Two items measured benefit to the target of gene-editing: "…the people/animals who receive it"; "…the descendants of people/animals who receive it" (*Target Benefit*; α = .78).[5]

Unfairness. Participants reported the extent to which they thought the use of CRISPR in the scenario would be unfair: "It gives some *people (vs. animals)* unfair advantages over others" (1 = *Strongly Disagree*, 7 = *Strongly Agree*).

Oral Disgust. In Study 4, disgust and anger were highly correlated. One potential explanation for this is that reports of disgust reflect participants' sociomoral stance on GMHs rather than oral inhibition. To examine potential differences between oral inhibition and socio moral displays of disgust I included separate measures of the two (Giner-Sorolla et al., 2018).

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[5] *Note.* I also included the same questions to measure Target Harm, Social Harm and Natural Harm. However, the presentation order of benefit and harm measures were not randomised. The harm measures were consistently presented after benefits and thus may have been subject to order effects. Specifically, none of the predictions concerning these variables were confirmed. Specifically, Social Harm did not mediate the effect of Purpose on Support for human targets, nor farm animal targets. See Appendix F for an additional moderated mediation analysis with these items.

The same two items from Study 4 measured metaphorical, oral disgust: “When it comes to this use of CRISPR in *people/farm animals*, to what extent do you agree or disagree with the statements below”: “It makes me gag.” and “It makes me lose my appetite” (1 = *Strongly Disagree*, 7 = *Strongly Agree*; $\alpha = .90$).

Disgust Terms. Two items measured endorsement of disgust terms: “To what extent do you find this use of CRISPR…”: “repulsive” and “disgusting” (1 = *Strongly Disagree*, 7 = *Strongly Agree*; $\alpha = .97$). The measures of Disgust Terms and Oral Disgust only correlated at $r = .66$, $p < .001$, and thus were not collapsed into one measure.

Results

The effects of Purpose and Target on Support

I first conducted a 2 (Purpose: Treatment vs. Enhancement) x 2 (Target: Humans vs. Animals) between-Subjects Factorial ANOVA with Support as the dependent variable. See Table 8 for descriptive statistics. As expected, participants were more supportive of treatment compared to enhancement, $F(1, 351) = 15.41$, $p < .001$, $\eta^2 = .04$. There was no main effect of Target, $F(1, 351) = 1.77$, $p = .184$, $\eta^2 = .01$. Importantly, and as predicted, there was a significant Purpose x Target interaction, $F(1, 351) = 4.48$, $p = .035$, $\eta^2 = .01$. Simple main effects analyses revealed that when the target of gene-editing was people, there was higher support for treatment vs. enhancement purpose, $F(1, 351) = 18.41$, $p < .001$, $\eta^2 = .05$, while there was no significant difference in support of treatment vs. enhancement purpose when the target was farm animals F(1, 351) = 1.62, $p = 204$. Further (see Figure 3), participants were significantly more supportive of gene-editing treatment in people than in farm animals, $F(1, 351) = 5.92$, $p = .015$, $\eta^2 = .02$, but not of gene-editing for enhancement, $F(1, 351) = 0.31$, $p = .578$, $\eta^2 = .00$. See Tables 9 and 10 for zero-order correlations of measures within treatment and enhancement conditions, for human and animal targets. Note that the Ns are low because of the between-subjects design.

Table 8.

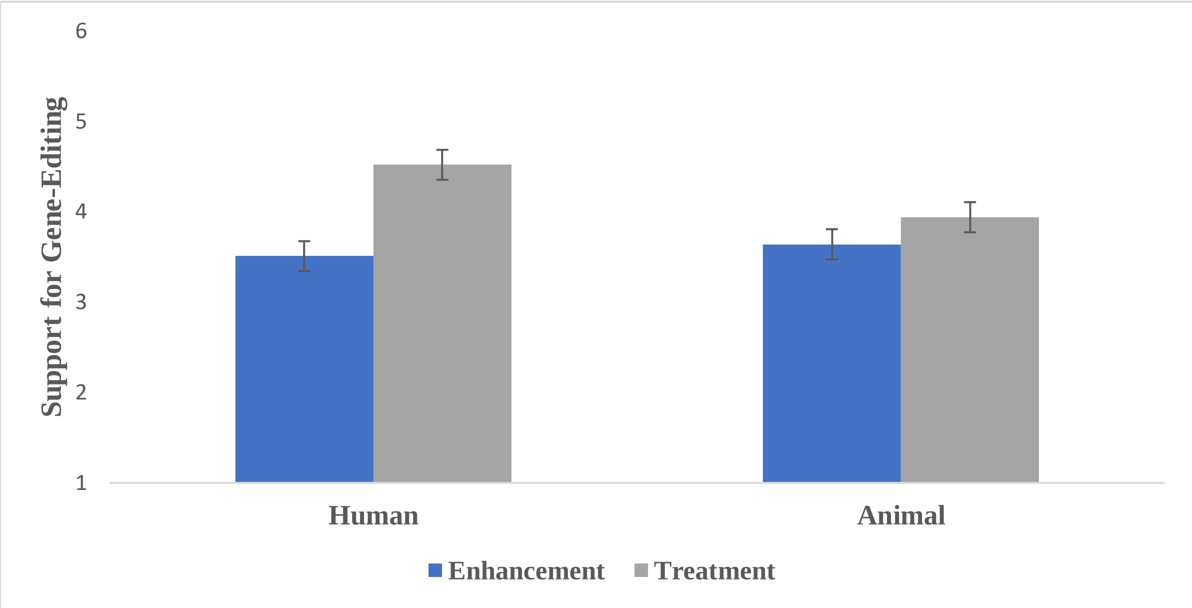
Summary Statistics (Study 5)

	Animal		Human	
	Enhancement	Treatment	Enhancement	Treatment
Support	3.64 (1.67)	3.94 (1.46)	3.51 (1.67)	4.52 (1.45)
Rule-based	3.48 (1.84)	3.33 (1.74)	3.76 (1.90)	2.81 (1.73)
Social Benefit	4.33 (1.79)	4.62 (1.52)	3.97 (1.62)	5.16 (1.42)
Unfairness	3.83 (1.90)	3.48 (1.65)	5.08 (1.77)	3.83 (1.94)
Target Benefit	4.81 (1.62)	5.27 (1.36)	5.36 (1.31)	5.84 (1.08)
Natural Benefit	3.10 (1.71)	3.22 (1.60)	2.82 (1.76)	3.52 (1.74)
Oral Disgust	2.64 (1.71)	2.16 (1.40)	2.32 (1.59)	1.57 (1.00)
Disgust Terms	3.03 (1.85)	2.52 (1.71)	3.01 (2.00)	2.16 (1.54)

Note. N = 352. Support = Dependent Variable. M(SD).

Figure 3.

Support for Gene-Editing Across Conditions (Study 5)



Note. Error bars represent Standard Errors.

Table 9.

Bivariate Correlations Human Target (Study 5)

	1.	2.	3.	4.	5.	6.	7.	8.
1. Support for Gene-Editing	-	-.62***	40***	.50***	.35**	.42***	-.31**	-.52***
2. Rule-Based	-.57***	-	-.21	.56***	-.31**	-.28**	.49***	.66***
3. Social Benefit	.66***	-.34**	-	-.16	.53***	.52***	-37***	-.30**
4. Unfairness	-.34**	.57***	-.11	-	-.05	.33**	.18	.33**
5. Target Benefit	.38***	-.10	.54***	.13	-	.23*	-.50***	-.33**
6. Natural Benefit	.50***	-.25*	.59***	-.13	.30**	-	-.14	-.12
7. Oral Disgust	-.31**	.55***	-.24*	.27*	-.12	.00	-	.60***
8. Disgust Terms	-.57***	.59***	-.40***	.27*	-.23*	-.18	.71***	-

Note. Treatment above diagonal N = 89*; Enhancement below diagonal*: *N* = 90. **p* < .05. ***p* < .01. ****p* < .001.

Table 10.
Bivariate Correlations Animal Target (Study 5)

	1.	2.	3.	4.	5.	6.	7.	8.
1. Support for Gene-Editing	-	-.52***	.45***	-.30**	.44***	.41***	-.42***	-.51***
2. Rule-Based	-.66***	-	-.23*	.32*	-.27*	-.22*	.42***	.44***
3. Social Benefit	.59***	-.47***	-	.02	.45***	.37***	-.36**	-.47***
4. Unfairness	-.25*	.45***	-.28**	-	-.06	-.12	.22*	.10
5. Target Benefit	.57***	-.47***	.58***	-.14	-	.38***	-35**	-46***
6. Natural Benefit	.43***	.,23*	.51***	-.14	.43***	-	-.06	-24*
7. Oral Disgust	-.49***	.71***	-.49***	.41***	-.39***	-.05	-	.50***
8. Disgust Terms	-.65***	.78***	-.48***	.31**	-.52***	-.21*	.73***	-

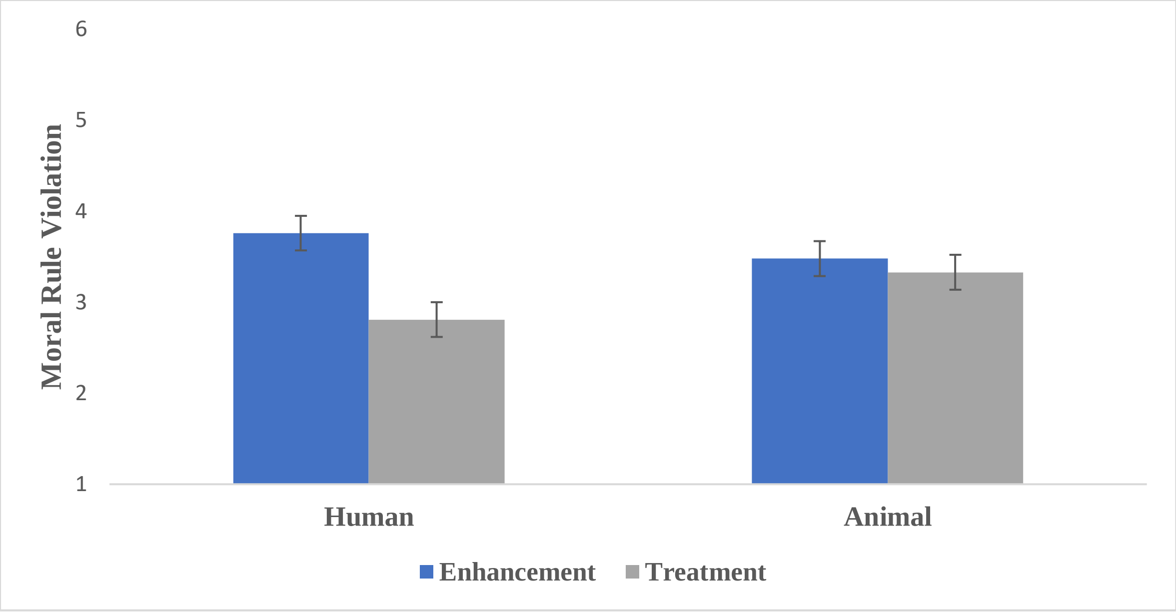
Note. Treatment above diagonal N = 88*; Enhancement below diagonal*: *N* = 88. **p* < .05. ***p* < .01. ****p* < .001.

The Effect of Purpose on Candidate Mediators Rule-based

Since my main hypothesis about the key outcome variable was supported, I examined whether a similar pattern was present for the proposed mediating variables. For Rule-Based Consideration, $F(1, 351) = 8.15$, $p = .005$, $\eta^2 = .02$, Social Benefit, $F(1, 351) = 19.31$, $p < .001$, $\eta^2 = .05$, and Unfairness, there was a main effect of Purpose, $F(1, 351) = 17.11$, $p < .001$, $\eta^2 = .05$. As predicted, enhancement (vs. treatment) was perceived as more of a moral rule violation, lower in benefits to society and more unfair. There was no main effect of Target for Rule-Based Consideration, $F(1, 351) = 0.40$, $p = .528$, $\eta^2 = .00$ or Social Benefit, $F(1, 351) = 0.25$, $p = .617$, $\eta^2 = .00$. However, there was a significant main effect of Target for Unfairness, $F(1, 351) = 17.19$, $p < .001$, $\eta^2 = .05$. Importantly, as predicted, there was a significant Purpose x Target interaction for Rule-Based Consideration, $F(1, 351) = 4.35$, $p = .038$, $\eta^2 = .01$, Social Benefit, $F(1, 351) = 7.01$, $p = .008$, $\eta^2 = .02$, and Unfairness, $F(1, 351) = 5.35$, $p = .021$, $\eta^2 = .02$. Enhancement (vs. treatment) was viewed as more of a moral rule violation, lower in benefits to society and more unfair when people were the target of gene-editing, but not when farm animals were (See Table 8; See Figures 4-7).

Figure 4.

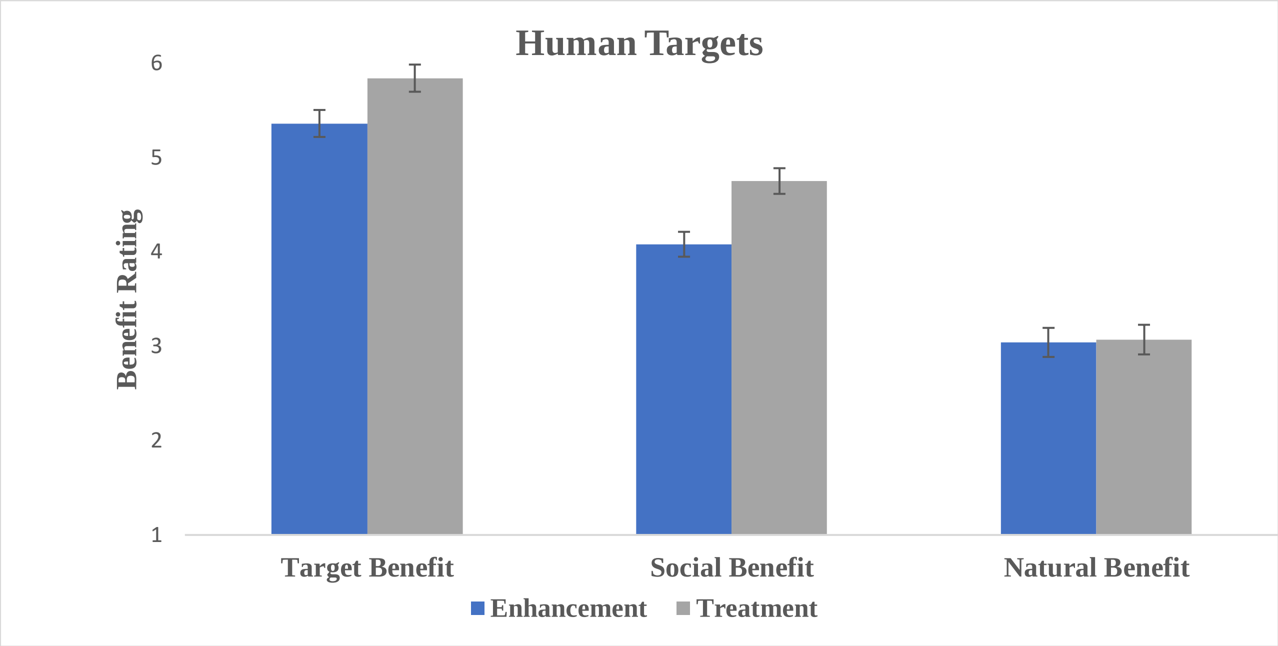
Perceived Moral Rule Violation Across Conditions (Study 5)



Note. Error bars represent Standard Errors.

Figure 5.

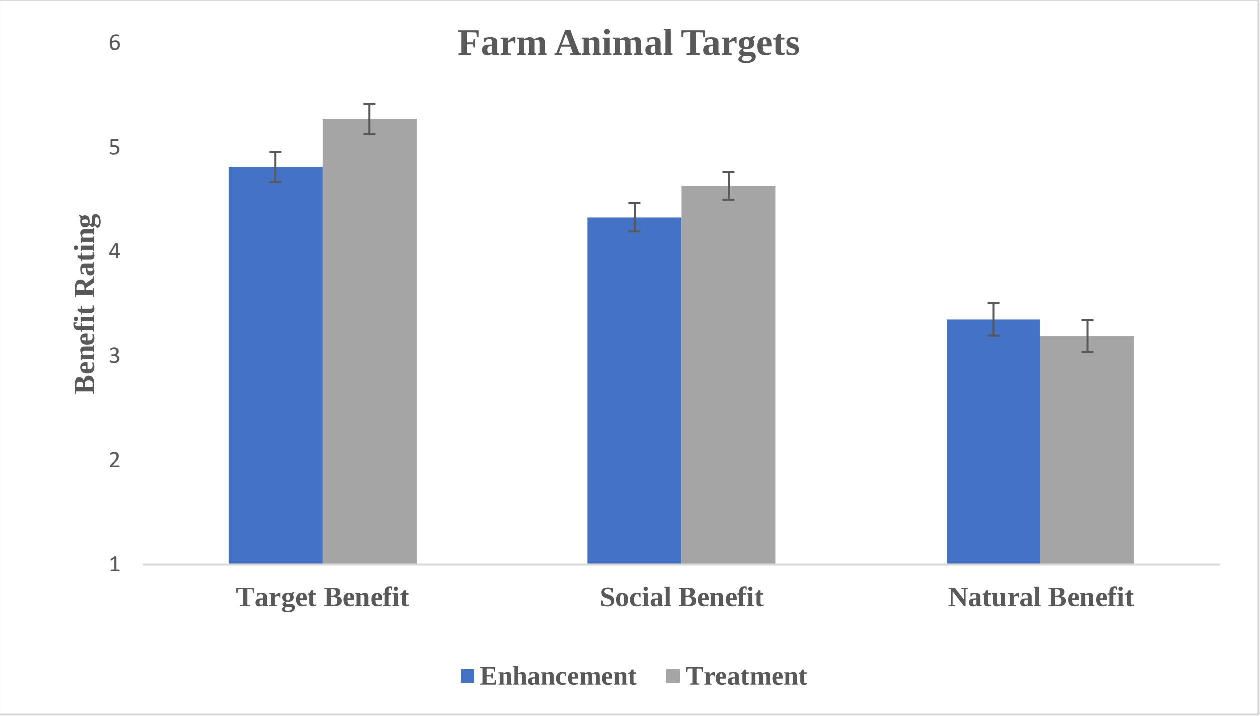
Endorsement of Outcome-Based Considerations Among Human Targets (Study 5)



Note. Error bars represent Standard Errors.

Figure 6.

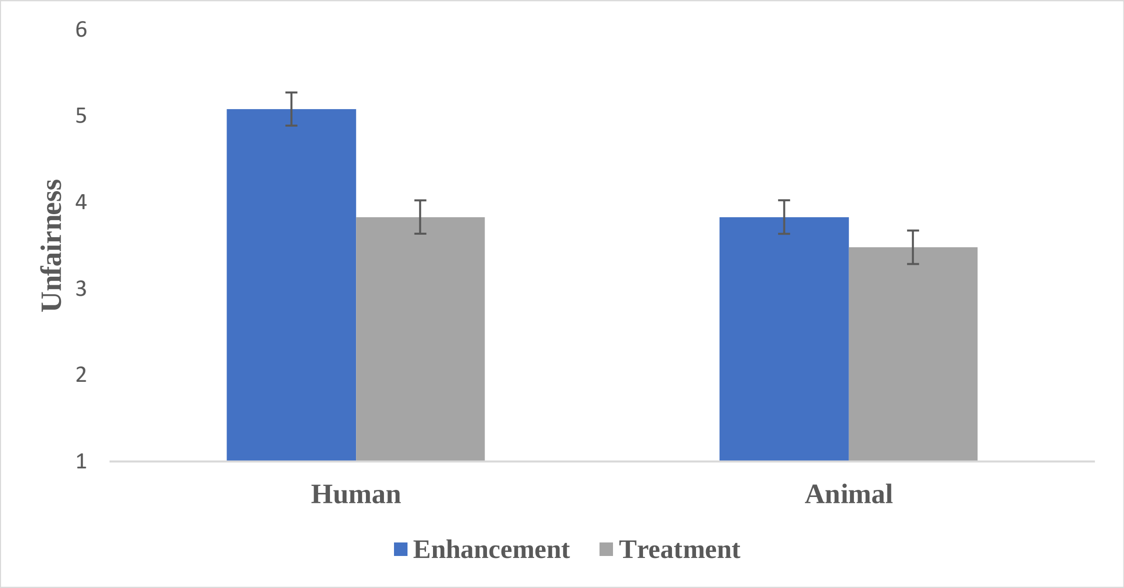
Endorsement of Outcome-Based Considerations Among Farm Animal Targets (Study 5)



Note. Error bars represent Standard Errors.

Figure 7.

Unfairness Ratings Across Conditions (Study 5)



Note. Error bars represent Standard Error.

In contrast, for Target Benefit, consistent with my prediction, there was a main effect of Purpose, $F(1, 351) = 10.54$, $p = .001$, $\eta^2 = .03$. Treatment purpose was seen as more beneficial to recipients compared to enhancement. Further, as predicted, there was a significant main effect of Target, $F(1, 351) = 14.91$, $p < .001$, $\eta^2 = .04$. The gene-editing of people was seen as more beneficial than the gene-editing of farm animals. There was no significant Purpose x Target interaction, $F(1, 351) = 0.01$, $p = .925$, $\eta^2 = .00$. See Figures 5 and 6. For Natural Benefit, there was a main effect of Purpose, $F(1, 351) = 5.00$, $p = .026$, $\eta^2 = .01$, with treatment seen as more beneficial to nature than enhancement. There was no significant main effect of Target, $F(1, 351) = 0.00$, $p = .954$, $\eta^2 = .00$, nor was there a significant Purpose x Target interaction, $F(1, 351) = 2.58$, $p = .109$, $\eta^2 = .01$.

Mediation Analysis

See Appendix G for multiple regression analysis of the proposed mediators. To examine whether enhancement (vs. treatment) purpose is afforded lower support because it is viewed as more of a moral rule violation, lower in social benefits and more unfair when people are the target of genetic modification, but not when farm animals are, I ran a moderated-mediation using PROCESS (Hayes, 2014; Model 7). Purpose (1 = Enhancement, -1 = Treatment) was entered as the predictor variable (X), Rule-Based Consideration, Target Benefit, Social Benefit, Natural Benefit and Unfairness were entered as the mediators (M), Support for Gene-Editing was entered as the outcome variable (Y). Target (1 = Human, -1 = Animal) was entered as a moderator for the a path (W). All continuous predictor variables were standardized prior to analysis, and 95% confidence intervals with 5000 bootstrap resamples was used to assess significance.

The overall model was significant, $F(6, 348) = 72.31$, $p < .001$ (See Figure 8). The direct effect of Purpose on Support was not significant $B = -.05$, $p = .437$. Consistent with my predictions, there was a significant indirect effect of Purpose through Rule-Based Consideration when people were the target of gene-editing, $B = -.17$, $SE = .05$, [-0.28, -0.07], but not for farm animals, $B = -.03$, $SE = .05$, [-0.12, 0.07]. In a pairwise comparison, the indirect effect of Purpose on Support via Rule-Based Consideration with People minus Farm Animals, the effect of Rule-Based Consideration was significantly larger when people were targeted compared to farm animals, $B = -.14$, $SE = .07$, [-0.28, -0.01]. Consistent with the proposition that rule-based considerations are more important in explaining the support of GMHs than the support of GMOs.

Further, consistent with my prediction, for Social Benefit there was an indirect effect of Purpose through Social Benefit when people were the target of gene-editing, $B = -.14$, $SE = .04$, [-0.23, -0.07], but not when farm animals were the target of gene-editing, $B = -.04$, $SE = .03$, [-0.10, 0.03]. In a pairwise comparison of the indirect effects with People minus Farm Animals, the effect of Social Benefit were larger when people were targeted compared to farm animals, $B = -.11$, $SE = .05$, [-0.21, -0.03]. Consistent with the proposition that concerns pertaining to society are more central in explaining support of GMHs than support of GMOs.

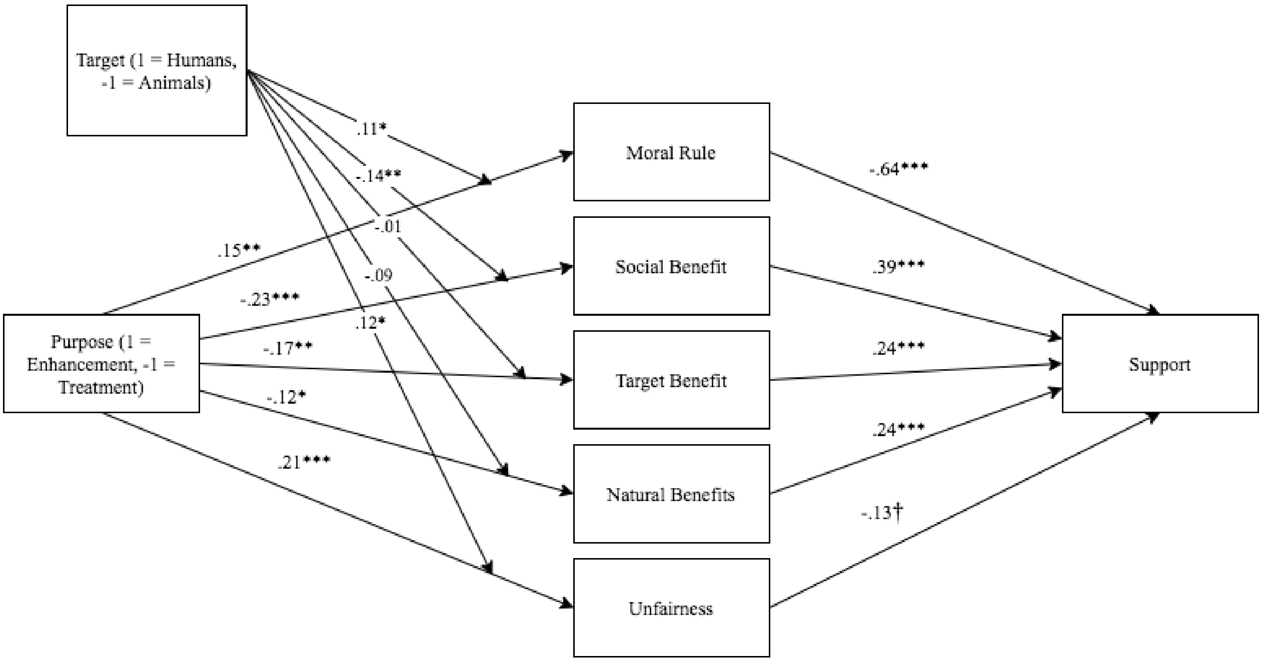
As expected, there was an indirect effect of Purpose on Support through Target Benefit both when people were the target of gene-editing, *B* = -.04, *SE* = .02, [-0.09, -0.01], and when farm animals were the target of gene-editing *B* = -.04, *SE* = .02, [-0.09, -0.001] (See Figure 8). Further, a pairwise comparison of the indirect effect with People minus Farm Animals showed that there was no significant difference, *B* = -.00, *SE* = .03, [-0.05, 0.05].

There was an indirect effect of Purpose on Support through Natural Benefit, when people were the target of gene-editing, *B* = -.05, *SE* = .02, [-0.11, -0.01], but not when farm animals were the target, *B* = -.01, *SE* = .02, [-0.05, 0.03]. However, this difference was not statistically significant in a pairwise comparison with People minus Farm Animals, *B* = -.04, *SE* = .03, [-0.11, 0.01].

However, contrary to predictions, there was no indirect effect of Purpose on Support through Unfairness, neither when the target of gene-editing was people, b = .04, *SE* = .02, [-0.09, 0.002], nor when the target was farm animals, b = -.01, *SE* = .01, [-0.04, 0.01]. This was contrary to the prediction that concerns about fairness would be particularly important in explaining support of GMHs, but not GMOs.

Figure 8.

Moderated Mediation Analysis of the Effect of Purpose on Support (Study 5)



Note. Moral Rule = Rule-Based Consideration. **p < .05, **p < .01. ***p < .001.* † *p* < .10.

Exploratory Analyses Examining Rule-based Consideration and Unfairness

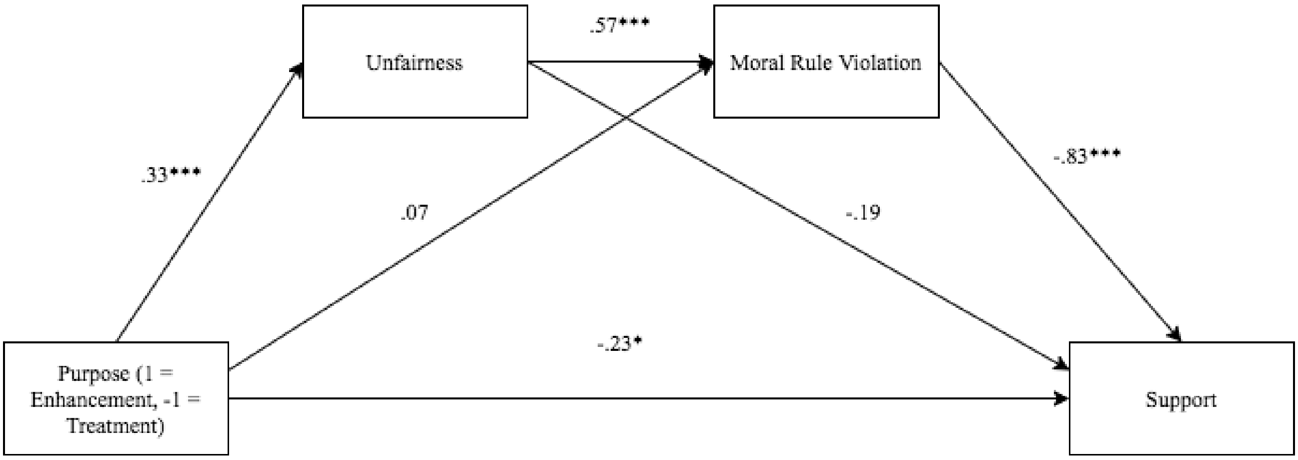
Following the unexpected result that there was no indirect effect of purpose on support through unfairness when rule-based consideration was included in the model, I wanted to examine whether unfairness might be related to support via rule-based consideration. That is, that the perceived unfairness of enhancement (vs. treatment) is viewed as a moral rule violation, which in turn is related to support. I deemed this plausible given that rule-based consideration might be a more proximal predictor of support since the measure addresses whether the use of gene-editing would violate a moral rule. Specifically, ensuring that some do not have unfair advantages over others and are treated fairly is likely viewed as a moral rule (Cropanzano et al., 2015; Holyoak & Powell, 2016).

I ran two separate serial mediation analyses, one for when the target of genetic modification was people and for when it was farm animals, using Hayes PROCESS (Model 6; 2017) with 95% confidence intervals based on 5000 bootstrap re-samples to examine the indirect of Purpose through Unfairness and then Rule-Based Consideration on Support. The overall model was significant, $F(3, 175) = 42.20$, $p < .001$ (See Figure 9). For human targets, the results showed that there was an indirect serial mediation effect of Purpose on Support via Unfairness and then Rule-Based Consideration ($B = -.16$, $SE = .05$, [-0.16, -0.08]. Further, there was no indirect effect of Purpose through Unfairness, ($B = -.06$, $SE = .04$, [-0.16, .01], nor through Rule-Based Consideration, ($B = .06$, $SE = .06$, [-0.18, 0.05].

Repeating the analysis for farm animal targets only, the overall model was significant, $F(3, 172) = 33.23$, $p < .001$. The direct effect of Purpose on Support was not significant, $B = -.11$, $SE = .10$, [-0.29, 0.08]. There was no indirect serial mediation effect of Purpose on Support via Unfairness and then Rule-Based Consideration, $B = -.04$, $SE = .03$, [-0.10, 0.02], nor was there an indirect effect only through Unfairness, $B = -.01$, $SE = .02$, [-0.05, 0.02], or through Rule-Based Consideration only, $B = .00$, $SE = .06$, [-0.13, 0.13].

Figure 9.

Serial Mediation Analysis of the Effect of Purpose on Support (Human Targets; Study 5)



Note. N = 179. Moral Rule Violation = Rule-Based Consideration. *$*p < .05$. $**p < .01$. $***p < .001$.*

Oral and disgust terms

Finally, I examined the effects of Purpose and Target on Oral Disgust and Disgust Terms. I repeated the 2 x 2 between-subjects ANOVA with Disgust Terms and Oral Disgust as the dependent variables (See Table 8). For Oral Disgust there was a significant main effect of Target, $F(1, 351) = 8.89$, $\eta^2 = .03$, $p = .003$, with the genetic modification of farm animals evoking more oral disgust than that of people. For Disgust Terms there was no significant main effect of Target, $F(1, 351) = 0.99$, $\eta^2 = .00$, $p = .320$. There was also an unexpected main effect of Purpose both for Oral Disgust, $F(1, 351) = 15.76$, $\eta^2 = .04$ $p < .001$, and Disgust Terms, $F(1, 351) = 13.01$, $\eta^2 = .04$, $p < .001$, where enhancement was rated as more disgusting than treatment. Importantly, the effect of Target on Oral Disgust was not qualified by a Purpose x Target interaction, $F(1, 351) = 0.82$, $p = .367$, nor was it for Disgust Terms, $F(1, 351) = 0.82$, $\eta^2 = .00$, $p = .366$. However, it should be noted participants were not particularly disgusted by the gene-editing of animals or humans on either measure of disgust, with mean scores significantly below the scale mid-point of 3.5 for both Oral Disgust (Farm animals: $t(175) = -9.27$, $p < .001$; People: $t(178) = -15.11$, $p < .001$) and Disgust Terms (Farm animals: $t(175) = -5.38$, $p < .001$; People: $t(178) = -6.68$, $p < .001$).

Discussion

Replicating Studies 3 and 4 – participants reported lower support for human gene-editing for enhancement (vs. treatment) purpose. Further, the results provide evidence in support of my theorising concerning the differences in moral judgments about GMOs and GMHs. The results showed that enhancement (vs. treatment) was afforded less support, seen as more of a moral rule violation, less beneficial to society and more unfair when the target was people (vs. farm animals). In mediation analysis, endorsement of the rule-based consideration and social benefit accounted for the lower support afforded to enhancement (vs. treatment) only when the target was people, not farm animals.

Further, an exploratory serial mediation analysis revealed an indirect effect of purpose on support through unfairness and then rule-based consideration when people are genetically modified, suggesting that enhancement (vs. treatment) is viewed as violating a moral rule about fairness. This could explain why unfairness was not a significant mediator of the effect of purpose on support when entered as a simultaneous mediator as rule-based consideration. Finally, the present results demonstrated that the gene-editing of farm animals evoked more oral disgust than did the editing of humans.

General Discussion

These studies are the first to employ a carefully matched experimental manipulation, varying gene-editing purpose and target in a between-participants design, documenting that both rule-based and outcome-based considerations are associated with moral judgments about human gene-editing. The findings further demonstrate that the treatment versus enhancement distinction is especially important in judgments of gene-editing in humans compared to in farm animals. Finally, the findings show that perceived benefits to society, perceived moral rule violation, and concerns about unfairness uniquely explain the lower support for enhancement (vs. treatment) purpose in the gene-editing of humans, but not farm animals.

Importantly, by employing a carefully matched experimental design, the present results extend research on opposition to GMOs. The findings demonstrate that people distinguish between enhancement and treatment purpose in human gene-editing, and that in so doing they take both rule-based and outcome-based moral considerations into account. Furthermore, the lower support afforded to enhancement (vs. treatment) purpose is explained both by the perception that enhancement purpose is seen as violating a moral rule and viewed as yielding less benefits to the recipient of genetic modification. This is consistent with studies showing that people draw on both rule-based- and outcome-based considerations when they make moral judgments about human gene-editing (Sadler & Zeidler, 2004).

Expanding Studies 3 and 4, Study 5 was the first to compare attitudes to the genetic modification of people versus farm animals in an experimentally controlled manner, revealing important differences in moral judgments about the genetic modification of people versus animals. Consistent with my theorising, I found the effect of purpose on support to be greater for human targets, compared to farm animals. Specifically, participants differentiated between enhancement (vs. treatment) purpose when the target of gene-editing was people, showing less support for genetic modification in this case. However, this effect was not evident when the target of genetic modification was farm animals.

Results further demonstrated that both the perception that a moral rule had been violated and the lower perceived benefit to society were especially important in explaining the lower support for genetic modification for enhancement (vs. treatment) purposes when people, but not farm animals, were targeted. Further, an exploratory serial mediation indicated that the moral rule that was seen as violated by enhancement purpose might be about fairness. Analyses revealed an indirect effect of purpose on support through unfairness, then rule-based consideration for human targets, but not farm animals. This could also account for why unfairness did not mediate the effect of purpose on support when entered as a parallel mediator with rule-based consideration. However, the measures in the present studies did not specify which moral rule was being violated. Further research should address this by employing measures that explicitly address different moral rule violations in relation to gene-editing (e.g., fairness, sanctity, purity).

These results are consistent with qualitative studies showing that participants are particularly concerned with the impact of enhancement technologies on exacerbating inequality (e.g., Kalfoglou et al., 2005; Sadler & Zeidler, 2004). Although caution should be exercised in interpreting mediation models, the results could suggest that enhancement evokes concerns consistent with a deontological principle about fairness (Holyoak & Powell, 2016). Further research should examine this possibility in an experimental design, for instance by elucidating which aspects of a fairness rule is particularly salient.

In terms of outcome-based considerations, the lower perceived benefits to the recipient of genetic modification for enhancement (vs. treatment) purpose consistently explained the lower support afforded to enhancement (vs. treatment) across all studies. Study 4 further revealed that human gene-editing for enhancement purposes is viewed as more harmful to society compared to treatment, and this also accounts for the lower support of enhancement. Finally, Study 5 extended these findings showing that while the lower perceived benefits to the recipient explain the lower support for enhancement (vs. treatment) when both people and farm animals are genetically modified, lower benefits to society explain the reduced support for enhancement (vs. treatment) only when people are the target of genetic modification.

Beyond moral considerations about potential outcomes, the findings also suggest that disgust might be differentially related to attitudes to GMOs and GMHs. In Study 3, a dispositional measure of disgust did not predict support for human gene-editing, while in Study 5 the gene-editing of farm animals evoked more oral disgust compared to that of human targets. In contrast, the endorsement of disgust terms did not differ between human and farm animal targets. This is consistent with findings showing that disgust predicts opposition to GMOs (Scott et al., 2016). This suggests that disgust may be less important in moral judgments about GMHs compared to those about GMOs. One potential explanation for this difference could be that GMOs are typically for consumption, while GMHs are not. Thus, oral disgust may be a more important predictor in attitudes to GMOs because it is specifically the thought of *ingesting* an organism that has been genetically modified that elicits disgust. Theorising on oral disgust typically emphasizes it as a category of food rejection (Rozin et al., 2008). In contrast, the genetic modification of humans may not evoke oral disgust because they are not for ingestion.

The results also complement another area of the moral psychology literature: research on purity concerns in attitudes to novel technologies (Koleva et al., 2012). In Study 3 purity was not a significant predictor of support for gene-editing. It is also inconsistent with qualitative studies identifying concerns about human gene-editing relating to the sanctity of God (e.g., Sadler & Zeidler, 2004). Similarly, religiosity did not predict lower support in studies 3 and 4. I interpret this with caution due to the student sample of Study 3, since younger people typically are less religious than the population (PEW Research Center, 2018b). Nonetheless, religious orthodoxy did not predict lower support in a sample of British adults. Thus, the present findings indicate that outcome-based considerations in terms of perceived harms and benefits might be a more proximal predictor of support for gene-editing than religious ones.

Although the present findings suggest that that people consistently afford lower support to enhancement (vs. treatment), one key limitation is in need of mentioning.

Specifically, caution should be exercised in interpreting the results of the mediation analyses. Because both the mediator and dependent variables are measured, the significant mediation models in studies 3-5 do not provide evidence of mediation; only that the effect of purpose on support can be accounted for by the proposed mediators (Fiedler et al., 2011). Additionally, the current studies experimentally manipulated gene-editing purpose using only one scenario depicting people (vs. farm animals) with or without physical disabilities. Consequently, it is not clear whether the effect of purpose on support generalizes to other domains such as intelligence and longevity. I sought to address this limitation in Chapter 4, employing a wider range of scenarios to examine whether the effect of purpose on rule-based and outcome-based moral considerations and support of genetic modification. Further, given the differences that emerged in the moral considerations about GMHs and GMOs, I sought to examine how genetic modification compares to other methods of intervention. Thus, Chapter 4 further included an experimental manipulation of the method of intervention.

Chapter 4: Support of GMHs Across Different Domains and Methods

Chapter 4 sought to examine whether the effect of purpose on support for genetic modification generalise across different domains beyond physical functioning and across different methods of interventions beyond genetic modification. To examine whether the results would generalise to interventions in other domains I therefore introduced five new domains: intelligence, longevity, mobility, height and disease resistance. I also wanted to examine potential differences between interventions using genetic modification compared to other, more conventional methods. Thus, I introduced an experimental manipulation varying whether the intervention method was genetic modification or a conventional method such as drugs, vaccination, diet or education.

I have theorised that moral judgments about GMHs are different from those about GMOs both in *degree* and *kind*. The findings outlined in Chapter 3 seem to go some way in corroborating this proposition. The findings of Chapter 3 showed that moral considerations about moral rules, social benefit and unfairness uniquely explain the lower support for genetic modification when humans are the target, but not when farm animals are. Further, participants reported greater support for GMHs than GMOs. It could be that the genetic modification of humans (vs. animals) is viewed as more akin to other medical interventions rather than GMOs. In the present investigation I therefore wanted to provide the first controlled comparison of the moral considerations that underpin attitudes to GMHs and other, conventional methods of intervention, including drugs, vaccination, education, and diet.

If moral judgments about GMHs are similar to those about conventional interventions for the same purpose, I would expect the same moral considerations to account for the effect of purpose on support both for GMHs and conventional methods. That is, I would expect there to be a main effect of Purpose, such that enhancement (vs. treatment) is consistently afforded lower support, both when the method of intervention is gene-editing and when it is conventional. Further, if the effect of purpose on support is due to perceived moral rule violation, the reduced benefit and greater unfairness of enhancement (vs. treatment), I would expect it to generalize across other domains.

Study 6: Replicating the Effect of Purpose Across Different Domains and Methods

Method

Participants and Design

Participants were 370 British UK students, wherein 41 failed the attention check, leaving 329 in the final sample (Women = 261, Men = 65; Other = 3; M_{age}= 20.73, *SD* = 4.97, 18-49). The majority of participants identified their ethnicity as White = 74.1% (*N* = 244), 7.3% (*N* = 24) as Black and the remaining identified with other ethnicities, Other = 18.5% (*N* = 61).

The study employed a 2 (Purpose: Enhancement vs. Treatment) x 2 (Method: Gene-Editing vs. Conventional) x 5 (Domain: Intelligence, Longevity, Mobility, Disease Resistance & Height) mixed design, where participants were randomly allocated to either read about gene-editing (vs. conventional) for enhancement (vs. treatment) across five different domains. The dependent variable was support for human gene-editing.

Materials

Experimental Manipulation

In order to examine whether the effect of purpose held beyond the domain of physical abilities, the present study included scenarios involving the genetic modification of humans for five additional domains: Intelligence, longevity, Mobility, Disease Resistance and Height. Further, in order to investigate whether genetic modification is viewed differently from other medical interventions I also included a comparison of interventions using genetic modification vs. conventional methods (e.g., drugs, vaccine).

In each of four conditions participants read five scenarios either describing genetic modification or a conventional intervention (i.e., a drug, a vaccine) for the purpose of treatment or enhancement across five different domains (Intelligence, Longevity, Mobility, Disease Resistance & Height). The scenario varied on whether the intervention was conventional (i.e., vaccine, drug, education, dieting) or used gene-editing, and whether the purpose was enhancement or treatment: "*A* novel *vaccine/ gene-editing technique that involves editing the human genome* to improve the disease resistance of people with *weakened/normal* immune systems." (See Appendix H for all scenarios). Following each of the five scenarios participants completed various measures described below.

Support. Support for gene-editing was measured with five items, one for each of the five domains: "Please indicate the extent to which you would support or oppose the following:" (1 = *Strongly oppose*, 7 = *Strongly support; α* = .77).

Rule-Based Consideration. The extent to which participants perceived gene-editing to violate a moral rule participants was measured by five items, one per domain: "It violates an important moral rule or principle?" (1 = *Strongly Disagree*, 7 = *Strongly Agree; α* = .81).

Perceived Benefits. Outcome-based consideration was assessed using two items per domain (10 in total), addressing perceived benefit to the target and society of the intervention: "It would be beneficial to the people who receive it" and "It would be beneficial to society" (1 = *Strongly Disagree*, 7 = *Strongly Agree; α* = .81). These were collapsed into one measure since I had no competing predictions between target and social benefits in the present study.

Unfairness. The extent to which the intervention was seen as unfair was assessed with five items, one per domain "It gives some people unfair advantages over others" (1 = *Strongly Disagree*, 7 = *Strongly Agree*; *α* = .80).

Oral Disgust. Two items adapted from Royzman, Altanasov, Landy, Parks, and Gepty (2014) measured the extent to which participants felt oral disgust in response to each scenario: "It makes me gag" and "It makes me lose my appetite" (1 = *Strongly Disagree*, 7 = *Strongly Agree;* α = .88).

Demographics and Other Measures. Participants further reported some of their demographic information including gender, political orientation, age, ethnicity, religious affiliation. Further, for other purposes participants reported their religiosity and perceptions of genetically modified humans and animals (See Appendix I). Finally, participants were asked an open-ended question at the end of the study "In your opinion, does human gene-editing pose any ethical challenges? Please explain." where they could type responses if they wished to do so.

Procedure

The study received ethical approval from the Ethics Committee. On the site of the research participation scheme and Prolific Academic (an online crowdsourcing site), participants select the studies from a list of projects. Participants participated in a study on attitudes towards technologies and were informed that it would take 15 minutes. Participants were randomly allocate to their respective conditions and all measures were randomly presented to participants. Finally, participants were debriefed, thanked an awarded either 1 credit (on RPS) or £1 (on Prolific) for their participation.

Results

The Effects of Purpose, Method and Domain on Support

I conducted a 2 (Purpose: Enhancement vs. Treatment) x 2 (Method: Gene-editing vs. Conventional) x 5 (Domain: Longevity, Intelligence, Height, Mobility & Disease resistance) Mixed ANOVA on Support. See Table 11 for descriptive statistics. There was a significant main effect of Purpose, $F(1, 325) = 49.23$, $p < .001$, $\eta 2 = .13$, such that people were less supportive of enhancement vs. treatment, as predicted. There was also a significant main effect of Method, $F(1, 325) = 24.89$, $p < .001$, $\eta 2 = .07$, with people being less supportive of gene-editing vs. conventional methods. Importantly, there was no significant two-way interaction between Purpose x Method, $F(1, 325) = 1.80$, $p = .181$, $\eta 2 = .01$, suggesting that the effect of Purpose on Support is the same irrespective of the method of intervention. There was a significant main effect of Domain, $F(4, 325) = 184.02$, $p < .001$, $\eta 2 = .36$. There was a significant Purpose x Domain interaction, $F(4, 325) = 19.62$, $p < .001$, $\eta 2 = .06$. Further, there was also a significant Domain x Method interaction, $F(4, 325) = 15.12$, $p < .001$, $\eta 2 = .04$. There was no significant three-way interaction between Domain x Purpose x Method, $F(4, 325) = 0.52$, $p = .721$, $\eta 2 = .00$.

I used contrasts to examine whether the effect of Purpose held across all domains, following the significant Domain x Purpose interaction. Enhancement (vs. Treatment) Purpose received significantly less support across all domains aside from Height: Intelligence ($F(1, 325) = 41.36$, $p < .001$, $\eta 2 = .11$), Longevity ($F(1, 325) = 29.21$, $p < .001$, $\eta 2 = .08$), Mobility ($F(1, 325) = 78.06$, $p < .001$, $\eta 2 = .19$), Height ($F(1, 325) = 0.29$, $p = .589$, $\eta 2 = .00$) and Disease Resistance ($F(1, 325) = 25.13$, $p < .001$, $\eta 2 = .07$). Similarly, I used contrasts to examine whether the effect of Method held across all domains, following the significant Domain x Method interaction. Conventional (vs. gene-editing) methods were preferred across all domains aside from Height and Disease Resistance: Intelligence ($F(1, 325) = 67.54$, $p < .001$, $\eta 2 = .17$), Longevity ($F(1, 325) = 15.34$, $p < .001$, $\eta 2 = .05$), Mobility ($F(1, 325) = 12.34$, $p = .001$, $\eta 2 = .04$), Height ($F(1, 325) = 0.45$, $p = .503$, $\eta 2 = .00$), and Disease Resistance ($F(1, 325) = 1.43$, $p = .232$, $\eta 2 = .00$).

The Effect of Purpose on Candidate Mediators

Since the main hypothesis concerning the key outcome variable was supported, I then examined whether a similar pattern emerged for the proposed mediating variables. There was a significant main effect of Purpose on Rule-Based Consideration, $F(1, 325) = 24.95$, $p < .001$, $\eta2 = .07$, Perceived Benefit, $F(1, 325) = 12.29$, $p < .001$, $\eta2 = .04$, Unfairness, $F(1, 325) = 133.29$, $p < .001$, $\eta2 = .29$. As predicted, enhancement (vs. treatment) was perceived as more of a moral rule violation, lower in benefits, and more unfair. As predicted, there was also a significant main effect of Method on Rule-Based Consideration, $F(1, 325) = 29.77$, $p < .001$, $\eta2 = .08$, Perceived Benefit, $F(1, 325) = 5.68$, $p < .018$, $\eta2 = .02$, with Genetic Modification (vs. Conventional) being viewed as more of a moral rule violation and lower in perceived benefits. Unexpectedly, genetic modification was also viewed as more unfair, compared to conventional methods, $F(1, 325) = 41.98$, $p < .001$, $\eta2 = .11$. Finally, there was a main effect of Domain on Rule-Based Consideration, $F(4, 325) = 26.57$, $p < .001$, $\eta2 = .08$, Perceived Benefit, $F(4, 325) = 275.82$, $p < .001$, $\eta2 = .46$, and on Unfairness, $F(4, 325) = 46.89$, $p < .001$, $\eta2 = .13$.

There was no significant two-way interaction between Purpose x Method on Rule-Based Consideration, $F(1, 325) = 2.03$, $p = .155$, $\eta2 = .01$, Perceived Benefit, $F(1, 325) = 0.54$, $p = .463$, $\eta2 = .00$, or Unfairness, $F(1, 325) = 1.81$, $p = .180$, $\eta2 = .01$, suggesting that the effect of Purpose on each of the proposed mediators was the same irrespective of the method of intervention. There was however a significant Purpose x Domain interaction on Rule-Based Consideration, $F(4, 325) = 10.42$, $p < .001$, $\eta2 = .03$, Perceived Benefit, $F(4, 325) = 10.42$, $p < .001$, $\eta2 = .03$, and Unfairness, $F(4, 325) = 13.72$, $p < .001$, $\eta2 = .04$. Finally, there was also a significant Domain x Method interaction on Rule-Based Consideration, $F(4, 325) = 6.12$, $p < .001$, $\eta2 = .02$, Perceived Benefit, $F(4, 325) = 6.12$, $p < .001$, $\eta2 = .02$, and Unfairness, $F(4, 325) = 3.67$, $p = .006$, $\eta2 = .01$. Finally, there were no significant three-way interactions between Domain x Purpose x Method for Rule-Based Consideration, $F(4, 325) = 1.18$, $p = .318$, $\eta2 = .00$, Perceived Benefit, $F(4, 325) = 0.53$, $p = .716$, $\eta2 = .00$, or Unfairness, $F(4, 325) = 2.13$, $p = .077$, $\eta2 = .01$, Using contrasts I examined whether the effect of Purpose on each of the proposed mediators held across all domains, following the significant Domain x Purpose interaction. Enhancement (vs. Treatment). Purpose was seen as more of a moral rule violation in all domains aside from Height: Intelligence ($M_{enhancement}$ = 3.93, $SD_{enhancement}$ = 1.96; $M_{treatment}$ =2.97, $SD_{treatment}$ = 1.50; F(1, 325) = 24.07, p < .001, $\eta 2$ = .07), Longevity ($M_{enhancement}$ = 3.65, $SD_{enhancement}$ =1.83; $M_{treatment}$ = 2.96, $SD_{treatment}$ = 1.82; F(1, 325) = 13.13, p < .001, $\eta 2$ = .04), Mobility ($M_{enhancement}$ = 3.78, $SD_{enhancement}$ = 1.93; $M_{treatment}$ = 2.57, $SD_{treatment}$ = 1.58; F(1, 325) = 40.81, p < .001, $\eta 2$ = .11), Height ($M_{enhancement}$ = 3.40, $SD_{enhancement}$ = 1.85; $M_{treatment}$ = 3.51, $SD_{treatment}$ = 1.94; F(1, 325) = 0.26, p = .608, $\eta 2$ = .00) and Disease Resistance ($M_{enhancement}$ = 2.90, $SD_{enhancement}$ = 1.75; $M_{treatment}$ = 2.18, $SD_{treatment}$ = 1.40; F(1, 325) = 18.56, p < .001, $\eta 2$ = .05) p = .608. Similarly, I used contrasts to examine whether the effect of Method held across all domains, following the significant Domain x Method interaction. Gene-editing (vs. conventional) methods were viewed as more of a moral rule violation across all domains aside from Height: Intelligence ($M_{gene\text{-}editing}$ = 4.05, $SD_{gene\text{-}editing}$ = 2.01; $M_{conventional}$ = 2.87, $SD_{conventional}$ = 1.74; (F(1, 325) = 34.62, p < .001, $\eta 2$ = .10), Longevity ($M_{gene\text{-}editing}$ = 3.77, $SD_{gene\text{-}editing}$ =1.92; $M_{conventional}$ = 2.86, $SD_{conventional}$ =1.67; F(1, 325) = 22.51, p < .001, $\eta 2$ = .07), Mobility ($M_{gene\text{-}editing}$ = 3.50, $SD_{gene\text{-}editing}$ = 1.95; $M_{conventional}$ = 2.88, $SD_{conventional}$ = 1.73; F(1, 325) = 10.96, p = .001, $\eta 2$ = .03), Height ($M_{gene\text{-}editing}$ = 3.66, $SD_{gene\text{-}editing}$ = 1.95; $M_{conventional}$ = 3.25, $SD_{conventional}$ = 1.83; F(1, 325) = 3.75, p = .054, $\eta 2$ = .01) and Disease Resistance ($M_{gene\text{-}editing}$ = 2.91, $SD_{gene\text{-}editing}$ = 1.80; $M_{conventional}$ = 2.19, $SD_{conventional}$ = 1.35; F(1, 325) = 18.07, p < .001, $\eta 2$ = .05).

For Perceived Benefit, enhancement (vs. treatment) was only seen as less beneficial in the domains of longevity, $M_{enhancement}$ = 5.37, $SD_{enhancement}$ = 1.43; $M_{treatment}$ = 5.60, $SD_{treatment}$ = 1.19; F(1, 325) = 22.73, p < .001, $\eta 2$ = .01, and mobility ($M_{enhancement}$ = 4.70, $SD_{enhancement}$ = 1.36; $M_{treatment}$ = 5.39, $SD_{treatment}$ = 1.32; F(1, 325) = 30.37, p < .001, $\eta 2$ = .07). Across the remaining domains, there was no difference in the benefit ratings of treatment and enhancement purpose, Intelligence, ($M_{enhancement}$ = 5.03, $SD_{enhancement}$ = 1.52; $M_{treatment}$ = 5.83, $SD_{treatment}$ = 1.09; F(1, 325) = 2.46, p = .118, η2 = .01, Height ($M_{enhancement}$ = 3.45, $SD_{enhancement}$ = 1.56; $M_{treatment}$ = 3.37, $SD_{treatment}$ = 1.47; F(1, 325) = 0.24, p = .626, $\eta 2$ = .00), and Disease Resistance, $M_{enhancement}$ = 6.01, $SD_{enhancement}$ =1.12; $M_{treatment}$ = 6.08, $SD_{treatment}$ = 1.08; F(1, 325) = 0.32, p = .570, $\eta 2$ = .00. Similarly, examining the Domain x Method interaction, conventional (vs. gene-editing) methods were seen as more beneficial in the domains of Intelligence, ($M_{gene\text{-}editing}$ = 5.28, $SD_{gene\text{-}editing}$ = 1.38; $M_{conventional}$ = 5.68, $SD_{conventional}$ = 1.23; F(1, 325) = 7.89, p = .005, $\eta 2$ = .02, Longevity, ($M_{gene\text{-}editing}$ = 4.78, $SD_{gene\text{-}editing}$ =1.46; $M_{conventional}$ =5.29, $SD_{conventional}$ = 1.24; F(1, 325) = 12.84, p < .001, $\eta 2$ = .04, Disease Resistance, ($M_{gene\text{-}editing}$ = 5.91, $SD_{gene\text{-}editing}$ = 1.15; $M_{conventional}$ = 6.18, $SD_{conventional}$ =1.03; F(1, 325) = 5.03, p = .026, $\eta 2$ = .02, while there was no difference in the perceived benefit of genetic modification (vs. conventional methods) for Mobility, ($M_{gene\text{-}editing}$ = 5.32, $SD_{gene\text{-}editing}$ =1.40; $M_{conventional}$ = 5.53, $SD_{conventional}$ = 1.36; F(1, 325) = 2.40, p = .122, $\eta 2$ = .01, or Height, ($M_{gene\text{-}editing}$ = 3.54, $SD_{gene\text{-}editing}$ = 1.59; $M_{conventional}$ = 3.28, $SD_{conventional}$ = 1.42; F(1, 325) = 2.40, p = .122, $\eta 2$ = .01.

For Unfairness, following the significant Domain x Purpose interaction, contrasts revealed that enhancement (vs. treatment) Purpose was seen as more unfair all domains. However, the effect was largest in the domains of Intelligence, ($M_{enhancement}$ = 5.50, $SD_{enhancement}$ = 1.68; $M_{treatment}$ = 3.15, $SD_{treatment}$ = 1.98; F(1, 325) = 151.87, p < .001, η2 = .32), compared to in Longevity, ($M_{enhancement}$ = 4.69, $SD_{enhancement}$ = 1.84; $M_{treatment}$ = 3.25, $SD_{treatment}$ = 1.79; F(1, 325) = 59.81, p < .001, $\eta 2$ = .16), Mobility, ($M_{enhancement}$ = 3.78, $SD_{enhancement}$ = 1.93; $M_{treatment}$ = 2.57, $SD_{treatment}$ = 1.58; F(1, 325) = 40.81, p < .001, $\eta 2$ = .11), Height, ($M_{enhancement}$ = 4.39, $SD_{enhancement}$ = 1.88; $M_{treatment}$ = 3.60, $SD_{treatment}$ = 1.94; F(1, 325) = 14.71, p < .001, $\eta 2$ = .04) and Disease Resistance, ($M_{enhancement}$ = 4.49, $SD_{enhancement}$ = 1.97;

$M_{treatment}$ = 2.67, $SD_{treatment}$ = 1.65; $F(1, 325) = 85.72$, $p < .001$, $\eta 2 = .21$). Similarly, following the significant Domain x Method interaction, contrasts showed that genetic modification (vs. conventional methods) were seen as more unfair in all domains. However, the effect was largest in the domains of Intelligence, ($M_{gene\text{-}editing}$ = 4.93, $SD_{gene\text{-}editing}$ = 2.04; $M_{conventional}$ = 3.77, $SD_{conventional}$ = 2.16; $F(1, 325) = 39.24$, $p < .001$, $\eta 2 = .11$), and Longevity, ($M_{gene\text{-}editing}$ = 4.58, $SD_{gene\text{-}editing}$ =1.83; $M_{conventional}$ = 3.41, $SD_{conventional}$ = 1.90; $F(1, 325) = 39.67$, $p < .001$, $\eta 2 = .11$), compared to in the domains of Mobility, ($M_{gene\text{-}editing}$ = 3.50, $SD_{gene\text{-}editing}$ = 1.95; $M_{conventional}$ = 2.88, $SD_{conventional}$ = 1.73; $F(1, 325) = 10.96$, $p = .001$, $\eta 2 = .03$), Height, ($M_{gene\text{-}editing}$ = 4.30, $SD_{gene\text{-}editing}$ =1.92; $M_{conventional}$ = 3.71, $SD_{conventional}$ = 1.93; $F(1, 325) = 8.28$, $p = .004$, $\eta 2 = .03$), and Disease Resistance, ($M_{gene\text{-}editing}$ = 3.93, $SD_{gene\text{-}editing}$ = 2.07; $M_{conventional}$ = 3.27, $SD_{conventional}$ = 1.94; $F(1, 325) = 11.91$, $p = .001$, $\eta 2 = .04$).

Table 11.

Support for Intervention Across Different Conditions (Study 6)

	Genetic Modification		Conventional Intervention		
Domain	Treatment	Enhancement	Treatment	Enhancement	Total
Intelligence	4.63 (1.78)	3.35 (1.88)	6.00 (1.14)	4.95 (1.67)	4.73(1.89)
Longevity	5.27 (1.52)	4.21 (1.79)	5.77 (1.20)	5.02 (1.49)	5.07 (1.61)
Mobility	5.69 (1.30)	3.89 (1.92)	6.09 (1.23)	4.74 (1.87)	5.10 (1.82)
Height	3.22 (1.77)	3.30 (1.73)	3.32 (1.72)	3.45 (1.70)	3.32 (1.73)
Disease Resistance	6.37 (1.65)	5.27 (1.57)	6.27 (1.13)	5.76 (1.44)	5.91 (1.52)
Total	5.04 (1.18)	4.00 (1.32)	5.49 (0.86)	4.79 (1.07)	

Note. *N* = 329. *M(SD)*.

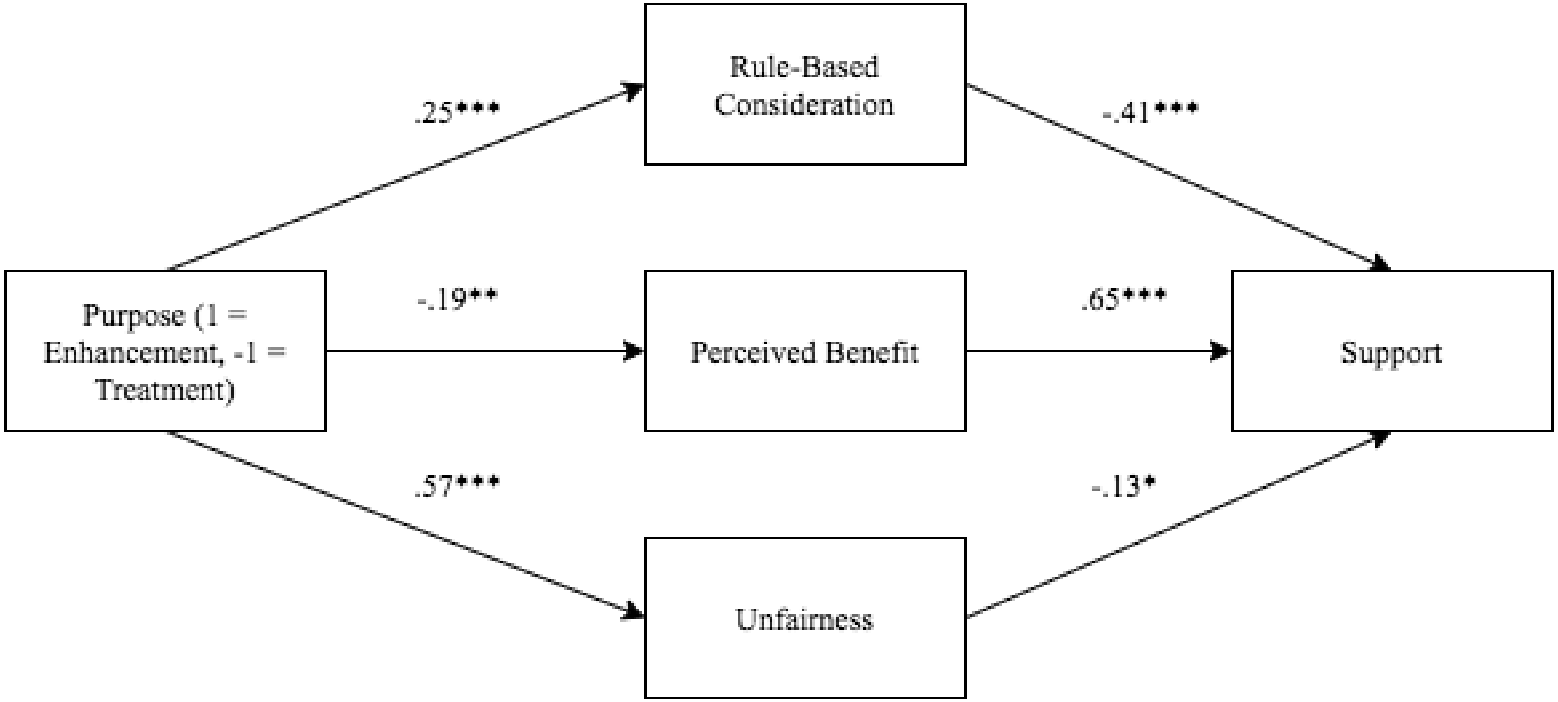
Mediation Analysis

See Appendix J for multiple regression analysis of the proposed mediators. To examine whether enhancement (vs. treatment) purpose is afforded lower support because it is viewed as more of a moral rule violation, lower in benefits and more unfair when people I ran a mediation analysis using PROCESS (Hayes, 2014; Model 4). Purpose (1 = Enhancement, -1 = Treatment) was entered as the predictor variable (X), Rule-Based Consideration, Perceived Benefit and Unfairness were entered as the mediators (M), Support was entered as the outcome variable (Y). All continuous predictor variables were standardized prior to analysis, and 95% confidence intervals with 5000 bootstrap resamples was used to assess significance.

The overall model was significant, $F(1, 327) = 21.92$, $p < .001$ (See Figure 10). The direct effect of Purpose on Support was significant $B = -.13$, $p = .001$. Consistent with my predictions, there was a significant indirect effect of Purpose through Rule-Based Consideration, b = -.10, *SE* = .03, [-0.16, -0.05]. Further, consistent with my prediction, there was an indirect effect of Purpose through Perceived Benefit, b = -.12, *SE* = .03, [-0.19, -0.05]. As expected, there was also an indirect effect of Purpose on Support through Unfairness, b = -.07, *SE* = .03, [-0.14, -0.01].

Figure 10.

Mediation Analysis of the Effect of Purpose, Rule-Based Consideration, Perceived Benefit, Unfairness on Support (Study 6)



Note. *p < .05. **p < .01. ***p < .001.

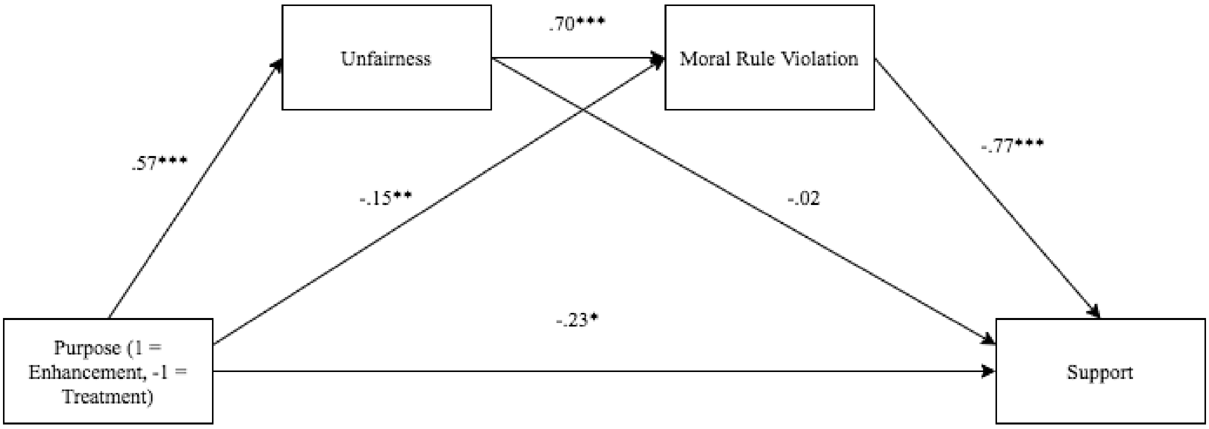
Serial Mediation Analysis Examining Rule-based Consideration and Unfairness

As in Study 5, I examined whether unfairness might be related to support via rule-based consideration. That is, that the perceived unfairness of enhancement (vs. treatment) is viewed as a moral rule violation, which in turn is related to support for gene-editing.

I ran a serial mediation analysis, using Hayes PROCESS (Model 6; 2017) with 95% confidence intervals based on 5000 bootstrap re-samples to examine the indirect of Purpose through Unfairness and then Rule-Based Consideration on Support. The overall model was significant, $F(3, 325) = 105.31$, $p < .001$ (See Figure 11). The results showed that there was an indirect serial mediation effect of Purpose on Support via Unfairness and then Rule-Based Consideration ($B = -.31$, $SE = .05$, [-0.40, -0.22]. Further, there was an indirect effect of Purpose through Rule-Based Consideration, ($B = .11$, $SE = .04$, [0.04, 0.19], but not through Unfairness, ($B = -.01$, $SE = .04$, [-0.10, 0.08].

Figure 11.

The Effect of Purpose on Support Through Unfairness and Rule-Based Consideration (Study 6)



Note. Moral Rule Violation = Rule-Based Consideration. ***$p < .001$.

Oral Disgust

Finally, I examined the effect of Purpose and Method on Oral Disgust. I repeated the 2 (Purpose: Enhancement vs. treatment) x 2 (Method: Genetic modification vs. conventional) x 5 (Domains: Intelligence, Longevity, Mobility, Disease Resistance & Height) mixed ANOVA with Oral Disgust as the dependent variable (See Table 12). There was an unexpected main effect of Purpose, where enhancement was rated as more disgusting than treatment, $F(1, 325) = 4.97$, $p = .026$, $\eta 2 = .02$. Importantly, there was no main effect of Method, $F(1, 325) = 0.21$, $p = .646$, $\eta 2 = .00$. Further, there was no significant Purpose x Method interaction, $F(1, 325) = 0.00$, $p = .993$, $\eta 2 = .00$, nor a significant Domain x Method interaction, $F(1, 325) = 0.94$, $p = .033$, $\eta 2 = .00$. There was also no significant Purpose x Domain interaction, $F(1, 325) = 2.99$, $p = .085$, $\eta 2 = .01$, nor a significant three-way interaction between Purpose x Domain x Method, $F(4, 325) = 0.45$, $p = .770$, $\eta 2 = .00$.

Table 12.

Oral Disgust Ratings Across Different Conditions (Study 6)

	Genetic Modification		Conventional Intervention		
Domain	Treatment	Enhancement	Treatment	Enhancement	Total
Intelligence	1.46 (0.87)	1.74 (1.31)	1.27 (0.68)	1.64 (1.04)	1.53 (1.02)
Longevity	1.68 (1.21)	1.67 (1.12)	1.59 (1.03)	1.68 (0.98)	1.66 (1.07)
Mobility	1.41 (0.82)	1.81 (1.24)	1.48 (0.96)	1.76 (1.14)	1.62 (1.06)
Height	1.52 (1.03)	1.77 (1.31)	1.58 (0.97)	1.76 (1.17)	1.66 (1.13)
Disease Resistance	1.46 (0.88)	1.60 (1.06)	1.38 (0.89)	1.53 (0.96)	1.49 (0.95)
Total	1.51 (0.78)	1.72 (1.03)	1.46 (0.69)	1.67(0.90)	

Note. *N* = 329. *M(SD).*

Discussion

The present study replicated Studies 3-5 – participants showed lower support for enhancement (vs. treatment) purpose in a wide range of domains including intelligence, mobility, and disease resistance. Only in the domain of height did participants not show a treatment (vs. enhancement) preference. Further, both when the method of intervention was genetic modification and when it was conventional did participants report lower support for enhancement (vs. treatment). Importantly, consistent with predictions, irrespective of the method, the perceived moral rule violation of enhancement (vs. treatment) as well as the lower perceived benefits to society and the target, accounted for the effect of purpose on support. Similarly, the present findings also replicated the serial mediation model from Study 4, showing an indirect effect of purpose on support through the perceived unfairness of enhancement (vs. treatment), and then rule-based consideration.

General Discussion

The present study is the first to replicate the effect of purpose on support across a wide range of domains. Further, it offers the first comparison of genetic modification and other, conventional methods of intervention in the same domains. The results of replicated the effect of purpose, showing that participants consistently report lower support for enhancement (vs. treatment) across a wide range of domains, and irrespective of whether the intervention utilises genetic modification or a conventional method such as vaccination or drugs.

In Study 6, the preference for treatment over enhancement was evident in all domains aside from height. At present, it is unclear why this is the case. One potential explanation is that height is a domain that highlights the grey area around what constitutes as treatment vs. enhancement. Compared to other domains such as mobility, longevity, intelligence, and disease resistance, where the treatment scenarios involved interventions aimed at improvements for those with reduced mobility, life expectancy, mental capacity, and disease resistance, an intervention aimed at people of below average height may not be classified as a treatment. Further research should examine the possibility that the enhancement (vs. treatment) distinction in levels of support afforded to GMHs might be reduced or even diminish in certain cases.

The opposition to enhancement mirrors existing research on performance enhancing drugs. For instance, in a sample of university students Scheske and Schnall (2012) found that participants disapproved of cognitive enhancement drugs in cases where they were seen to provide a competitive advantage in an assessment situation, compared to someone not using the drug. This suggest that fairness in competitive situations was a particular important moral consideration to participants. Other studies on enhancement drugs, in both cognitive and athletic domains, have also highlighted fairness as an important moral consideration (Sabini & Monterosso, 2005; Schelle et al., 2014). The result of the present study mirror this perspective in that participants particularly disapproved of enhancement in domains of intelligence and mobility – mirroring areas where competitive fairness concerns are especially salient. This could also explain why participants did not differentiate between treatment and enhancement in the domain of height. It could also suggest that participants might have more objections to a height intervention if an increase or decrease in height would confer obvious advantage such as in competitive basketball. Future research should adapt research designs on pharmaceutical enhancements and examine how the treatment (vs. enhancement) distinction varies both depending on domain as well as contextual factors (competitive vs. non-competitive).

The present study also included a measure of disgust response. Interestingly, the results showed that there was no effect of method. Participants did not view genetic modification as more disgusting compared to other intervention methods. This is consistent with the proposition that genetic modification is viewed more akin to other medical interventions. This finding is also consistent with my theorising that disgust may be less important in support of GMHs, compared to GMOs. Future research should examine this possibility by experimentally comparing genetic modification vs. conventional methods in people and animals.

Chapter 5: General Discussion

Advances in gene-editing technologies are outpacing policy and legislation. These technologies have the potential to fundamentally change many aspects of our existence – ranging from medical treatments, food production to environmental ecosystems and even the evolution of different species. Developments in human gene-editing, in particular, pose many novel ethical challenges. Yet, little is known about how people judge the morality of different applications of human gene-editing. Most previous research has examined the psychological predictors that underpin moral judgments about GMOs, and human gene-editing has received relatively limited attention. The research on GMOs has identified a series of psychological factors that affect people's attitudes towards GMOs.

In this thesis, I have proposed that moral judgments about human gene-editing are different from those about GMOs for two key reasons. One, humans are given much greater moral standing compared to plants and animals (Caviola et al., 2019). Thus, moral concern about the potential harms and benefits of genetically modifying humans ought to be greater compared to those about other GMOs. Secondly, the purpose for which human gene-editing can be applied is much more varied (e.g., spanning improvements in intelligence and appearance to the prevention of congenital disease), and have implications for social inequality and organisation (Gyngell et al., 2017). Thus the distinction between treatment versus enhancement becomes more important.

Summary of Key Findings

The Role of Perceived Harm and Benefits of Human Gene-editing (Chapter 2)

The aim of Chapter 2 was to provide a preliminary investigation into the potential psychological factors that are associated with support for human gene-editing. The results of Study 1 showed that Religiosity and Disgust Sensitivity were only marginally, negatively related to support of human gene-editing. Further, they became non-significant when perceived harm and benefits were included in the second step. Meanwhile, perceived harm and benefits remained the strongest predictors of support for human gene-editing, when other variables including religiosity, purity, and disgust sensitivity were controlled for.

The goal of Study 2 was to offer a more extensive investigation of the moral considerations associated with attitudes to GMHs. Thus, it included more granular measures of social benefit, social harm, sanctity concerns, dignity and individuality concerns and free will considerations adapted from qualitative research. Study 2 also examined support of GMHs both in general and across four different domains: Intelligence, longevity, mobility and disease resistance). The results showed that genetic modification of humans to improve disease resistance received the highest support, while intelligence received the least. Further, Study 2 replicated the findings of Study 1 in that a more granular measure of perceived social benefit of genetic modification showed the largest, positive correlation with support.

The results also showed that endorsement of a more proximal measure of sanctity concerns was negatively associated with support. The perceived social harm of genetic modification of humans was also negatively associated with support, but only in the domain of longevity. In contrast, neither Dignity and Individuality Violation, Religiosity, Spirituality or Faith in Science were significantly associated with support. Consequently, judgments about the extent to which the genetic modification of humans is *morally right* or *morally wrong* with reference to moral considerations about social benefit, social harm, and sanctity concerns are associated with support. Together these results suggest that moral considerations relating to harms and benefits are important in people's support of human gene-editing, while the relations between other variables are less straightforward.

These results provide initial support for the role of perceived harm considerations in moral judgments about gene-editing. Nevertheless, it should be noted that there was no experimental manipulation of the purpose of gene-editing. This is central for two reasons.

Firstly, a controlled experimental manipulation of purpose elucidates whether people are in fact sensitive to the potential application. Secondly, whether the distinction between treatment vs. enhancement affects perceptions of outcome-based moral considerations in terms of perceived harms and benefits. However, the present studies show that compared to other variables, perceived harms and benefits are consistently associated with support for human gene-editing.

Moral Judgments About Human Gene-editing Depend on its Purpose: The Treatment vs. Enhancement Distinction (Chapter 3)

The aim of Chapter 3 was to examine how the purpose of human gene-editing affects support and the endorsement of outcome- and rule-based moral considerations in an experimentally controlled manner. Finally, the chapter also investigated the proposed distinction between moral judgments about GMOs and human gene-editing in that moral judgments about human gene-editing are subject to both greater moral concern as well as different moral considerations than those about other GMOs.

Study 3 was the first to experimentally manipulate the purpose of human gene-editing to examine the differences in levels of support for enhancement vs. treatment. The results showed a clear preference for treatment over enhancement purpose in terms of levels of support. Further, this effect was mediated by both outcome-based and rule-based moral considerations. Specifically, participants saw enhancement (vs. treatment) as producing fewer positive outcomes and more of a moral rule violation.

Study 4 replicated these results and further extended the investigation to examine whether the lower support afforded to enhancement (vs. treatment) was associated with different perceptions of specific types of harm: Social and Natural Harm. The results indicated that enhancement (vs. treatment) purpose was associated with perceptions of social harm, but not natural harm, and that this mediated the effect of purpose on support.

Study 5 sought to replicate and extend the previous two studies by examining whether the distinction between enhancement and treatment is uniquely important in moral judgments about GMHs. In this study, I experimentally manipulated whether the target of gene-editing was people or farm animals. Further, the study included a measure of perceived unfairness and measures of specific types of benefits: benefits to society, the target and the natural order. As predicted, the effect of purpose was unique to humans, such that enhancement (vs. treatment) was afforded less support. Enhancement (vs. treatment) was seen as more unfair and less beneficial to society, when humans were genetically modified, but not when farm animals were. Further, the results showed that enhancement (vs. treatment) was seen as more unfair, and in turn seen as a moral rule violation, and thus enhancement (vs. treatment) received less support when the target of gene-editing was people, but not when the target was farm animals. Finally, perceived benefit to society mediated the effect of purpose on support only for human targets, with enhancement (vs. treatment) seen as less beneficial to society and thus less supported.

Taken together, the studies in Chapter 3 indicate that the purpose is central to the level of support afforded to human gene-editing. Specifically, when the purpose of human gene-editing is enhancement, the results show that participants are consistently less supportive than when the purpose is treatment. This is the case even when the scenario is identical in terms of the function that is targeted (e.g., physical functioning). Further, Study 4 was consistent with the theorising that the genetic modification of humans raises greater moral concern as well as different moral considerations compared to other GMOs. Specifically, the genetic modification of humans evokes moral considerations pertaining to society and social organisation such as fairness. Indeed, the genetic modification of humans is often coached in terms of its potential to exacerbate social inequality and entrench existing inequalities further at a genetic level (e.g., Sadler & Zeidler, 2004). In contrast, GMOs are less directly linked with concerns about social organisation and fairness. These are the first studies to suggest that the moral considerations that about GMHs and GMOs are distinct both in *degree* and *kind*.

The effects of domain and method on support (Chapter 4)

The goal of Chapter 4 was twofold. One, to examine whether the effect of purpose on support held across different domains in addition to physical functioning. Two, to investigate whether human gene-editing is seen as different from other conventional methods of intervention such as drugs and vaccination. Since the effect of the purpose manipulation thus far have emerged with one scenario involving physical functioning, it was crucial to explore whether the effect of purpose on support would replicate in different domains. Further, because human gene-editing seemed to be underpinned by different moral considerations than other GMOs, I wanted to examine whether it might be evaluated more like other medical interventions targeted at humans. Rather than the focus being on the process of genetic modification as is the case in attitudes to GMOs (e.g., Swiney et al., 2020), attitudes to GMHs may be more driven by moral considerations that also underpin other medical interventions targeting humans such as perceived harm and benefits (e.g., Calnan et al., 2005; Rudski, 2014; Schelle et al., 2014).

The aim of Study 6 was to investigate whether the effect of purpose held across different domains beyond physical functioning. Moreover, Study 6 sought to examine whether attitudes toward GMHs are underpinned by similar moral considerations as attitudes to other, more conventional medical interventions. Specifically, Study 6 was the first to experimentally manipulate both Domain and Method, in addition to Purpose. Participants were randomly allocated to read a scenario involving human gene-editing (vs. a conventional method) for enhancement (vs. treatment), across five different domains: intelligence, longevity, mobility, disease resistance and height. Results revealed that irrespective of the method of intervention, people consistently expressed lower support for enhancement (vs. treatment) in all domains aside from height. Further, regardless of purpose, conventional methods, such as vaccination, drugs, education and diet, were preferred over gene-editing across all domains aside from height and disease resistance.

Study 6 also replicated the findings concerning rule-based and outcome-based moral considerations. Irrespective of the method of intervention, perceived rule-based consideration, social benefit and target benefit mediated the effect of purpose on support. That is, enhancement (vs. treatment) was seen as more of a moral rule violation, and as producing less social and target benefit. This accounted for the lower support afforded to enhancement (vs. treatment). Study 6 further replicated the finding that enhancement (vs. treatment) was seen as more unfair, and in turn as a more of a moral rule violation. This accounted for the lower support afforded to enhancement (vs. treatment). The results suggest that not only does the effect of purpose on support replicate across most domains beyond physical functioning, but also to different methods of intervention. Although people prefer conventional methods over human gene-editing, the moral considerations that underpin the treatment (vs. enhancement) preference are the same, irrespective of the method.

Theoretical Implications

The present results demonstrate that the purpose of human gene editing plays a causal role in people’s support of the technology. It offers the first experimental evidence for this effect. The findings also show that both outcome- and rule-based moral considerations account for the effect purpose has on support of human gene-editing. Further, the thesis documents, for the first time, that moral judgments about human gene-editing are different from those about GMOs. I will first discuss the present findings within the context of the research literature examining attitudes to GMOs, including research on disgust, religiosity and purity. Further, I will outline what the findings mean in terms of the literature on the role of different moral considerations. Then, I will outline the questions that remain unanswered in the current investigation. Finally, I will detail the limitations of the present research and outline avenues for future research.

GMO literature

Disgust. The present findings diverge from previous research and theory identifying disgust as an important factor explaining opposition to GMOs and other novel technologies (Clifford & Wendell, 2015; Terrizzi et al., 2010). Whereas past research has found disgust to be both a correlate and cause of opposition to a range of different biological technological innovations including GMOs and stem cell research, the present findings suggest that disgust is less important in moral judgments about human gene-editing. The greater level of disgust in response to genetic modification of farm animals is consistent with findings showing that disgust predicts absolutist opposition to GMOs (Scott et al., 2016). This suggests that disgust may be less important in moral judgments about GMHs compared to those about GMOs.

One potential explanation for the difference in the role of disgust in attitudes to GMHs compared to GMOs could be that GMOs are typically for ingestion, while GMHs are not. Thus, disgust may be a more important predictor of attitudes to GMOs because it is specifically the thought of ingesting an organism that has been genetically modified that elicits disgust. Indeed, theorising on disgust typically emphasizes it as a category of food rejection, focused on ingestion (Rozin et al., 2008). In contrast, the genetic modification of humans does not evoke disgust because they are not for ingestion.

The present findings also diverge from a more recent investigation linking disgust with support of human gene-editing. The study by Halstead and Lewis (2020) showed that that while disgust sensitivity was positively related to opposition to GMOs, contrary to their predictions, it was modestly *negatively* correlated with opposition to human gene-editing. That is, higher levels of disgust sensitivity were associated with greater support of human gene-editing. The researchers suggested that this might be due to an aversion to physical imperfections sometimes present among high scorers in disgust sensitivity and viewing gene-editing as a means to amend this (e.g., Lieberman et al., 2012).

On the other hand, in the present investigation there was no evidence supporting the association between disgust and support of human gene-editing. Across three different measures of disgust, there was no evidence that disgust was positively associated with support of human gene-editing or related at all, once other variables were accounted for. The null effects of disgust and support for GMHs in the present studies could be the result of opponent processes. That is, disgust might on one hand be negatively associated with the modification of genetic material, while on the other hand be positively associated with interventions that target conditions that people find disgusting. Future research should examine this possibility by isolating the processes by asking participants to report how disgusting they find the intervention and how disgusting they find the condition separately.

It could also be that a positive relation between disgust and support of human gene-editing exists for certain domains (e.g., attractiveness, physical disability), where the condition might evoke disgust. Indeed, some researchers have argued that bodily abnormalities can serve as a cue to infectious disease, and that because the pathogen detection system is so sensitive, even injuries with no risk of infection can elicit disgust (e.g., Park et al., 2003). In contrast, for gene-editing interventions targeting domains without these kinds of visual cues (e.g., longevity, intelligence), it could be the case that only the intervention evokes disgust. Future research should examine this possibility by incorporating a broader range of domains.

It should be noted that the association between disgust and attitudes to GMOs has been criticised and argued to be the product of issues with the measure of disgust sensitivity (Kahan & Hilgard, 2016). Specifically, Kahan and Hilgard (2016) documented that rather than purely capturing pathogen disgust response to genetic technologies, the disgust sensitivity measure in fact relates to a more *generalized* fear towards novel technological innovations. In their study, disgust sensitivity was correlated with not only opposition to GMOs, but other things such as fear of flying commercial airlines. Using different measures of disgust without this limitation, the present investigation failed to find empirical support for a relation between disgust and support of human gene-editing. This could suggest that disgust is of less importance in moral judgments about human gene-editing. That other factors such as the purpose and perceived harms and benefits are more central – a point I return to in a later section.

Beyond the challenge of measuring disgust sits the broader question of what role disgust plays in moral judgments. Kupfer and Giner-Sorolla (2017; see also Giner-Sorolla et al., 2018) proposed that people's expression of disgust in response to different moral violations is the result of a desire to convey a more disinterested moral motivation. Their research findings showed that perceivers attributed greater moral motivation to an expression of disgust compared to an expression of anger. Further, in two follow-up studies participants preferred expressions of disgust when displaying moral concern, while anger was chosen more often to dispute harms to participants' self-interest. This could explain why people reported being more disgusted by the human gene-editing for enhancement (vs. treatment). That is, rather than evoking disgust as a pathogen-avoidance emotion, the genetic modification of humans instead affects reports of disgust as a more impartial sociomoral signal that enhancement (vs. treatment) purpose constitutes a moral violation. If GMHs evoked disgust as a pathogen-avoidance emotion, one would not expect these differences to emerge as it would be the genetic modification itself, irrespective of its purpose, that elicited disgust.

The interpretation that the displays of disgust in response to gene-editing for enhancement (vs. treatment) fits with a recent investigation into the role of pathogen avoidance in responses to physical injuries. Kupfer (2017) argues that rather than being the product of pathogen avoidance, the disgust observed in response to physical injuries and mutilation is the result of empathic simulation leading unpleasant feelings that are displaced as disgust. Results from four studies showed that injury stimuli evoked feelings of empathy and vicarious pain as opposed to feelings of disgust commonly related to infection stimuli. Further, perceptions of pain and horror were stronger predictors of disgust responses toward injuries than perceptions of infectiousness. These findings further highlight how disgust as a pathogen-avoidance emotion can be conflated with other psychological processes such as empathic simulation. Thus, although disgust may seem like a good candidate in explaining moral judgments in many cases, in certain cases it may conceal other, important processes be it fear avoidance, sociomoral signalling or empathic simulation.

Purity Concerns. Beyond the role of disgust, the present findings also diverge from the research literature linking purity concerns and opposition to GMOs. Previous research has shown that the endorsement of purity concerns is associated with the perception that GMOs are morally wrong (Jarudi, 2009) and that the consumption of GMO products is harmful (Swiney et al., 2020). In a similar vein I theorised that purity concerns could be important in moral judgments about human gene-editing. This proposition follows from the perception of gene-editing as a violation of what is seen as sacred, such as scientists being perceived as playing God, as well as a violation of bodily purity, through the artificial altering of the human genome (e.g., Jarudi, 2009). However, in contrast to research linking moral judgments about GMOs with purity concerns, the present investigation showed that support for human gene-editing was only moderately negatively correlated with purity concerns at zero-order in Studies 1 and 3. Furthermore, it was unrelated once other variables were accounted for. Only a more proximal measure of specific sanctity concerns about GMHs was negatively associated with support of GMHs (Study 2).

At present it is unclear why purity was unrelated to attitudes to GMHs in the current investigation. One potential explanation could be the many measurement problems of the MFQ identified in previous research. For instance, the MFQ has been found not to generalize well across different countries (Iurino & Saucier, 2020). Across 27 countries, Iurino and Sacuier (2020) failed to find consistent support for the five factor model proposed by Moral Foundations Theory using a short form of the MFQ. The researchers argue that the lack of measurement invariance across different countries suggest that the foundations measured by the MFQ are not *foundational,* emerging from evolutionary development. Thus, the MFQ may not accurately capture concerns about purity that are relevant in attitudes to GMHs.

Another measurement problem of the MFQ is the consistent low reliability of the measures of each foundation (Harper & Rhodes, 2021). Also, the purity foundation shows low reliability across different studies (Harper & Rhodes, 2021). Indeed, in the present studies, reliability was acceptable, but not particularly high .65 (Study 1) and .73 (Study 3). Similarly, it should be noted that the measure of purity concerns works differently for religious and non-religious individuals (Davis et al., 2017). This could be especially important in the present studies, as religious and non-religious individual may emphasise different aspects of purity concerns relevant to GMHs. For instance, religious individuals may perceive GMHs more as a violation of sanctity and humans playing God, while non-religious individuals may view GMHs more so as unnatural.

Beyond measurement problems, the MFQ's conceptualisation of moral values has also been questioned. Specifically, the MFQ has been criticised for measuring moralization rather than foundational moral values. Specifically, McNease and Sinn (2018) argued that MFQ merely reflect one potential set of moralizations from a wider set of moral values, rather than a set of *foundational* moral values. Consistent with this claim, they found that the Schwartz Value Theory (SVT) provided a better explanation for ideological differences compared to Moral Foundations Theory. The researchers adapted the measure of SVT to four measures of Obedience, Status, Self-Direction and Universalism, in the same response format as the MFQ and termed it Moral Forces scales. The results showed that the scale constructed based on the SVT better explained attitude differences between conservatives and liberals, compared to the MFQ. Consequently, it could be that the limited set of moralizations measured by the purity foundation, may not be relevant in attitudes to GMHs, and thus was unrelated to support in the present study. Relatedly, a more proximal measures of specific purity concerns about GMHs was negatively associated with support. Together these results suggest that future research should employ a wider set of purity considerations when examining the potential relation with attitudes to GMHs.

Religiosity. Although purity concerns appeared to be of less importance, the present investigation produced mixed results in terms of the relation between religiosity and opposition to human gene-editing. This is contrary to previous research that has linked religiosity and opposition to human gene-editing (McCaughey et al., 2016; Scheufele et al., 2017). In Study 1 religiosity was negatively correlated with support of human gene-editing, even when perceived harm and disease reduction was accounted for. However, in Study 2 religiosity was not significantly associated with support of human gene-editing when spirituality and faith in science were accounted for. Finally, in Study 3 neither belief in God nor religious orthodoxy were significant predictors of support of human gene-editing when rule- and outcome-based moral considerations were accounted for. Together these results suggest that when other, more proximal factors are included in the model - including moral considerations around potential outcomes, moral rules and perceived benefits, religiosity becomes less important in explaining people’s support for human gene-editing.

These results do not suggest that religiosity is an unimportant factor – but rather that when more proximal measures of moral considerations about human gene-editing are included, religiosity becomes less important. Thus, the divergence from previous research linking religiosity and support of human gene-editing is likely the product of introducing measures of moral considerations that more proximally capture the different concerns people harbour when they consider the ethicality of human gene-editing. For instance the perception that human gene-editing is a moral rule violation could in part be a product of religiosity, such as moral values about the perception of God as the creator and the sanctity of life (e.g., Rutjens et al., 2018a). Nonetheless the present investigation represents an important advance in capturing the specific moral considerations that are associated with support of human gene-editing.

The inconsistent findings regarding the association between religiosity and attitudes to human gene-editing also mirror the wider literature on attitudes to science. Beyond acceptance of evolution, previous research has failed to find a consistent link between religiosity and general attitudes to science and scientific innovations (Rutjens et al., 2018b). Some studies suggest that religiosity may be of limited importance in attitudes toward science in Western European countries due to greater levels of secularism compared to the U.S. (Halman & Draulans, 2006; Houtman & Aupers, 2007; Rutjens et al., 2018b). The present findings contribute to this literature by demonstrating that a similar pattern emerges for religiosity and attitudes to human gene-editing.

The association between religiosity and moral judgment more generally is also not straightforward. Some research findings suggest religious and non-religious individuals display similar moral judgments and levels of empathy (Rabelo & Pilati, 2021). Further, in a review paper, Getz (1984) argues that the association between religiosity and moral judgments is highly contingent on how religiosity is operationalized. For instance, research suggest that religious affiliation is unrelated to moral judgment, while religious knowledge is positively associated with moral judgment (Getz, 1984). This pattern was also present in an investigation by Baumsteiger et al. (2013) which showed that although religiosity was positively associated with moral idealism and spiritualism, it was negatively related to moral relativism, both accounted for very limited variance in moral reasoning. Relatedly, other research findings suggest that rather than there being an intrinsic link between religiosity and moral judgment, the manner in which people process religious contents is associated with their moral judgments (Duriez & Soenens, 2006). Together these findings indicate that, at best, the importance of religiosity in moral judgments is subject to great variability depending on how it is conceptualised.

It should be noted that the samples recruited in the present studies may to some extent have led to an underestimation of the role of religiosity in support of human gene-editing. For instance, participants scored well below the scale-midpoint on the measures of belief in God and religious orthodoxy in Study 3 as well as the religiosity scale in Study 5 – suggesting that participants were quite low in religiosity. Consequently, samples with a normal distribution of religious individuals might yield different results. Further, due to collaborative data collection the measures of religious beliefs varied across the present studies – this is likely part of the reason for the somewhat inconsistent findings. Future research should examine the relation between religiosity and moral judgment about human gene-editing including these moral considerations, in more representative samples.

The Treatment vs. Enhancement Distinction

The moral considerations posed by human gene-editing are qualitatively different from those posed by GMOs and thus might be influenced by different factors. I theorised that because human gene-editing entails changing the genome of people, unlike GMO which entails editing the genome of plants and animals for consumptions, it presents a much wider array of moral considerations. Some of these issues are raised by the various purposes for which genes are edited.

The studies in Chapter 3 were the first to employed a carefully matched experimental design showing that human gene-editing for enhancement is consistently afforded lower support compared to human gene-editing for treatment, when the trait targeted is held constant. Consistent with my theorising, I found the effect of purpose on support to be greater for human targets, compared to farm animals. Specifically, participants differentiated between enhancement (vs. treatment) purpose when the target of gene-editing was people, showing less support for genetic modification in this case. However, this effect was not evident when the target of genetic modification was farm animals. Further, the study in Chapter 4 documented that the preference for treatment over enhancement was not limited to the domain of physical functioning, but held across different domains including longevity, intelligence, disease resistance and mobility.

These results extend qualitative investigations that have shown that people distinguish between enhancement and treatment when considering the ethicality of human gene-editing (e.g., Sadler & Zeidler, 2004). Further, the present findings represent an important extension of both survey research (PEW Research, 2018) and a recent psychological investigation (Halstead & Lewis, 2020) that have shown different levels of support afforded to human gene-editing for enhancement vs. treatment. However, these studies did not compare the applications in an experimentally controlled manner. Specifically, consistent with Halstead and Lewis (2020) investigation which found that items on human gene-editing for treatment vs. enhancement loaded on separate factors, the present results extend this finding by documenting the effect in an experimentally controlled design. Together the present findings show that people are quite sensitive to the application of human gene-editing and that this affects their subsequent support. There is little evidence for absolutist opposition to human gene-editing – instead it depends on the purpose for which the technology is used.

The present findings are also consistent with studies examining the enhancement vs. treatment distinction in other areas such as the use of pharmaceutical interventions (Rudski, 2014; Schelle et al., 2014). Similarly, other studies on pharmaceutical interventions with the goal of cognitive enhancement have also highlighted concerns about fairness as a key factor in explaining the lower support typically afforded to enhancement compared to treatment. The findings of the thesis contribute to this literature by providing the first evidence that human gene-editing for enhancement (vs. treatment) is associated with the perception that some will have unfair advantages over others. This partly explains the lower support for enhancement (vs. treatment) purpose. The finding suggests that moral concerns about human gene-editing increasing unfairness is one important factor when participants consider the ethicality of human gene-editing.

The present findings also mirror qualitative investigations that exposed people's concerns that the application of human gene-editing will exacerbate inequality and social stratification. Specifically, worries that gene-editing will be available only to the wealthy, commonly emerge as moral concerns about human gene-editing (Kalfoglou et al., 2005; Sadler & Zeidler, 2004). The present investigation is the first to document that moral concerns about fairness account for the lower support afforded to human gene-editing for enhancement (vs. treatment) in an experimental design. Further, the findings show that these concerns about fairness are particular to moral judgments about human gene-editing, but not the gene-editing of farm animals. Additionally, the results of Study 6 replicated the lower support of enhancement vs. treatment across a wider range of domains including intelligence and longevity, as well as across different methods of interventions such as drugs and vaccination. This suggests that moral judgments about human gene-editing may be similar to judgments about other medical interventions, such as drugs, or even other methods of intervention such as diet and education. Further, the findings indicate that the treatment vs. enhancement distinction affect levels of support also for other methods of intervention including drugs, education, diet and vaccination. This is an important extension to existing research on the effect of purpose (e.g., Rudski, 2014; Schelle et al., 2014), showing that the effect generalises across a wide range of intervention methods.

It should be noted that ethicists have identified several issues with the enhancement vs. treatment distinction. For instance, certain interventions aimed at reducing the probability of disease and death such as vaccination does not neatly fit into one category. It can be construed as an immune system enhancement, or as a preventative treatment intervention (Bostrom & Roache, 2008; See also Savulescu, 2016). Similarly, the enhancement vs. treatment distinction is contingent upon a definition of a normal state, which in itself is subject to great variability. Further, since capacities vary both within a population and within the lifespan of an individual, it becomes unclear whether an intervention aimed at enabling an 80-year old to function physically as a 20-year old is a treatment of age decline or an enhancement (Bostrom & Roache, 2008). Bostrom and Roache argue that the ambiguities with the enhancement vs. treatment distinction causes problems for those who think that that the distinction has normative implications. For instance that interventions for treatment but not enhancement should receive public funding.

Despite these ambiguities with the enhancement vs. treatment distinction, the present studies suggest that, unlike some ethicists, lay people do differentiate between the two. They afford enhancement less support and view it as less beneficial and more of a moral rule violation compared to treatment. These studies contribute to the literature on the enhancement vs. treatment in medical interventions (e.g., Daniels, 2000; Schelle et al., 2014). Specifically, the differential levels of support for enhancement vs. treatment purpose emerged using a carefully matched experimental design where treatment was conceptualised as an intervention targeting individuals with some kind of ailment (e.g., with physical disability), while an enhancement intervention targeted individuals without an ailment (e.g., without physical disability). This method held the trait targeted for enhancement vs. treatment constant, and varied the baseline, allowing for a carefully controlled examination of the effect of purpose on support.

As for the method of intervention, the present findings indicate a divergence between the opinions of some ethicists and lay people when it comes to the acceptance of conventional methods compared to genetic modification. Savulescu (2009) argues that there is no difference between conventional methods of intervention such as diet and education compared to genetic modification. He states that both genetic and environmental intervention methods produce change by altering our biology and that changes in either case are no more or less irreversible than the other. In contrast, participants in the present studies clearly differentiated genetic modification from other conventional methods of intervention such as diet, education and vaccination, displaying a consistent preference for these over genetic modification. Future research should examine whether this preference is merely the result of familiarity with conventional methods such as drugs, vaccination, education compared to genetic modification, or whether the preference is also driven by the perception that genetic interventions are viewed as more invasive or irreversible. For instance, it could be that especially genetic modification of the germline is viewed as irreversible.

Outcome- and Rule-based Moral Considerations

Beyond offering the first systematic, experimentally controlled examination of the enhancement vs. treatment distinction in moral judgments about human gene-editing, the present investigation also provided the first exploration of the role of outcome- and rule-based moral considerations. The present results are in line with previous qualitative investigations of moral judgments about human gene-editing showing that people distinguish between enhancement and treatment (e.g., Kalfoglou et al., 2005; Sadler & Zeidler, 2004). Furthermore, they employ both rule-based and outcome-based considerations when they evaluate the ethicality of human gene-editing. Specifically, compared to treatment, enhancement was viewed as producing fewer benefits, and reducing harm less. This partially accounted for the lowered support of enhancement (vs. treatment). Similarly, enhancement (vs. treatment) purpose was viewed as more of a moral rule violation. This too partially accounted for the lowered support for human gene-editing for enhancement (vs. treatment) purpose.

Previous qualitative investigations have shown that those in favour of certain technological innovations such as stem cell research, report moral considerations about the potential good the technology is seen to produce. Or in other words, the harm the innovation is expected to reduce (e.g., Kalfoglou et al., 2014; Sadler & Zeidler, 2004). In the present studies harm considerations were an important predictor of support of human gene-editing. In Studies 1 and 2 (Ch. 2), the perceived harm genetic technologies were seen to produce along with the perceived benefits were the strongest correlates of support for genetic technologies. Similarly, in Studies 3-6 (Ch. 3), endorsement of outcome-based considerations in terms of the perceived benefits of human gene-editing accounted for the lower support afforded to enhancement (vs. treatment). The lower perceived benefits to society were especially important in explaining the lower support of human gene-editing for enhancement (vs. treatment) purposes (Studies 4-5).

The endorsement of outcome-based moral considerations also mirrors literature on other technological innovations such as stem cell research. Specifically, the present findings are consistent with qualitative research on stem cell research were harm words were found to be frequently referenced in a sample of New York time articles (Clifford & Jerit, 2013). In contrast, purity words were found to be uncommon. Relatedly, in the present investigation endorsement of harm considerations was a more important correlate than purity concerns. This is the first investigation to show this in a correlational design and in moral judgments about human gene-editing.

In a similar vein, qualitative investigations have also demonstrated that people endorse rule-based moral considerations when making moral judgments about human gene-editing (Sadler & Zeidler, 2004; See also Kalfoglou et al., 2009). Consistent with this literature, the perceived moral rule violation also partly accounted for the effect of purpose on support of human gene-editing. The present finding that enhancement (vs. treatment) was viewed as more of a moral rule violation, which partially explained the lower support for gene-editing for enhancement purpose (Studies 3-6), replicate the role of rule-based moral objections to gene-editing from qualitative investigations. Sadler and Zeidler (2004) found that in addition to outcome-based considerations, participants also endorsed rule-based moral considerations, including the perception that it is a violation of nature and sanctity (see also Kalfoglous et al., 2005). Together the present findings show that genetic modification for enhancement (vs. treatment) is perceived as more of a moral rule violation and lower in benefits, and both considerations partly account for the lower support afforded to enhancement over treatment purpose.

The present findings further demonstrated that both the perception that a moral rule had been violated and the lower perceived benefits to society were especially important in explaining the lower support for genetic modification for enhancement (vs. treatment) purposes when people, but not farm animals, were genetically modified. Further, an exploratory serial mediation indicated that the moral rule that was seen as violated by enhancement purpose might be about fairness. Analyses revealed an indirect effect of purpose on support through unfairness, then rule-based consideration for human targets, but not farm animals. This could also account for why unfairness did not mediate the effect of purpose on support when entered as a parallel mediator with rule-based consideration. That is, the inclusion of the more proximal predictor rule-based consideration, rendered unfairness no longer significantly related to support. This result is consistent with qualitative studies showing that participants are particularly concerned with the impact of enhancement technologies on inequality (e.g., Kalfoglou et al., 2005; Sadler & Zeidler, 2004). The results could suggest that enhancement evokes concerns consistent with a deontological principle about fairness (Holyoak & Powell, 2016). Further research should examine this possibility in an experimental design, for instance by elucidating which aspects of a potential fairness rule is particularly salient.

One important limitation of the present findings is need of addressing. Specifically, caution should be exercised in interpreting the results of the mediation analyses. Although the results seem to indicate that both outcome- and rule-based considerations are important in the support afforded to GMHs, the present studies do not experimentally manipulate these variables. Instead, the findings rely on measuring endorsement of these moral considerations and support of GMHs. Because both the mediator and dependent variables are measured, the significant mediation models in the present studies do not provide evidence that the proposed mediator variables do in fact mediate the effect of purpose on support. It only provides evidence that the effect of purpose on support can be accounted for by the proposed mediators (Fiedler et al., 2011). Indeed, the perceived moral rule violation and lower benefits of genetic modification for enhancement (vs. treatment) could reflect post-hoc justifications for the lower support afforded to enhancement purpose.

Beyond the limitations of mediation analysis, there is still an ongoing debate as to whether perceptions of harm are conjured post hoc in the attempt to justify a moral stance (Haidt, 2001; 2012) or the result of an internal cognitive template that forms moral judgments on the basis of harm (Schein & Gray, 2018). The judgments of harm observed in the present studies could be post-hoc rationalisations. Although the results suggest that these considerations at least respond in a nuanced way to specific variations in the purpose of human gene-editing. That is, casting opposition to or support for human gene-editing as post-hoc rationalisations does not mean people are indiscriminate in their reactions to the technology. Instead, consideration of issues relating to harm, benefits and fairness make up part of people's moral judgments about human gene-editing. In the present studies participants clearly distinguished between the purpose of human gene-editing, both in their support and perceived harms and benefits. This suggests at least some level of reflection about the implications of the technology.

Naturally the present studies offer only one piece of the puzzle that make up our understanding of people's moral judgments about GMHs, and it would be amiss not to acknowledge some other, central theoretical perspectives that aid our understanding of this topic. One key theoretical perspective is the knowledge deficit model of science communication – which posits that people simply lack sufficient knowledge to understand scientific issues (Miller, 1983). Some studies show that scientific knowledge emerges as the most consistent predictor of people's beliefs on a wide range of issues (McPhetres et al., 2019; although see Simis et al., 2016). The knowledge deficit model may be of particular relevance when it comes to attitudes toward GMHs in particular. Specifically, the public opinion research reviewed in this thesis in general show quite high levels of support for human gene-editing, at least for treatment purposes. Simultaneously, the general public's understanding of genetics remains low (e.g., Dar-Nimrod & Heine, 2011). One possibility is that some knowledge in the case of GMHs leads to greater acceptance, while very high levels of knowledge could in some cases make people more apprehensive of the technology – for instance if they understood how traits and behaviours are the result of an incredibly complex interplay between numerous genes and the environment or the risks of off-target effects in gene-editing (Dar-Nimrod & Heine, 2011). Anecdotally, experts in the field of human gene-editing urge great caution about gene-editing technology (e.g., Doudna & Sternberg, 2017). Further research should examine whether there is such a curvilinear effect of knowledge in people's attitudes toward GMHs.

Beyond knowledge, reasoning ability has also been proposed as central in the acceptance of science beliefs (Lawson, 1982; McPhetres et al., 2019). McPhetres et al. (2019) proposed that the extent to which people engage in analytic and critical thinking – referred to as cognitive sophistication – can account for different levels of acceptance of science beliefs. In one study McPhetres et al. (2019) found that cognitive sophistication was positively associated with the acceptance of science beliefs across a wide range of scientific issues. Similarly, other studies have found that greater inclination to think analytically is associated with support for evolutionary theory (Gervais, 2015). More specifically, also scientific reasoning ability – which encapsulates a range of different abilities - has been suggested as important in science acceptance. Scientific reasoning includes probabilistic reasoning, correlational and causational reasoning, hypothetico-deductive reasoning (Lawson, 1982), and has been identified as a key predictor of achievement in scientific subjects such as biology and genetics (Lawson et al. 2007; 2000). In line with these perspectives, reasoning ability likely plays a role in people's attitudes toward GMHs. For instance, future research could examine how cognitive sophistication might not merely be positively associated with acceptance of human gene-editing, but simultaneously interact with contextual factors relating to risks and benefits.

Another key factor affecting people's attitudes identified in the literature on science understanding and attitudes toward GMOs is motivated reasoning (Rutjens et al., 2018; Sinatra et al., 2014; Kunda, 1990). This perspective posits that people's reasoning can be motivated by so called accuracy goals – that is to arrive at an accurate conclusion, or they can be driven by a directional goal (Kunda, 1990). In the case of the latter, people are motivated to process information in a manner which suits their goals, leading them to expend additional effort recalling or paying attention to information that supports their existing belief and suppress information that contradicts it (Kahan, Jenkins-Smith, & Braman, 2011; Kunda, 1990). This goal directed kind of motivated reasoning is well documented in a range of different science attitudes, such as in the opposition to climate change (Hart & Nisbett, 2011), GMOs (Druckman & Bolsen, 2011; see Druckman & McGrath, 2019 for a critical perspective) and vaccines (Joslyn & Sylvester, 2017). Although GMHs is still very novel and thus unlikely to have become polarized in the same manner as other science issues such as climate change and vaccines, people's moral judgments are likely shaped by their existing opinions about the safety and efficacy of gene-editing, as well as other motivations for instance relating to their desire for advances in treatment.

Policy Implications

It should be noted that the samples recruited in the present thesis might differ from people in general in important ways, meaning that great caution should be exercised in extrapolating from the current findings as they may not apply to all people. That said, they could suggest that people are nuanced in their moral judgments about human gene-editing. They consider the purpose for which it is used and their support is associated with moral considerations both about the potential outcomes human gene-editing is seen to produce and moral rules it is considered to violate. Specifically, participants are more supportive of treatment (vs. enhancement) purposes of human gene-editing. This seems to be in part because these are perceived to reduce harm and produce greater benefits than enhancement. Participants also prefer treatment over enhancement purpose in part because human gene-editing for enhancement is perceived as more of a moral rule violation than treatment purpose. Importantly, this suggest that rather than having any absolutist opposition to human gene-editing, participants distinguish between different purposes of genetic modification in their judgments. Further, the current findings show that the reduced support for human gene-editing for enhancement (vs. treatment) is in part explained by perceived unfairness. The present investigation is the first to document that this is a moral concern particular to human gene-editing which is not relevant in moral judgments about the gene-editing of farm animals in the same manner.

Public opinion research has emphasised the importance of including the general public in debates and policy making on issues pertaining to human gene-editing, arguing that their inclusion can aid trust in science (Hendriks et al., 2018). This has been deemed especially important when it comes to the development of gene-editing technologies, given the profound societal implications (Calnan et al., 2005). While some ethicists have questioned the merit of the enhancement vs. treatment distinction (e.g., see Harris, 2010; Savulescu, 2006), the present findings suggest that this distinction is nonetheless important in the support afforded to genetic modification (and conventional methods) by lay people. Given that the general public has also voiced the need to be consulted before any clinical trials become a reality (Scheufele et al., 2017), policy makers should bear this in mind when creating new regulatory frameworks for the development and application of human gene-editing. For instance by highlighting the grey areas of the enhancement vs. treatment distinction, as well as communicating considerations about the potential benefits.

Attitudes to science are shaped not merely by facts, but pre-existing values and beliefs (e.g., Kunda, 1990; Kahan et al., 2010). Indeed, Dietz (2013) argues that public participation in science inevitably involves both facts and values. Attitudes to human gene-editing is no exception, and so it is important that the communication of advances in human gene-editing reflects this. Scientific advancement does not occur in a vacuum and cannot be separated from its societal implications (Dietz, 2013; Scheufele, 2013). Scheufele (2013) argues that it is essential that science communication takes into account the manner in which science intersects with people's political and social realities. The present findings also highlight this, with participants reporting both hopes about the potential societal benefits as well as concerns about fairness in response to scenarios involving human gene-editing. Consequently, it is important that these issues are front and centre both in the science communication about advances in human gene-editing as well as in the development of regulatory frameworks.

Policy makers may also want to consider the possibility that human gene-editing could become more polarized in the future as the availability of the technology increases. From the perspective of cultural cognition (Kahan & Braman, 2006), cultural values shape the perception of risks and benefits of scientific innovations. In line with this, the pattern of increased polarization has been observed for other GMOs: as the awareness of the technology grows, the number of opponents and proponents do too (Doxen & Henderson, 2020; Macer & Ng, 2000). Future research should examine this possibility by experimentally manipulating the stance on GMHs of various relevant identities. For example, a study could experimentally manipulate partisan stance on human gene-editing and examine whether this affects subsequent levels of support.

Limitations and Future Directions

The current studies were the first to employ a systematic, carefully controlled experimental manipulation of the enhancement vs. treatment distinction to examine the effect of purpose on support of human gene-editing. The present findings indicate that enhancement (vs. treatment) purpose is consistently afforded less support across a wide range of domains, irrespective of whether the method of intervention is gene-editing or conventional. Future research should examine whether the purpose matters less for interventions in domains that are seen as either particularly high or low in utility. Specifically, in the present study disease resistance was afforded the most support and height the lowest. At the same time there was no difference in support of enhancement vs. treatment in the domain of height, and the effect of purpose in the domain of disease resistance was significant, but smaller than in other domains. In other words, it could be that when the stakes are either particularly high (reducing disease) or low (increasing height), purpose becomes less important. Relatedly, further research should also examine how grey areas of the enhancement vs. treatment distinction might impact support.

Specifically, the current studies treated the enhancement vs. treatment distinction as somewhat straightforward – either an intervention aims to bring functioning to an average level or elevate it beyond this (Daniels, 2000). For instance, the effect of purpose on support was replicated across all domains aside from height. One explanation for this could be that height constitutes one of these grey areas and that editing someone of below average height is not viewed as a treatment. Indeed, when it comes to the use of growth hormone, the classification of what constitutes “clinical shortness” has been disputed (Conrad & Potter, 2004). Far from being reserved for children with a clinical deficiency of growth hormone, the use of growth medication has been widely applied to increase the height of children without any deficiency (Conrad & Potter, 2004). Further, with height varying between nations, it is difficult to see a clean cut off point wherein lower height would classify as clinical (e.g., Natale & Rajagopalan, 2014). Future research could introduce a wider range of less clear-cut cases and examine how the effect of purpose may operate differently in these cases.

The present investigation is also the first to have directly compared the genetic modification of humans and animals. Further research should expand on this and examine how the target of gene-editing affects the kinds of moral considerations that are salient and how these moral considerations are associated with subsequent support for gene-editing. For instance, studies could explore how the differential moral status afforded to humans and animals affect the acceptability of gene-editing for different purposes (Caviola et al., 2019; Caviola et al., 2020). Given the lower levels of moral worth afforded to animals compared to humans, one could expect that the level of perceived benefits required to warrant a gene-editing intervention would be lower for animals than for people. Future studies should also examine whether endorsement of speciesism moderates this effect. I would expect that participants with lower levels of speciesism would differentiate less between the genetic modification of humans and animals, compared to participants with higher levels of speciesism. This study could also include a measure of the moral standing afforded to different entities.

Future research should also employ experimental designs to elucidate the role of disgust in moral judgments about gene-editing in different targets. At present it is unclear why the genetic modification of farm animals evoked greater ratings of oral disgust compared to human gene-editing. One potential explanation is that the disgust response is uniquely activated at the thought of consuming a genetically modified food product, which would render disgust less important in moral judgments about human gene-editing, as this does not involve ingestion (Clifford & Wendell, 2015; Hartmann & Siegrist, 2020; Rozin et al., 2008). The fact that the genetic modification of farm animals (vs. people) was rated as more disgusting only on the measure of oral disgust, and not the measure of endorsement of disgust terms, is consistent with this interpretation. However, further research should examine this by experimentally manipulating whether the genetic modification is applied to an animal for consumption vs. an animal kept for another purpose. For instance, one study could experimentally compare a genetically modified fish/ pig/ bird for consumption vs. for pet ownership, to see whether only the ingestion scenarios affect subsequent disgust levels.

Beyond the different levels of disgust ratings for genetically modified farm animals vs. people, further research should examine whether the non-significant associations between disgust and support of human gene-editing is the result of opponent processes. Specifically, future studies could involve scenarios asking participants to report how disgusting they find the intervention and how disgusting they find the condition separately. Future studies could also manipulate how disgusting a medical condition is depicted, to examine whether high disgust scenarios vs. control (holding severity constant) increases support for genetic modification.

Moreover, a central shortcoming of the present work is the lack of representative samples. The studies in the present thesis either recruited UK undergraduate students or online workers. Although some research suggests that the data quality from online crowdsourcing platforms is good (Behrend et al., 2011; Buhrmester et al., 2011; Clifford & Jerit, 2014), it is still crucial to replicate the present findings in a larger, representative sample. If the current studies are to contribute to the understanding of attitudes to human gene-editing, it is essential to examine whether the observed results generalize to the wider population. It should also be noted that the present studies only sampled from WEIRD (Western, Educated, Industrialised, Rich and Democratic) countries (Henrich et al., 2010), the UK and U.S. respectively. Consequently, it is highly likely that moral considerations concerning the genetic modification of people and animals are subject to cultural variation. Future research should examine this possibility by recruiting non-WEIRD samples and including a wider set of measures of different moral considerations.

A final limitation of the current research that needs reiteration is the reliance on mediation analyses. Although the results suggest that enhancement vs. treatment purpose is seen as producing fewer benefits, and perceived as more of a moral rule violation and more unfair, the present studies cannot rule out the possibility that the level of support afforded to enhancement vs. treatment in turn affects the endorsement of outcome- and rule-based considerations. In all likelihood the effect is bidirectional such that the level of support afforded to genetic modification influences outcome- and rule-based considerations and vice versa (e.g., Kahan et al., 2010; Ditto et al., 2012). Thus, experimental manipulations of outcome-based consideration, rule-based consideration and unfairness are necessary in order to establish a causal relation between these mediator variables and support. For instance, future studies could employ scenarios where genetic modification of humans is described as leading to unfair advantages for some over others vs. a control scenario with no reference to potential unfair outcomes, and examine whether this leads to lower support. Similarly, future investigations could use a scenario where potential social benefits of genetic modification, for instance in terms of population health, are described vs. a control condition with no mention of this. Such research could shed a light on whether this leads to greater levels of support.

Concluding Remarks

In her book "A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution" one of the pioneers of the CRISPR gene-editing technique, Dr. Jennifer Doudna wrote about the implications of the technological innovation she co-created along with her colleague Dr. Emmanuelle Charpentier:

"*The power to control our species' genetic future is awesome and terrifying. Deciding how to handle it may be the biggest challenge we have ever faced.*". (Doudna & Sternberg, 2017, p. 242.).

Today, policy makers face an enormous challenge in trying to carve out ethical frameworks and regulations that adequately deal with both the potential benefits and risks posed by human gene-editing. A vital first step is understanding what moral considerations play a role in people's moral judgments about human gene-editing. This thesis provides a starting point to the examination of the psychological underpinnings of moral judgments about human gene-editing. Its findings show that people respond in a nuanced way to the purpose of human gene-editing. Further, the studies demonstrate that the reduced support for human gene-editing for enhancement compared to treatment purposes can be explained both through lower perceived benefits as well as the perception that enhancement purpose represents a moral rule violation.

The thesis also contributes to the literature on opposition to GMOs more generally, suggesting that moral judgments about human gene-editing are guided by somewhat different moral considerations. These moral considerations are in part the product of the change in target from animals and plants in GMOs to humans themselves in human gene-editing, as well as the increased relevance of the treatment vs. enhancement distinction. Human gene-editing is here to stay. As Doudna writes "*just because we are not ready for scientific progress does not mean it won't happen*" (Doudna & Sternberg, 2017, p. 246). Researchers have a responsibility to shed light on the moral considerations that guide people's moral judgments about human gene-editing. They can aid the creation of policies that accurately reflect the moral concerns and hopes people hold for this revolutionary technology.

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Appendix A

Study 1: Support for Genetic Technologies

1. Genotyping an embryo to provide expecting parents with information about its genetic traits.
2. Using eggs that have been fertilized in a laboratory to create a pregnancy.
3. Using the cells (e.g., skin cells) of adult women and men to create female sperm or male eggs.
4. Using an artificial uterus to grow an embryo.
5. Before pregnancy, selecting eggs, sperm or early embryos that are not carrying genes for various diseases.
6. Choose certain genes of interest and subsequently select the egg, sperm or embryo that have these genes.
7. Using organs from animals that have been gene-edited to be suitable for humans in organ transplants.

Responses were recorded on a six-point Likert-scale (1 = *Strongly Oppose*, 6 = *Strongly Support*).

Appendix B

Study 1: Additional Measures

Study 1 also included some measures for purposes unrelated to the present study including a measure assessing estimates of trait selection following the use of gene-editing (i.e., “Please indicate how likely you think it is that gene-editing technologies will lead people to select certain genetic traits over others (e.g., eye colour, height).”; *0-100%*). Further, participants were asked to report the extent to which the scientists responsible for the development and application of such technologies should be recipients of various punitive responses on 10 items such as “The scientists responsible should be stripped of funding to develop genetic technologies”. Responses were recorded on a six-point scale (1 = *disagree strongly*, 6 = *agree strongly*). Finally, on the same scale participants also responded to two items measuring their support for monitoring scientists responsible for developing and using genetic technologies: “The emails and other records of the scientists responsible should be scrutinized” and “Researchers working on issues related to genetic technologies should be monitored.”).

Study 1 further included six items from a 13-item scale assessing Consequentialist moral thinking developed by Piazza and Sousa (2014). This enabled us to distinguish between a general tendency for outcome oriented moral reasoning and harm-based considerations. The scale was reduced to six items due to time constraints. Participants were asked to indicate their position to different topics (e.g., “Which of the following statements best characterizes your position on killing?”) on a three-point scale (1 = *It is never morally permissible to kill someone*., 2 = *If killing someone will produce greater good than bad consequences, then it is morally permissible to kill that person.*, 3 = *If killing someone will produce greater good than bad consequences, then it is morally obligatory to kill that person.*). Reliability was relatively low (α = .57).

A categorical measure was also used where participants simply chose between three options (1 = *The Bible is the actual word of God, and is to be taken literally word for word*; 2 = *The bible is the inspired word of God but not everything in it should be taken literally, word for word*.; 3 = *Neither*.).

Appendix C

Study 2: Domain Scenarios

1. Editing the human genome to increase the intelligence of people without learning disabilities.
2. Editing the human genome to improve the longevity of people with normal life expectancy.
3. Editing the human genome to improve the physical functioning of people without physical disabilities.
4. Editing the human genome to improve the disease resistance of people with normal immune systems.

Responses were recorded on a seven-point Likert-scale (1 = *Strongly Oppose*, 7 = *Strongly Support*).

Appendix D

Study 2: Proportion of the Population Measure

In both the general gene-editing scenario and across the four domains participants were asked to indicate how much they would support different percentages of the population to have their genes edited:

"Now please consider the amount of people who might have their genes edited. How much would you oppose or support the following proportions of the population having their genes edited?".

Participants reported their support on a 7-point scale (1 = *Strongly oppose*, 7 = *Strongly support*) on seven different proportions of the population 0%, 1%, 5%, 50%, 80%, 95%, and 100%.

Appendix E

Study 2: Free-Text Question

At the beginning of the study, right after reading the definition of gene-editing and responding to the general gene-editing question, participants were asked to respond to the question: “In your opinion, does human gene-editing pose any ethical challenges? Please explain.” in a free-text format. Participants could continue to the next questions without writing anything.

Appendix F

Study 5: Mediation Analysis Details

Study 5 also included the same questions about benefits (Social Benefit, Target Benefit, & Natural Benefit) to measure Target Harm, Social Harm and Natural Harm. However, the presentation order of benefit and harm measures were not randomised. When we conducted a moderated mediation analysis using PROCESS (Hayes, 2017; Model 7) with 95% confidence intervals and 5000 bootstrap resamples, neither Social Harm, Target Harm or even Natural Harm mediated the effect of Purpose on Support. Target did not moderate the effect of Purpose on Social Harm, Target Harm or Natural Harm. The harm measures were consistently presented after the benefit measures and thus may have been subject to order effects. I deem this likely since the questions are identical and only vary on whether they ask about benefits or harms. Consequently, I report the benefit measures in text and detail the moderated mediation analysis with harm measures below.

Specifically, the direct effect of Gene-Editing Purpose on Support for Gene-Editing was negative, with Enhancement (vs. Treatment) being negatively associated with Support, $B = -.33$, $SE = .08$, [-0.48, -0.17]. However, enhancement (vs. treatment) was unrelated to perceptions of Social Harm (a path), $B = .02$, $SE = .05$, [-0.09, 0.12]. Social Harm in turn was unrelated to Support of Gene-Editing (b path) $B = -.13$, $SE = .12$, [-0.37, 0.11]. Enhancement (vs. treatment) was unrelated to perceptions of Target Harm (a path), $B = .10$, $SE = .05$, [-0.00, 0.20], which in turn was not associated with Support, $B = -.03$, $SE = .11$, [-0.24, 0.18]. Enhancement (vs. treatment) was also unrelated to Natural Harm, (a path), $B = -.01$, $SE = 05$, [-0.11, 0.10], which in turn was significantly associated with Support, (b path) $B = -.53$, $SE = .05$, [-0.74, -0.34]. Target did not moderate the effect of Purpose on Social Harm, $B = .02$, $SE = 05$, [-0.09, 0.12], Target Harm, $B = .00$, $SE = 05$, [-0.10, 0.11], or Natural Harm, $B = .03$, $SE = 05$, [-0.07, 0.14].

Appendix G

Study 5: Multiple Regression Analysis of Proposed Mediators

To test whether the candidate mediators were significant predictors of Support, I conducted a simultaneous multiple regression analysis. Purpose (1 = Enhancement, -1 = Treatment), Target (1 = Humans, -1 = Farm Animals), Rule-Based Consideration, Social Benefit, Target Benefit, Natural Benefit, Social Harm, Target Harm, Natural Harm, and Unfairness were entered as simultaneous predictor variables, while Support was the outcome variable.[6]

Rule-Based Consideration, $\beta = -.34$ ($sr^2 = .07$), $t(344) = -7.33$, $p < .001$ was negatively associated with Support, while Social Benefit, $\beta = .26$ ($sr^2 = .04$), $t(344) = 5.35$, $p < .001$, Target Benefit, $\beta = .15$ ($sr^2 = .01$), $t(344) = 3.32$, $p = .001$ and Natural Benefit, $\beta = .13$ ($sr^2 = .01$), $t(344) = 2.86$, $p = .005$. In contrast Purpose, $\beta = -.04$ ($sr^2 = .00$), $t(344) = -1.09$, $p = .275$, Target, $\beta = .03$ ($sr^2 = .00$), $t(344) = 0.89$, $p = .374$, Social Harm, $\beta = -.04$ ($sr^2 = .00$), $t(344) = -0.64$, $p = .524$, Target Harm, $\beta = .00$ ($sr^2 = .00$), $t(344) = 0.08$, $p = .936$, Natural Harm, $\beta = -.10$ ($sr^2 = .00$), $t(344) = -1.84$, $p = .067$, and Unfairness, $\beta = -.06$ ($sr^2 = .00$), $t(344) = -1.38$, $p = .169$, were not significantly associated with Support.

[6] *Note*. I included the measures of harm in this analysis despite the potential order effects detailed in Appendix F.

Appendix H

Study 6: Purpose and Method of Intervention Manipulations Across Different Domains

Treatment x Gene-Editing

1. *Intelligence:* A novel gene-editing technique that involves editing the human genome to increase the intelligence of people with learning disabilities.
2. *Longevity:* A novel gene-editing technique that involves editing the human genome to improve the longevity of people with reduced life expectancy.
3. *Mobility:* A novel gene-editing technique that involves editing the human genome to improve the physical functioning of people with physical disabilities.
4. *Disease Resistance*: A novel gene-editing technique that involves editing the human genome to improve the disease resistance of people with weakened immune systems.
5. *Height:* A novel gene-editing technique that involves editing the human genome to increase the height of people with below average height.

Treatment x Conventional

1. *Intelligence:* A novel educational technique that involves different exercises to increase the intelligence of people with learning disabilities.
2. *Longevity:* A novel dieting technique to improve the longevity of people with reduced life expectancy.
3. *Mobility:* A novel drug to improve the physical functioning of people with physical disabilities.
4. *Height:* A novel drug to increase the height of people with below average height.
5. *Disease Resistance:* A novel vaccine to improve the disease resistance of people with weakened immune systems.

Enhancement x Gene-Editing

1. *Intelligence:* A novel gene-editing technique that involves editing the human genome to increase the intelligence of people without learning disabilities.
2. *Longevity:* A novel gene-editing technique that involves editing the human genome to improve the longevity of people with normal life expectancy.
3. *Mobility:* A novel gene-editing technique that involves editing the human genome to improve the physical functioning of people without physical disabilities.
4. *Height:* A novel gene-editing technique that involves editing the human genome to increase the height of people with average height.
5. *Disease Resistance:* A novel gene-editing technique that involves editing the human genome to improve the disease resistance of people with normal immune systems.

Enhancement x Conventional

1. *Intelligence:* A novel educational technique that involves different exercises to increase the intelligence of people without learning disabilities.
2. *Longevity:* A novel dieting technique to improve the longevity of people with normal life expectancy.
3. *Mobility:* A novel drug to improve the physical functioning of people without physical disabilities.
4. *Height:* A novel drug to increase the height of people with average height.
5. *Disease Resistance:* A novel vaccine to improve the disease resistance of people with normal immune systems.

Appendix I

Study 6: Additional Measures

Study 6 also included a measure of religiosity and perceptions of genetically modified humans and animals for exploratory purposes. Participants responded to four items assessing their level of religiosity: "How often do you attend religious services?"; "In general, how important are your religious or spiritual beliefs in your day to day life?"; "When you have problems or difficulties in your work, family or personal life, how often do you seek spiritual comfort?" and "In general, would you say you are a religious person?" (1 = *Not at all*, 7 = *A great deal*; α = .95).

Further, participants were asked to indicate how they perceived humans and animals that have been genetically modified on two questions. In response to question: "To what extent would you view a human/ an animal that has received gene-editing as..." participants indicated the extent to which they saw the human/ animal as Natural – Unnatural, Essentially the same as before the gene-editing – Essentially different from before the gene-editing, Not at all creepy – Very creepy, Not at all unsettling – Very unsettling, on a 10-point scale.

Appendix J

Study 6: Multiple Regression Analysis of Proposed Mediators

To test whether the candidate mediators were significant predictors of Support, I conducted a simultaneous multiple regression analysis. Purpose (1 = Enhancement, -1 = Treatment), Method (1 = Conventional, -1 = Genetic Modification), Rule-Based Consideration, Perceived Benefits and Unfairness were entered as simultaneous predictor variables, while Support was the outcome variable.

Purpose was negatively associated with support, $\beta = -.12$ ($sr^2 = .01$), $t(323) = -3.22$, $p = .001$, Method, $\beta = .07$ ($sr^2 = .00$), $t(323) = 2.34$, $p = .020$, Rule-Based Consideration, $\beta = -.32$ ($sr^2 = .05$), $t(323) = -7.24$, $p < .001$, was negatively associated with Support, while Perceived Benefit, $\beta = .72$ ($sr^2 = .05$), $t(323) = 14.84$, $p < .001$ was positively correlated with Support. Finally, Unfairness, $\beta = -.08$ ($sr^2 = .00$), $t(323) = -1.70$, $p = .091$, was not significantly associated with Support.