

automation,” she says.

Developers should routinely run tests such as those performed by Obermeyer’s group before they deploy an algorithm that affects human lives, says Rayid Ghani, a computer scientist at Carnegie Mellon University in Pittsburgh, Pennsylvania. That kind of auditing is more common now, he says, since reports of biased algorithms have increased.

He thinks that the results of these audits should always be compared to human

decision-making. Unpublished analyses by Ghani’s team have compared algorithms used in public health, criminal justice and education to human decision-making, and found that the machine-learning systems were biased – but less so than the people.

“We are still using these algorithms called humans that are really biased,” says Ghani. “We’ve tested them and known that they’re horrible, but we still use them to make really important decisions every day.”

gradient of same-sex attraction. The app cited the *Science* study and warned users that it did not predict same-sex attraction.

The researchers behind the *Science* study say that Bellenson’s app misrepresents their work. The test “is not grounded in science. It is not predictive. It won’t tell you anything”, says Benjamin Neale, a geneticist at the Broad Institute and an author of the *Science* analysis. He and his colleagues examined the DNA of around 475,000 people and found 5 genetic variations loosely correlated with people who said they’d had sex with someone of the same sex at least once. But none of the variants was so prevalent that the researchers could use them to predict a person’s sexual identity.

Neale sent a letter to GenePlaza on 14 October asking that it take down the app – or remove references to his study. The next week, Bellenson renamed the app ‘122 Shades of Gray’ and added a note explaining that the authors of the *Science* study weren’t affiliated with the project. He says that because the app has always warned users that it is not predictive, it does not misrepresent the study.

But the chorus of angry scientists on Twitter grew louder. Some echoed Vitti’s concern that the app could be abused. In his petition, Vitti noted that Bellenson lives in Uganda, where gay sex is punishable by life in prison. Vitti worried that, regardless of the app’s scientific flaws, Ugandan authorities could get hold of a person’s results and use them as evidence of sexual preferences.

Bellenson says that there are much simpler ways of discovering a person’s sexual preference, such as looking at their social-media accounts. “The idea that a government would need a DNA test to figure out if someone is gay is ridiculous,” he says.

# ‘GAY GENE’ APP PROVOKES FEARS OF A GENETIC WILD WEST

## Debate highlights broader concerns about apps that use the results of direct-to-consumer genetic testing.

By Amy Maxmen

Joseph Vitti’s stomach turned when he opened a link an acquaintance had sent him. It took him to an app called ‘How Gay Are You?’ that purported to gauge a person’s level of attraction to others of the same sex, according to their genes.

The app’s creator, Joel Bellenson, a US entrepreneur living in Kampala, Uganda, based the test on the findings of a massive study on the genetics of same-sex sexual behaviour – even though the analysis, published in *Science* in August, concluded that a person’s genes cannot predict their sexuality (A. Ganna *et al. Science* 365, eaat7693; 2019).

Vitti, a computational geneticist at the Broad Institute in Cambridge, Massachusetts, thinks the app was misleading – even dangerous. “There are vulnerable queer people all over the world,” says Vitti, “and this app stands to hurt them.” On 11 October, he started an online petition to remove the test. Within two weeks, more than 1,660 people had signed it.

Bellenson says that the idea his test could endanger people is an “absurd scenario” and notes that the test also included a warning that it could not predict same-sex attraction.

But the furore over his app highlights a growing problem in the field of genetics. Researchers conduct statistically sophisticated analyses of hundreds of thousands of genomes, searching for associations between genetic variations and diseases, behaviours or other characteristics. Anyone can take the variations identified by such studies, strip them of caveats and nuance, and market a simple genetic-interpretation tool online.

Scientists and genetic counsellors say that

these unregulated tools can harm individuals and society, causing anxiety, unnecessary medical expenses, stigmatization and worse. “It’s the Wild West of genetics,” says Erin Demo, a genetic counsellor at Sibley Heart Center Cardiology in Atlanta, Georgia. “This is just going to get harder and harder.”

Bellenson posted his app on GenePlaza, an online marketplace for DNA-interpretation tools, in early October. For US\$5.50, a person could upload their genetic data – as supplied by consumer DNA sequencing companies such as 23andMe of Mountain View, California – and the app would place them along a



Millions of people have had their DNA sequenced by consumer genetic-testing companies.

## News in focus

On 24 October, GenePlaza co-founder Alain Coletta removed the app from his platform. He and Bellenson both say they did not intend to hurt anyone by making the app available. And they echo other creators of third-party tools that interpret DNA sequencing data, who say that even if their tests aren't predictive, they encourage public engagement in science. "It may not be much better than a horoscope or a tarot-card reading, but at least it lets bioinformatics be something fun," Bellenson says.

This argument concerns genetic counsellors, who have seen a surge in the number of people seeking help for conditions that third-party tools have identified in their DNA – often inaccurately.

Tens of millions of people worldwide have now had their DNA sequenced by direct-to-consumer companies. But these sequencing companies only highlight certain genetic associations. If customers want more information, they can download their raw genetic data from these firms' sites for further exploration.

Up to 62% of customers ultimately upload their genetic data to third-party websites for a small fee, a study published in August found (T. Moscarello *et al. Genet. Med.* **21**, 539–541; 2019). GenePlaza, for example, offers DNA-interpretation apps that purport to assess intelligence, neuroticism and taste perception. Other websites advertise services that use

DNA to explore a person's ancestry, disease risk, ideal romantic partner, fondness for marijuana, nutritional needs, sleep habits and more.

In 2015, 23andMe learnt that its customers could feed their DNA data directly from 23andMe's servers into a secondary application associated with white supremacists

**“Scientists have a responsibility to describe the human condition in a more nuanced and deeper way.”**

that evaluated a person's degree of European ancestry. 23andMe shut down the app's access to data on its servers. The company went further last year by restricting direct access to its data to select collaborators.

23andMe also warns customers who download their data it cannot ensure the accuracy of third-party interpretation tools. Developers of these tests might base them on genome-wide analyses that find weak correlations, or associations that have been contradicted by additional analyses.

But Vitti thinks scientists should bear more responsibility for how their results are used – especially now that geneticists are delving deeper into social and behavioural traits,

such as links between a person's DNA and their political persuasion.

He argues that ethical review boards should assess whether the benefits of such studies outweigh the potential for harm. Genome-wide analyses are not scrutinized to the same degree as research on individuals because the data they rely on are pooled and anonymized. But the How Gay Are You? app illustrates how such analyses could lead to harmful outcomes, Vitti says.

Despite his distaste for the app based on his study, Neale says research must go on. “Scientists have a responsibility to describe the human condition in a more nuanced and deeper way,” he says.

But Sarah Nelson, a geneticist at the University of Washington, Seattle, who has studied third-party interpretation tools, worries that her peers aren't fully aware how difficult their studies can be for the public to understand. Even if researchers take pains to explain that their genome-wide analyses aren't predictive, she says, companies can still use the science as they please – and the barrier to entry is low.

Indeed, Bellenson says he whipped together his app in a weekend. He knew enough about genetics and computer programming to write an algorithm, and find a home for it online. “Genetics and bioinformatics is so mature,” he says. “Academia can no longer control it.”

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