Making Sense of Genetics: *The Problem of Essentialism*

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While the pace of scientific progress continues to increase, laypersons are left in a quandary. If they don't have years of specialized training and education at their disposal, how can they make sense of new scientific findings that are inherently complex? What makes our efforts to understand difficult scientific concepts even more challenging is that we typically don't process information in an accurate and even-handed way. Much of contemporary psychology is predicated on the various shortcuts, metaphors, biases, and motivations that people recruit when they try to understand their worlds. It is because of shortcuts such as that known as the "availability heuristic" that people are more worried about being killed in a plane crash despite the far greater likelihood that they'll meet their end in a car crash. Our reliance on metaphors to scaffold our understanding of unfamiliar concepts leads us to have a very different understanding of "love" if we hear that "love is a journey" than if we hear that "love is an addiction." The presence of a durability bias makes academics fear that an unfavorable tenure decision will leave them miserable for the rest of their lives. And our motivated reasoning biases convince us that the referees are biased in favor of the opposing team. The information that ultimately guides our behavior does not necessarily reflect the actual state of things, but rather is filtered through a set of illusions, intuitions, and biases that can distort it beyond recognition.

Given the biased nature of human information processing that often detracts from our ability to appropriately apprehend reality, it is perhaps not surprising that lay people have difficulty in accurately understanding genetic concepts. The way genomes underlie phenotypes is vastly complex, and most people have little or no training in much of the relevant science. Yet, despite having little formal background in genetics, people encounter information about genetics on a regular basis, as in frequent media reporting on new genetic discoveries (such as "Infidelity lurks in your genes"), 23andMe commercials showing people acquiring new ethnic identities as the result of their genotyping, and stories of celebrities making serious medical decisions on the basis of their genetic testing results. How do people make sense of this kind of information in the absence of sufficient scientific education? The challenges we face are made that much worse because of an innate set of psychological intuitions that lead us to think about genetic concepts in a highly inaccurate and biased way. As we'll describe below, these intuitions often lead us astray, and they can have diverse and problematic consequences when people encounter genetic concepts. This suite of intuitions is known collectively as "psychological essentialism."

"Psychological essentialism" refers to tendencies of people to view the natural world as emerging from the result of deep, hidden, and internal forces called "essences." Essences, according to John Locke, "are the very being of anything, whereby it is what it is."[1] These essences are imagined to form the basis of identity for any natural entity, and they are what are believed to allow the entities to function as they do. While philosophers have debated about how such essences might underlie our worlds, psychologists have focused on the question of what intuitions people have about essences. The intuitions that people commonly share about essences are not acquired through the result of formal education, as they are clearly present among young children, and they are not dependent upon particular cultural learning, as they have been found to exist in every one of the many diverse cultures

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within which they've been studied.[2] Having such intuitions appears to be an innate feature of the human mind.

Our intuitions regarding psychological essentialism have a number of characteristics that are relevant for how people make sense of genetics. First, we view essences as the ultimate causes of the natural world. Consider the question, say, of why a lion is like a lion. What gives rise to its powerful frame, sharp teeth and claws, hunting prowess, furry mane, and penchant for zebras? Aristotle famously proposed that every entity possesses an essence that ultimately makes it what it is and that, without such an essence, the entity would no longer be itself. So we assume that a lion is the way it is because it has some kind of essence that makes it so. And if there were a way that one could surgically remove the lion's essence, then it would lose these attributes and would no longer seem like a lion as we know it. Essences are perceived to be the ultimate basis of everything in the natural world.

Second, people tend to think of essences as immutable—they cannot be changed by any external forces. So, for example, while a family may own a pet lion that usually behaves in a docile manner, no one would really be all that surprised to hear that one day the lion attacked the plumber. The lion's underlying essence that makes it such an imposing predator remained intact despite its being reared as a beloved pet. The essence remains impervious to the lion's experiences. We think of essences as forces that exert their influence regardless of what events may occur in an organism's life.

A third feature of psychological essentialism is that essences are believed to be deep down and internal. They exist invisibly, far past our vision, although we feel confident that they really are there deep below the surface, and we trust that scientists would be able to detect them. And we believe that any modifications that are made on the surface of an animal, such as performing surgeries or cosmetic changes to make, say, a raccoon look like a skunk, would not penetrate deeply enough to affect the underlying essence. Despite the powerful forces that we attribute to essences, we imagine that they lie too far beneath the surface for us to be able to witness them directly ourselves.

Fourth, we rely upon essences to draw the boundaries of categories. Members of the same category are seen to have a similar essence, which clearly differs from those that belong to a different category. In fact, the very basis of the categories is determined by the essences that underlie them. For example, the basis of modern scientific taxonomy developed by Carl Linnaeus was predicated on the assumption that different species possess different essences. We imagine that essences are what allows nature to be carved at its joints.

A fifth feature of essences is that they are thought to be natural—they are believed to specifically underlie natural entities, and not human-made artifacts. So people share the belief that gold possesses a different essence than does fool's gold, despite looking so similar, and they know that it's just not possible to change the one into the other without somehow modifying its underlying essence. In contrast, human artifacts are not seen as having an underlying essence—for example, the boundary that distinguishes a shirt from a blouse is one that is drawn by convention, and people have no problem with the alteration of one artifact such that it can become another.[3] [AU: the assertion that people "have no problem" with any alterations of this sort feels inaccurate. Many people would be upset to see, for instance, a church turned into a department store or a U.S. flag turned into a tablecloth. Is the idea that people can recognize or accept that the alteration is possible (whether they like it or not)?] We imagine that the natural world emerges from essences, but that artifacts do not.

And a last feature of essences is that they can be transferred. We can see evidence for this intuition in people's beliefs that an object that has been owned by someone comes to possess some of their essence, and this is a key reason that people will pay so much for objects that have been owned by celebrities—such as the tissue used by Scarlett Johansson that sold for more than $5000. This sense that essences can be transferred also underlies the tendency for approximately one third of heart-transplant recipients to feel they have come to acquire some aspects of their heart donor's behaviors.[4] So while we believe that an essence originates with an individual, it is imagined to have a contagious quality that can spread to other objects that come into contact with it.

It is this set of intuitions about essences that serves as our framework for thinking about how lay people make sense of genetics.[5] People's lay understanding of genes shares many features in common with their intuitions about essences. Like essences, an individual's genes are present at birth, and despite the huge physical and psychological transformations that occur across one's lifetime, they remain stable and largely unchanged throughout their lives. An individual's genes are unique to that individual (barring any monozygotic twins), and approximately half of them can be transferred to their offspring. While we can't see a person's genes ourselves, we trust that scientists are able to identify them with the right equipment and know-how. And most importantly, we understand that genes underlie a person's identity—they ultimately contribute to make the person who they are. Given this substantial overlap between a lay understanding of genetics and lay intuitions about essences, we argue that, when most people are thinking about genes, they are not really thinking about genes in the complex ways that good scientists are—they are thinking about them in the simplistic ways that lay people customarily think about essences.

Ilan Dar-Nimrod and one of us, Steven Heine, argue that people possess a set of genetic essentialist biases that are activated whenever people encounter genetic concepts—that is, people come to think about genes as possessing some of the same kinds of features that they view as characteristic of essences.[6] First, people tend to think of genetic causes as immutable—if a gene is perceived to have a particular outcome, then that outcome is viewed as being determined. For example, research finds that, when people learn of a genetic cause for a disease, they subsequently feel less in control of the disease.[7] Second, people tend to view genetic causes as ultimate causes. All other causal factors may be discounted once an individual learns of a genetic cause. Sometimes people may even equate the notion of having a genetic "risk factor" for a trait with having the trait itself. As an example, the controversial Christian radio host Bryan Fischer argued against the notion that sexual orientation could have a genetic component on the basis of twin studies. As he reasoned, in the case of identical twins, "If one of them is gay and it's genetically caused, the other one ought to be gay one hundred percent of the time."[8] He viewed a genetic cause as necessarily being absolute.

Third, people view genes as drawing the boundaries of categories of social groups. Those people who belong to the same group, such as "Chinese people" or "gay people," are seen to be more genetically similar to each other, and people who belong to different groups are seen to be more genetically different from each other. Last, people view genetic causes as natural. This also renders them vulnerable to the naturalistic fallacy, according to which what is natural is equated with being good or desirable, such that when genes are believed to be connected with something bad (such as schizophrenia), the result is viewed less negatively than when people don't view genes as being involved.[9] The flip side of this is that if genomes are modified through unnatural means, they will tend to be viewed as morally problematic, as genetically modified foods are by many [AU: ?].[10] We are not claiming that the only thoughts that people have about genes are ones that are consistent with these essentialist biases. Celeste Condit is indeed correct in highlighting, in her essay in this special report, that people have competing thoughts about causality and that particular circumstances can lead one kind of cause to be prioritized over another.[11] We are arguing, however, that people's essentialist intuitions make genetic attributions out to be [AU: ?] particularly potent, which can often lead them to have undue influence on people's judgments.

We term these intuitions "genetic essentialist biases"; however, one might question whether these tendencies can really be called biases or whether they reflect the true nature of genes. It's important to note that the ways genotypes relate to phenotypes are complex and lie along a continuum. On the one end, which Eric Turkheimer terms "strong genetic influence," are instances in which one gene has a direct and deterministic relationship with a phenotype, as in the case of Huntington disease—a fully penetrant autosomal dominant condition.[12] In this disease, the genetic influence is immutable (there is no known way to halt the disease's progression); the condition has an ultimate genetic cause (the only way to get the disease is to have a minimum number of repeating CAG trinucleotides on the *HTT* gene, and if one has a specific number of those repeating CAG strings, then one will get the disease); the presence of the problematic allele does divide people into somewhat discrete and homogeneous categories with respect to their disease risk; and the condition is natural—it is inherited at the moment of conception. These genetic essentialist biases are not an unreasonable way of considering the genetic risk of Huntington's.

However, this kind of direct Mendelian relation between genotypes and phenotypes is relatively rare with respect to common human conditions. The so-called fourth law of behavioral genetics specifies that "a typical human behavioral trait is associated with very many genetic variants, each of which accounts for a very small percentage of the behavioral variability."[13] In these cases, having a particular allele, or even a large suite of identified risk alleles, does not have a deterministic relation to the phenotype. In these far more common cases, of what Turkheimer refers to as "weak genetic influence," the phenotype is influenced by many, many genes, whose expression is dependent on experiences in the environment, the point in an organism's developmental trajectory, and various epigenetic markers.[14] For the vast majority of human traits and conditions, then, people's genetic essentialist biases really are biases—inaccurate and irrational ways of making sense of genetic causation. And the presence of these biases leads to distinct consequences in people's attitudes and behaviors, many of which are harmful, as we describe below.

Evidence for Genetic Essentialism

How can we see that people really do think about genetic causes in biased and inaccurate ways? Much of the evidence for these genetic essentialist biases comes from studies that explore the kinds of reactions people have when they learn that genes are purportedly involved in particular conditions.[15] Typically, these studies compare people's reactions to learning that a condition has a genetic cause to the reactions of those who learn that the same condition has an environmental cause or to responses from those [AU: Or? Were people in controls groups responding to some information?] in a neutral control group. Of course, in reality, the vast majority of human conditions are the product both of genes that an individual inherits and of life experiences. But the way these studies describe the influence of

genes on a particular condition is similar to the way genes are sometimes portrayed in the media. And research consistently finds that people have very different reactions to genetic versus environmental explanations.

For example, consider the causes of obesity. Much research has identified a variety of genetic variants that correlate with obesity risk—that is, that there is a genetic component to obesity. However, people's lifestyles also contribute to obesity risk—this is why obesity rates have risen dramatically over the past generation across most of the industrialized world. But how does reflecting on these different causes of obesity affect people? In one study, Canadian university students were randomly assigned to read one of three newspaper articles.[16] Those assigned to a "genes condition" read an article that accurately described scientific research that discussed genetic causes of obesity. Those assigned to an "environmental condition" instead read an article accurately describing research about environmental causes of obesity. And those assigned to a control condition read an unrelated article. Following this part of the study, participants ostensibly took part in a food-tasting study, where they were given a bowl of cookies to evaluate on a number of dimensions. The actual primary interest of the study was to assess how many cookies people ate after reading the essays. The results revealed that people consumed more cookies after reading the article about genetic causes of obesity than they did in the other two conditions, which did not differ significantly from each other. Those who learned about obesity genes reported believing that people's weight was less under their control than those who learned about environmental causes of obesity.

A conceptually similar study was conducted to assess how people think about gender. What is the best account for explaining why men and women often act in different ways? Do lay people tend to think that these behavioral differences are due to different experiences or to different genes? One study considered this by having female Canadian university students read one of three fictitious articles that discussed entirely bogus research on gender differences in math performance. Some read an article that described the purported discovery of math genes on the Y chromosome. Others read about how researchers had found that elementary school teachers tend to teach math differently to boys and girls. And a third group read that there was no evidence for any math performance differences between males and females. After reading one of these bogus articles, the participants all took an extremely difficult math test. The results indicated that those who read about "math genes" got fewer answers correct than those in the groups that read the other two essays (whose results did not differ from each other).[17] The poor performance for those in the genetics condition is evidence for stereotype threat—the tendency to choke under pressure when one realizes they are in a situation where they may act in ways consistent with a negative stereotype about their group.[18] In contrast, there was no evidence for stereotype threat among those women who read about environmental causes of a gender difference in math performance. To the extent that these findings can be generalized, they suggest that women feel they can escape a stereotype that is grounded in experiences, but they feel they cannot escape a stereotype grounded in genes.

Encountering genetic arguments does not just affect an individual's own behavior—it can also affect how people think about others. Consider how people think about those who belong to different races from themselves. What role do genes play in people's racial biases? Studies have found that when people are told that there is a genetic foundation to race (as opposed to a social foundation)[19] or are informed about the differential distribution of gene frequencies around the world,[20] they subsequently show more of a preferential bias for their racial ingroup. Learning about genetic differences between populations can even lower people's expectations for resolving international conflicts, and, on the flip side, learning about genetic similarities between groups can be associated with more positive attitudes toward other groups.[21] That is, encounters with ideas about the ways that genes underlie racial differences appear to exacerbate racial tensions. When we think of people around the world as having different essences from our own, it makes them seem different at a fundamental level. People with different genes seem to belong to different categories from ourselves, and this underlies many of our prejudices.

The consequences of lay people's essentialized views about genes as described above are clearly quite undesirable. Considering genetic differences between groups can underlie people's intolerance of those groups. But it's not

always the case that essentialism is associated with intolerance toward others. For example, consider the question of the role of genes in sexual orientation. Attitudes toward lesbian, gay, bisexual, and transgender individuals remain politically contentious, and much of the controversy revolves around people's theories about what causes different sexual orientations. For example, surveys reveal a striking positive correlation between one's support for gay rights and the belief that a person's sexual orientation is innate.[22] Moreover, other studies have found that, when people are informed about a biological basis of homosexuality, they become more supportive of gay rights.[23] It seems that when people consider the role of biology in sexual orientation, they are more likely to think different kinds of sexual orientation to be "natural" and thus more acceptable. This example echoes a point raised by Condit's essay in this special report, showing how people may employ their essentialist attitudes about genes in a strategic way.[24] When essentialist views are consistent with people's own preferences, they may embrace them, whereas when these views are inconsistent with their preferences, they may staunchly reject them.

The role of genes in sexual orientation is one example of a case in which people might use genetic foundations as a basis from which to derive moral appraisals. A related form of appraisal occurs as laypeople think about criminal responsibility based on the perceived genetic basis of criminal behavior. This is especially pertinent given that an important foundation of many legal systems is the establishment of criminal intent, or *mens rea*. If people reason about genes in essentialist terms, then learning about a "criminal gene" would also lead people to assume that criminal behavior is outside the realm of conscious control and willful intention—a mitigation of *mens rea*.

Several studies have tested people's perceptions of a "criminal gene" based loosely on what the media has simply dubbed the "warrior gene."[25] Popular portrayal of this gene emphasizes the idea that having a particular genetic allele predisposes one to aggression and antisocial behaviors. These studies asked participants to read a criminal briefing of a case in which the defendant is on trial for killing a stranger. Participants were then randomly assigned to read one of three explanations for the criminal's behavior: a genetic account based on [OK?] the commonly known concept of the "warrior gene," an environmental account that cited the defendant's rearing environment, and a control condition that did not include an explanation. To equalize the different causes as much as possible, the genetic and environmental explanations were explicitly described as leading to the same level of increased aggression. Following this description, participants answered several questions about the applicability of various criminal defenses, several perceptions of the defendant's mentality, and the appropriate prison sentence.

Results indicate that people generally thought about genetic causes differently from environmental causes, attaching more fatalism to genes. For instance, genetic explanations led people to think that insanity and diminished-capacity defenses (defenses that negate or mitigate *mens rea*) were more appropriate for the defendant than did environmental explanations. Furthermore, genetic causes (relative to environmental causes) also led people to ascribe less behavioral control and perceived intention to harm on the part of the defendant.

The above findings suggest that people perceived a lack of control regarding—and were more fatalistic about—criminal behavior when genes were used to explain it; however, this fatalism seems to be a double-edged sword. On the one hand, mediation analyses showed that people who focused on the lack of self-control based on genetic explanations prescribed more lenient sentencing for the defendant. This indicates that people felt that the defendant was not as deserving of a severe punishment in this case since it was beyond his control. On the other hand, this lack of self-control also means greater expected recidivism, and people who focused on this aspect of genetic criminality prescribed more severe sentencing—people wished to remove the criminal from the population for longer to keep others safe. These two opposing reactions to genetic attributions largely canceled each other out in terms of the length of the sentence that people were willing to assign to the defendant; and this perhaps suggests why court cases that reference genetic causes usually don't affect sentencing decisions.[26] Genetic essentialism, thus, can affect people's judgments and outcomes in complex ways that relate to a sense of fatalism and lack of control.

Some of the findings discussed above might seem surprising given what is argued elsewhere in this special report, as in Condit's essay on strategic use of genetics. We suggest that a key reason for this discrepancy is in the different methods that are used. As social psychologists, we come from a tradition where we see people as having multiple levels of understanding. There is the level at which people are aware of [/// "information"?] and can articulate understanding, and there is a level at which information may influence people's thoughts and behaviors, even though it lies outside their conscious awareness.[27] Indeed, social psychologists have long argued that people are only consciously aware of a small fraction of the information that they encounter.[28] Moreover, people's motivations shape the kinds of ideas they will endorse, with self-deceptive motives helping them to preserve a positive view of themselves and impression-management motives helping them to project a positive impression on others.[29] So, for example, when asked directly, very few people will endorse statements that they hold negative views about other races, even on anonymous surveys; however, various experimental meth-

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ods reveal that negative views about other races are far more commonly held. Hence, there can be a real difference in the kinds of understandings that people are consciously aware of and can articulate and the kinds of understandings that influence their behavior beneath their awareness, and these two kinds of understandings are assessed with different methods.

In addition to this methodological point, we also suggest that Condit's view and ours are largely complementary. We agree that people hold flexible, context-dependent views on the origin of phenotypes. However, the way that lay people understand genes makes them particularly apt as essence placeholders leading to essentialist biases. Environmental factors, by contrast, are external to the individual and therefore do not lend themselves well as essence placeholders. While people certainly understand that any outcome has multiple causes, and while any one explanation may be used strategically, as Condit notes, we contend that genetic explanations can shift people's views in more deterministic ways than can environmental accounts. Frequent exposures to simplistic genetic information can have important impacts on the ways that people think of the associated phenotypes.

Reducing Genetic Essentialism

In light of the often pernicious consequences that genetic essentialism can have, an important question to consider is whether it can be reduced. Are there any methods by which people can learn to respond to genetic information in more constructive ways?

One issue to consider is whether people can calibrate their responses to the magnitude of a specific genetic effect. While thinking about genetic causes as being close to deterministic may be appropriate for cases of strong genetic causation such as Huntington disease, viewing genes as deterministic would seem to be quite inappropriate for cases of weak genetic causation, where the risk factors of individual genes tend to be quite small. Given that the fourth law of behavioral genetics reminds us that the vast majority of individual genetic causes for human conditions are small in terms of their effect sizes, it would seem that, if people were being rational, they should have very little response to learning about a particular gene that by itself can explain very little. If this were the case, genetic essentialist reactions could be reduced by simply informing people accurately about the very small associations that most individual genes have with any human conditions. Yet polygenic risk scores based on the aggregation of thousands of variants with weak risk factors can have fairly strong predictive value. More research needs to be conducted to see how people respond to this kind of information.

But how well can people calibrate their reactions to information about genes that, by themselves, explain a large or a small part of the genetic influence on the trait of interest? We have investigated this question in the context of the same scenario described above, with participants asked to consider a hypothetical murderer with a putative genetic risk factor for his aggression. We compared participants' judgments for the defendant when they learned that he had a genetic risk factor that increased his violent tendencies that varied from as little as 0.5 percent to a risk factor as high as 80 percent.[30] Participants' judgments were compared with those who were not told of any risk factor. We found that participants who were told that the defendant's genetic risk was only 0.5 percent higher were significantly more likely to view him as not morally responsible for his crime t[illegible]were those who did not learn of any genetic risk. [C[illegible]ct?] Moreover, even though the amount of genetic risk that participants were informed of varied across conditions from 0.5 to 80 percent (in other words, they varied by a factor of 160), people's judgments did not differ anywhere near this extent. Participants were influenced more by whether a genetic risk was discussed than they were by the magnitude of the genetic effect. These findings suggest that it is unlikely that people's essentialist reactions can be corrected by accurately informing them of the small risk factors of most individual genes.

Another route by which genetic essentialism may possibly be mitigated is by making genes appear to be less like essences. How would people respond if, rather than imagining genes to have a direct and immutable correspondence with phenotypes, they could consider the relations between genotypes and phenotypes in light of their rich interactive complexity? If people were led to focus on the ways that environmental experiences interact with individual genes, then maybe they would be less likely to impart such deterministic powers to genes. Such kinds of interactive rela-

tions between genes and the environment would seem to undermine the essence-like character of genes.

We have investigated this question in a number of studies.[31] Again, we used the above scenario where people considered a murderer who was described as having some risk factors for violent behavior. Some participants learned that the defendant had a childhood history of abuse that increased his risk for violence; another group of participants learned that he possessed a single gene risk factor; another group learned that he possessed a small number of genetic risk factors that interacted with his childhood experiences of abuse; and another group learned of his polygenic risk score, which had been calculated based on more than one hundred genetic markers and that interacted with his childhood history of abuse. All of these participants were informed that the defendant had the same increased risk for violence (a 25 percent increased risk), and their judgments were compared with those of participants who were not told of any risk factors of the defendant. Participants were asked to consider the applicability of a diminished-capacity defense for the defendant. The results revealed that the more complex the genetic account, the less likely people were to conclude that the defendant had mitigated *mens rea*. When participants learned that the risk factors for the defendant were based on interactions between his genes and his experiences, they were less likely to view a diminished-capacity defense as applicable than they were when they learned of a single-gene risk factor. However, participants in the gene-environment interaction conditions were still more likely to see a diminished-capacity defense as applicable than were those who learned solely of an environmental cause of the defendant's violent behavior or those who learned of no risk factors at all—that is, describing complex genetic accounts reduced people's essentialist reactions, but it did not eliminate them completely.

In the above study, the ways that genes influence behavior was far more accurately conveyed by complex gene-environment interaction accounts than by straightforward accounts of single genes. When people learned of a more accurate account for genetic influences on behavior, they showed less-essentialist reactions than when they learned of grossly simplified genetic attributions. These results suggest that a way to combat people's harmful genetic essentialist reactions is to educate the public [OK?] so that people can gain an accurate understanding of the full complexity of the ways that genotypes get translated into phenotypes. Indeed, we have also found that people who have a better understanding of genes (as indicated by their performance on a genetic literacy test) tend to have less-essentialist understandings about genetics.[32] Hence, although combating people's essentialist biases will likely remain a formidable challenge, these findings point to an optimistic conclusion—perhaps people's genetic essentialism can be reduced somewhat by simply educating them about genetics.

Essentialism Evolving

The world is experiencing a genomics revolution, and people are being exposed to more information about genetic concepts than ever before. This presents some challenges, as the average layperson has a rather limited understanding of genes' technical functions. But this limited understanding does not prevent people from frequently invoking genetic concepts to explain a wide range of human behaviors and conditions. For the most part, the genetic attributions that people make are based on intuitions about the ways that genes underlie the natural world. Such intuitions are built upon people's mental scaffolding of understanding about psychological essentialism. Some of these intuitions are reasonable approximations for the ways that genes sometimes operate, particularly in the case of monogenic conditions. However, these intuitions lead people to have an overly deterministic understanding of genetics, which, as the studies described above indicate, can sometimes have harmful consequences—and sometimes have beneficial consequences.

Much has been learned about the consequences of people's genetic essentialist tendencies; however, a number of key questions have yet to be explored. For example, given that the vast majority of these studies have been conducted with Western populations, it remains to be seen whether the rest of the world has a similarly biased understanding of genetic concepts. In addition, most of the above studies have targeted people's immediate reactions to learning about genetic concepts, yet it's quite possible that people's reactions will be different after they have reflected upon matters longer. For instance, while many people report being quite fearful about the notion of having genetic testing, when people are assessed about their reactions to being genotyped a few months after receiving their testing results, the vast majority report levels of anxiety that are far lower than others had anticipated.[33] Future research that follows the time course of people's reactions to new genetic information will be important. Last, although we have identified some promising results of trying to reduce people's genetic essentialist tendencies, there is still much to learn about how these essentialist biases can be countered. As the genomics revolution continues and personalized medicine becomes a reality, people will surely continue to encounter much genetic information that they are unable to fully understand. It is important to help people understand genetic information better so they are able make well-informed decisions about their lives.

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