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Abstract

Long-range familial searches in recreational DNA databases have been the subject of intense interest since the high-profile case of the Golden State Killer. This technique has raised considerable media attention and has sparked immediate criticism from forensic geneticists and other professionals, regulators, policy advisors, and ethicists. However, the literature on this topic does not capture the complexities resulting from the commodification of genetic data and the marketization of science.

In this article, I explore how long-range familial searches conducted in recreational DNA databases reframe the trajectory of forensic genetics. Arguing that the advent and consolidation of long-range familial searches in recreational DNA databases represent the fourth wave of forensic genetics, I detail its implications, namely, the expansion of affected populations, the participatory turn, and the co-production of biovalue.

Key-words familial searches; recreational DNA databases; participatory turn; biovalue.

Introduction

In the twenty-first century, genomics research and its applications are one of the most rapidly expanding fields, which has been increasingly drawing academic, industry, and policy attention. In the last decades, the collection, analysis, processing, and use of genetic data has grown massively, leading to the establishment of large DNA databases in both the forensic and health domains (Hindmarsh and Prainsack 2010; Machado and Silva 2015; Williams and Johnson 2008). More recently, there has also been a significant increase in recreational DNA databases for commercial purposes. Such databases are used by citizens to voluntarily upload genetic data to know more about their health, ancestry, and/or search for relatives (Abu El-Haj 2012; Borry, Cornel, and Howard 2010; Chow-White et al. 2018; Raz et al. 2020; Tutton 2004; Wilkinson et al. 2009).

Such considerable investment in large scale DNA databases is highly influenced by genetics' aura of objectivity, of being able to produce "certainties" and "truths" (Lynch et al. 2008). Applied to the field of law enforcement, DNA technologies are conceived as capable of identifying offenders quickly and credibly, thereby improving the efficiency of the criminal justice system (Williams and Johnson 2008; Hindmarsh and Prainsack 2010). Mobilized in the industry of recreational DNA databases, DNA is framed as a source of empowerment, healing, and a means to recover kinship links (Abel and Tsosie 2019; Abu El-Haj 2012). However, critical commentators working in both fields have outlined DNA technologies' discriminatory potential and emphasized risks relating to the violation of genetic privacy and the indiscriminate expansion of genetic surveillance (Arnold 2020; Hindmarsh and Prainsack 2010; Machado and Granja 2020; Nelson 2016).

The significant increase in the collection and processing of massive amounts of data across several spheres of social life makes clear that the future may rest not on further building and expanding mass databases, but rather on the collation of existing genetic information and the exploitation of its potential. One example of this is how recreational DNA databases are currently being used for criminal investigation purposes, thereby blurring the boundaries between previously distinct kinds of genetic collection and genetic practice. Such is made possible by conducting long-range familial searches in recreational DNA databases aiming to detect genetic relatedness to identify criminal suspects (Kennett 2019; Machado and Granja 2020; Murphy 2018; Samuel and Kennett 2020).

In this article, I explore how long-range familial searches conducted in recreational DNA databases reframe the trajectory of forensic genetics. Arguing that the advent and consolidation of long-range familial searches in recreational DNA databases represent an unexpected fourth wave of forensic genetics, I detail its implications, namely, the expansion of affected populations, the participatory turn, and the co-production of biovalue.

Long-range familial searches are also commonly referred to as forensic genealogy (Phillips 2018; Syndercombe-Court 2018). In this article, I use the term long-range familial searches for law enforcement purposes for two main reasons. The first is to establish a direct connection to the previously established familial searches conducted in forensic DNA databases for criminal investigation purposes. It is important to reflect upon the similarities and differences of familial searches in forensic DNA databases and

recreational DNA databases (Murphy 2018), as they reflect wider changes in forensic genetics. The second is because this article solely focuses on the implications of the long-range familial searches based on genetic material on a certain DNA database. It does not reflect upon other issues brought by genealogy, which is a field that not only involves genetic-lead searches; it also entails an in-depth search of several other sources, such as birth, marriage, death and census records, social media, and online family trees (Thomson et al. 2020).

Long-range familial searches in recreational DNA databases have been the subject of intense interest since the high-profile case of the Golden State Killer[1], whose main suspect was identified by a long-range familial search in 2018[2]. This technique has raised considerable media attention and has sparked immediate criticism from forensic geneticists and other professionals, regulators, policy advisors, and ethicists (Arnold 2020; Berkman, Miller, and Grady 2018; Biometrics and Forensics Ethics Group 2020; Curtis et al. 2018; Kennett 2019; Murphy 2018; Phillips 2018; Syndercombe-Court 2018; Wickenheiser 2019).

Most academic work on the ethical and legal aspects of long-range familial searches has focused on issues of privacy, confidentiality, consent, and regulation, thereby being concerned with the protection of individual rights from unwarranted use of genetic information and with debating appropriate forms of regulation (Berkman, Miller, and Grady 2018; Murphy 2018). There is also a very recent and embryonic field of research exploring public perspectives of the use of long-range familial searches for criminal investigation purposes. More particularly, a survey of 1587 US residents found that the majority of respondents supported police searches on recreational databases to identify genetic relatives (79%) and its disclosure to the police (62%), as well as the creation of fake profiles of individuals by the police on recreational databases (65%).

[1] The Golden State Killer is the name coined by Michelle McNamara to refer to a serial killer and rapist who committed at least 12 murders, and more than 50 rapes in California, USA, from 1974 to 1986. He is believed to be responsible for three crime sprees throughout California, each of which spawned a different nickname in the press (East Area Rapist and Original Night Stalker) before it became evident, through DNA analysis, that they were committed by the same person.

[2] In that case, criminal investigators used DNA from crime scenes and uploaded the genetic information into an online public-access DNA database, *GEDmatch*. Based on that search, officers found partial matches with the profile of the presumed suspect, which were assumed to belong to distant relatives. Following up on the partial match, family trees were built upon the basis of several other sources (social media and other types of online records) and Joseph James DeAngelo, 72 years old, was identified as a suspect and his "abandoned" DNA was collected to conduct further analysis. The result of the tests confirmed it matched the crime scene samples.

However, respondents were significantly more supportive of these activities to identify perpetrators of violent crimes, perpetrators of crimes against children, and missing person cases (Guerrini et al. 2018). In addition, a recent article authored by Gabrielle Samuel and Debbie Kennett also addressed perceptions of professional and public stakeholders in the United Kingdom. Their study shows general support for the technology, coupled with a range of social and ethical concerns, namely impacts on individual users of genealogy databases, to the genetic genealogy community, and law enforcement (Samuel and Kennett 2020).

However, such kind of analysis does not capture the complexities resulting from the commodification of genetic data and the marketization of science. Discussion on long-range familial searches has been done separately from social Studies of Science and Technology (STS), therefore being undertheorized. In this article, I couple the reflection upon the ethical, social, and legal issues brought by the advent and consolidation of long-range familial searches with the reconfiguration of forensic science. More particularly, I focus on three main implications: the expansion of affected populations and its potential aftereffect of reproducing longstanding structures of power and inequality; the voluntary participation in recreational DNA databases made available for law enforcement purposes and its connections with biological citizenship (Novas and Rose 2000; Rose and Novas 2005); and the associated co-production of biovalue implied in such practices. Biovalue refers to the inscription of value into biomaterials throughout its life cycle, including collection, analysis, primary and expanded uses (Mitchell and Waldby 2010; Skinner and Wienroth 2019; Waldby 2002b). Although the concept tends to be framed in economic terms, in this article I connect biovalue with biolegality, which refers to the creation of new sets of suspects based on the interaction between the criminal justice system and biotechnology (Lynch and McNally 2009).

The following questions guide my reflection: What effects might the use of long-range familial searches in recreational DNA databases have on the trajectory of forensic genetics? How are new avenues for participation in criminal investigations being produced by the advent and consolidation of long-range familial searches? What kinds of biovalue are being engendered by such a technique? Such questions allow moving from a discussion mainly focused on the ethical issues brought by the advent and consolidation of long-range familial searches towards a debate anchored on the more structural implications that such technology might provoke in forensic science.

Forensic long-range familial searches in recreational DNA databases is a very recent and still unfolding phenomenon, and its sociotechnical consequences cannot be fully known at this stage. Consequently, my aim in this article is to raise questions and develop some theoretical approaches to this recent phenomenon, rather than provide definitive answers.

The article is organized in the following manner: first, I present an overview of familial searches applied in forensic DNA databases and explain the advent and consolidation of long-range familial searches in recreational DNA databases. Then, I argue that long-range familial searches in recreational DNA databases inaugurate an unexpected fourth wave of forensic genetics and explore in detail its implications, namely: the expansion of affected populations, its participatory turn, and the associated co-production of biovalue. In the final section, I reflect upon the present and future challenges for forensic genetics.

Familial searches: From forensic towards recreational DNA databases

Familial searches in forensic DNA databases

Familial search is a term that generally refers to searches conducted in forensic DNA databases to identify criminal suspects using their genetic connection to biological relatives (Debus-Sherrill and Field 2019; Granja and Machado 2019; Haimes 2006; Kim et al. 2011; Suter 2010). Therefore, familial searches usually refer to a process through which a DNA profile that does not match any other profile contained in a forensic DNA database is subjected to a new analysis, to determine whether there are close matches. If such partial matches exist, probably, the profile obtained at the crime scene or from the victim(s) belongs to a genetic relative of the person in the database.

Familial searches in forensic DNA databases were first implemented in the UK in 2002 (Haimes 2006) and since then its use has been expanding to other countries. The Netherlands and France introduced legislation that allows the use of this investigative technique (Maguire et al. 2014) and, more recently, Germany has also approved the use of familial searches in intelligence-led DNA massive screenings (Criminal Code of Conduct—StPO §81h). In other EU countries, the situation remains unclear, although there are records of criminal cases that involved the use of relatives' DNA to search for criminal suspects in countries such as Spain (Phillips et al. 2017, 35),

Poland (Dettlaff-Kakol and Pawlowski 2002), and Italy (Jones 2015). Nevertheless, familial searches remain unregulated in most EU countries. Beyond Europe, familial searches in forensic DNA databases were formally adopted by New Zealand and prohibited in Canada due to genetic privacy concerns (Flaus 2013; Rieger 2018; Thomas 2006). The same kind of differentiation is found in the US, where familial searches are not conducted on a national level. In March 2008, the FBI determined that individual states should determine familial searches regulations (Kim et al. 2011). Despite national differences, familial searches in forensic DNA databases are usually restricted to serious criminal cases, difficult to solve by other investigative means (Granja and Machado 2019; Murphy 2018). This implies that only a reduced number of criminal cases is authorized to make use of familial searches in forensic DNA databases. For example, in the UK, since 2012, 120 cases have been authorized for familial searches, of which 9 have been resolved through this technique (Biometrics and Forensics Ethics Group 2020, 11).

The advent and consolidation of long-range familial searches

Direct-to-consumer (DTC) genomics have been gaining increasing importance in the last few years. The DTC genomics industry has emerged in the early 2000s aiming to personalize healthcare and providing information about genetic "roots" by leveraging knowledge about a person's DNA (Borry, Cornel, and Howard 2010; Chow-White et al. 2018; Gregory 2019; Horowitz et al. 2019; Tutton 2004). Since then, the field has been subjected to significant interest and several scholars have critically addressed the meanings, uses, and implications of the DTC genomics industry (Harris, Wyatt, and Kelly 2013; Kalokairinou et al. 2018; Phillips 2016; Tutton and Prainsack 2011). As outlined by Katherine Gregory:

> What consumers get in return (…) is the promise of the discovery of a "core" genetic self with each purchase and the accumulation of social capital through the co-creation of data through self-surveillance and generation of more data (Gregory 2019, 17).

Companies conducting DTC genetic testing nowadays hold databases which together have more than 30 million genetic profiles (Kennett 2019), mainly composed of individuals with North European genetic background (Erlich et al. 2018). Besides

companies conducting DNA analysis (such as *FamilyTreeDNA*, *23andMe*, and *Ancestry.com*) and which have their DNA databases, there are also publicly accessible databases. In such databases, customers might upload the DNA data generated from testing conducted by different DTC companies to find genetic connections with others who have also uploaded their genomic data, as is the case with *GEDmatch*.

According to Katsanis (2020), until November 2019, long-range familial searches have been successful in identifying the DNA profiles of 78 individuals from either criminal investigations or unidentified human remains in the USA. However, those only relate to the cases publicly revealed; there are many others under investigation. According to the author, the large majority of long-range familial searches has been led by *Parabon NanoLabs*, a company offering forensic services, such as genetic genealogy, kinship inference, and forensic DNA phenotyping (on this respect see also Granja, Machado, and Queirós 2020; Machado and Granja 2020; Wienroth 2020).

Criminal investigations resorting to long-range familial searches are, however, occurring within a framework characterized by a lack of regulatory oversight (Kennett 2019; Murphy 2018). In 2019, the US Department of Justice issued an interim policy to guide the use of long-range familial searches, indicating the types of crimes that can make use of such searches, disallowing surreptitious use of DNA databases, and requiring that a search must be made on the national forensic DNA database before using long-range familial searches in recreational DNA databases (United States Department of Justice 2019). However, such an interim policy doesn't address the qualifications of genealogists conducting the analysis (see in this respect Kennett 2019) neither provides clear guidelines for how DTC companies should regulate the use of their genetic databases for law enforcement purposes.

Consequently, due to the lack of regulatory norms, several companies in the market reacted differently to law enforcement searches (Kennett 2019). Skeva, Larmuseau, and Shabani (2020) conducted a review of 22 companies' and databases' policies regarding access to customers' genealogy data for law enforcement purposes. Their study shows that all companies and databases communicated either the possibility of access for law enforcement purposes or the disclosure of users' information if requested by law. However, their policies differed in terms of how they formulated access by law enforcement bodies. For instance, the companies *23andMe*, *Ancestry*, and *MyHeritage* state that they will try to resist law enforcement inquiries. Furthermore,

23andMe, *Ancestry*, and *Helix* provide a transparency report in which they summarize all law enforcement and/or governmental requests they received. Among the 22 companies and databases, *FamilyTreeDNA* and *GEDmatch* do not require different formal requests to provide information to law enforcement (Skeva, Larmuseau, and Shabani 2020).

According to Skeva and colleagues (2020), *FamilyTreeDNA* instituted a policy in March 2019 that automatically opts-in users from matching in law enforcement searches. However, considering the EU General Data Protection Regulation (GDPR), European users of *FamilyTreeDNA* have all been automatically opted out. This means that European citizens must opt-in if they wish to have their DNA profile included in long-range familial searches for criminal investigation purposes (Biometrics and Forensics Ethics Group 2020).

Since the controversy caused by the Golden State Killer criminal case, *GEDmatch* went through two particularly important transformations. First, the company has undergone several modifications in its privacy policies, namely regarding the type of crimes for which the database could be used and whether users should have to opt-in to or opt-out of sharing their data with the police (Katsanis 2020). Nowadays users can opt-in for law enforcement searches, thereby leaving the decision to each citizen's individual choice. Such policy initially raised concerns about the future utility of *GEDmatch* for long-range familial searches as what was once a database of more than a million people shrunk to 18% that size (Katsanis 2020). However, the numbers of opting-in have been recently increased, which might be related to the popularity of news and TV shows showing the alleged "efficacy" of long-range familial searches. For instance, the *Genetic Detective* show, in which CeCe Moore, a geneticist working for *Parabon Nanolabs*, solves high-profile criminal cases. According to most recent data, about 280.000 out of 1.45 million profiles had been opted-in for law enforcement searches[3]. This is in line with studies that show high public support for long-range familial searches for law enforcement purposes (Ram, Guerrini, and Mcguire 2018; Samuel and Kennett 2020).

The second important transformation affecting *GEDmatch* refers to the fact that, in December 2019, the non-profit website owned by two genealogists (Curtis Rogers and John Olsen) (Kennett 2019), was acquired by *Verogen*, a profit-oriented forensic

[3] https://www.buzzfeednews.com/article/peteraldhous/hackers-gedmatch-dna-privacy

genomics company specialized in next-generation sequencing solutions for forensic laboratories. Although the purchase of *GEDmatch* was accompanied by promises of improving the system's security, in July 2020, there was a security breach in which all user permissions were reset, making all profiles visible to all users. This implied that, during a particular period, users who did not opt-in for law enforcement matching were available for law enforcement matching, and, conversely, all law enforcement profiles were made visible to *GEDmatch* users.

In the absence of legal precedence, companies holding recreational DNA databases, therefore, raise clear questions about accountability, ownership of data, and infringements of citizens' rights. The transnational nature of such databases, as companies provide services in several countries, complicates this scenario even further (Skeva, Larmuseau, and Shabani 2020; Thomson et al. 2020). Long-range familial searches in recreational DNA databases are mainly taking place in the USA. Nevertheless, this investigative method has captured the interest of other countries. For example, in Sweden, prosecutors have allowed investigators to use consumer genealogy databases to solve cold cases (Skeva, Larmuseau, and Shabani 2020): a missing person and a criminal case that is, at the date of writing, on trial[4]. In Canada (a country that forbids familial searches in forensic DNA databases) two cold cases were also solved through long-range familial searches in recreational DNA databases[5]. In the UK, a study assessed the likely effectiveness of long-range familial searches through *GEDmatch*. In such assessment, four of the ten donors were identified which confirms that, despite the over-representation of US citizens on publicly accessible recreational databases, there is still potential for effective use in investigations outside the US (Thomson et al. 2020). Subsequently, the Biometrics and Forensics Ethics Group also published a report on the feasibility of using long-range familial searches to assist in solving crime in the UK. Overall the report concludes that since UK possesses one of the most efficient DNA databases in the world, the bulk of perpetrators will be identified, without necessarily resorting to long-range familial searches that might significantly increase costs and effort. Nevertheless, the report concludes that the technique might be initially used for

[4] https://www.theguardian.com/world/2020/sep/15/man-on-trial-in-sweden-for-double-murder-after-15-year-dna-wait

[5] https://www.theglobeandmail.com/canada/article-genetic-genealogy-generates-heated-debate-over-privacy-while-helping/

identifying otherwise unidentifiable bodies (Biometrics and Forensics Ethics Group 2020).

Reframing forensic genetics: an unexpected fourth wave?

Wienroth, Morling, and Williams (2014) described the trajectory of forensics genetics as framed around four main waves. The first is largely focused on establishing the credibility of DNA profiling and regulating its uses in criminal trials (Aronson 2007; Derksen 2010, 2003; Jasanoff 2006; Lynch et al. 2008). The second wave relates to the establishment, expansion, and use of national forensic DNA databases across the world (Hindmarsh and Prainsack 2010; Williams 2010) and the associated transnational exchange of DNA data (Machado and Granja 2018, 2019; Machado, Granja, and Amelung 2020; Prainsack and Toom 2013, 2010). The third wave encapsulates the development and increasing application of technologies that go beyond identification, such as familial searches and forensic DNA phenotyping (Granja and Machado 2019; Granja, Machado, and Queirós 2020; Haimes 2006; Murphy 2010; Samuel and Prainsack 2018; Wienroth 2018, 2020).

The third wave aims to respond to cases in which a DNA profile can be obtained from biological evidence found at a crime scene but there is no correspondence with forensic DNA databases (Wienroth, Morling, and Williams 2014). This wave represents a historical change in the presence of forensic genetic technologies in criminal justice systems for two main reasons: First, because it shifts the focus from the construction of evidence towards the generation of intelligence valuable to criminal investigations. Second, moves the locus from individualization towards the clustering of suspect populations (M'charek 2008).

Advancing the possibility of a fourth wave on the horizon, Wienroth, Morling, and Williams (2014) referred to the blurring of boundaries between medical and forensic genetics. That is, the emergence of a type of analysis that aims to derive health and lifestyle information from epigenetic and genomic data to be used for forensic purposes (in this respect see, for example, Vidaki and Kayser 2018, 2017). I argue that we are assisting to the consolidation of a fourth wave in ways that were mainly unforeseen and unexpected. This does not imply, however, that what Wienroth, Morling, and Williams (2014) conceived as being the fourth wave won't occur. It just

means that there is a new wave in the trajectory of forensics genetics consolidating in the between, which brings new specificities.

Long-range familial searches are a combination of the second wave, which marks the establishment, expansion, and use of databases, and the third wave, that established the use of SNPs for forensic purposes. The fourth wave incorporates all of these changes brought by the previous waves but in ways that further consolidate and expand it. As I will discuss in the following sections of the article, the fourth wave further enlarges the datasets and data subjects that can be used to search for criminal suspects, implying that involvement with the criminal justice system is no longer a pre-requisite to participate in law enforcement searches. In addition, the fourth wave also puts into focus how the accelerated development of genomic technologies has opened up much leeway for the emergence of specialized markets in forensic genetics, therefore bringing to the center the commodification of genetic knowledge and marketization of science. Such trends were, to some extent, already present in previous waves (see, for example, Wienroth 2020).

However, the fourth wave also marks clear-cut distinctions with previous waves. First, because it blurs the boundaries between what is forensic and what is not forensic, e.g. using recreational databases for forensic purposes. In the first, second, and third waves data is produced and remains within the forensic domain. For example, biological samples are collected with the particular goal of being profiled and eventually included in forensic DNA databases; familial searches are used in forensic DNA databases and/or massive screenings specifically conducted to solve a given criminal case; and forensic DNA phenotyping expands the analysis of genetic profiles obtained from crime-scenes. Following a different approach, long-range familial searches combine profiles collected from crime scenes with profiles obtained outside of the forensic domain to search for potential criminal suspects. Although long-range familial searches do not "create" such data, it uses data that was collected for different purposes. Such repurposing thereby sheds light on how long-range familial searches relate to DNA "data journeys" (Bates, Lin, and Goodale 2016; Leonelli 2016), outlining genetic data as something that travels across different spaces, times, and domains of practice (both forensic and non-forensic). Such data journeys hold implications for the use of data as evidence as well as for the type of knowledge being produced (Leonelli and Tempini 2020). The second clear-cut distinction from previous waves regards the fact that long-range familial searches shift the mandatory involvement with law

enforcement searches towards voluntary participation, thereby outlining a participatory turn, a topic that will be further explored in the following sections.

Expansion of affected populations

Both familial searches performed in forensic DNA databases and long-range familial searches conducted in recreational DNA databases make use of family genetic data to search for criminal suspects. However, there are important differences between both techniques, mainly related to how the latter further enlarges the datasets and data subjects that can be used to search for criminal suspects. First, while forensic DNA databases make use of Short Tandem Repeat (STR), the so-called "non-coding genes" that presumably hold little value other than identification (Cole 2007), long-range familial searches make use of Single Nucleotide Polymorphism (SNP). SNPs are characterized by informational richness as they allow to infer information about health markers, as well as biogeographical and family ancestry. Such informational richness, therefore, allows long-range familial searches to locate more distant relatives (Murphy 2018). Familial searches conducted in forensic DNA databases through STRs can at best identify a potential sibling, parent, or child. In recreational DNA databases, there is a much wide reach. Yaniv Erlich and colleagues, in their analysis of 1.28 million profiles, estimated that a database of 3 million US individuals of European descent would return at least a third-cousin kinship for 99% of inquiries (Erlich et al. 2018).

The second main difference between familial searches conducted in forensic DNA databases and long-range familial searches conducted in recreational genetic databases regards the composition of each dataset. Forensic DNA databases generally overrepresent certain groups and social categories that are most affected by the actions of the criminal justice system, such as racial and ethnic minorities (Duster 2003; Skinner 2013). By opposition, recreational DNA databases are mainly composed of an economically privileged population of European-descent individuals (Murphy 2018). This implies that long-range familial searches allow to locate distant relatives and target a population that is usually not included in forensic DNA databases, therefore considerably expanding the reach of affected populations.

However, as further discussed in the following section, how affected populations are involved in criminal investigations is markedly different. While forensic databases tend to hold profiles of individuals due to mandatory decisions of the criminal justice

system, recreational databases include profiles of individuals who have *chosen* to submit their DNA data for analysis and might subsequently decide to make it available for law enforcement searches. Such difference brings into focus longstanding structures of power and inequality that co-create categorizations between citizens who are able and entitled to make decisions about the uses of their genetic data and "non-citizens", devoid of decision-making power (Aas 2011; Rose 2000).

The participatory turn in forensic genetics

The fourth wave of forensic genetics inaugurated by the advent and consolidation of long-range familial searches outlines changes in the *rationale* of participation in databases used for criminal investigation purposes. Having the profile included in forensic DNA databases generally implies a police/judicial mandatory decision based upon some type of involvement with the criminal justice system, as is the case with nominated suspects, convicted offenders, victims, and other persons of interest to criminal investigation work (Machado and Silva 2015). In the case of recreational DNA databases, individuals with no involvement with the criminal justice system might unwarily or voluntarily take part in such searches. The use of recreational DNA databases in criminal investigations, therefore, implies that genetic surveillance is no longer restricted to the "management of those already deemed criminal" (Williams and Johnson 2004, 11): nowadays it also encapsulates individuals that might never have had contact with the criminal justice system before.

Long-range familial searches create two groups of participants. The first group regards individuals who were/are unaware that their genetic data is being used for law-enforcement purposes and/or did not provide explicit consent for such purposes. In this group, some have voluntarily uploaded their data into recreational DNA databases not expecting that it would ever be used by law enforcement. This was the case for individuals involved in long-range familial searches in *GEDmatch* before policy changes, as well as non-European Union citizens currently on the *FamilyTreeDNA* database that become automatically opted-in for law enforcement searches. In addition, in this group, some individuals did not permit their DNA data to be used in law enforcement long-range familial searches but due to episodes of data breach had their DNA exposed to such uses. One episode of such a situation happened in July 2020 when all DNA profiles at *GEDmatch* were made available to law enforcement searches.

Finally, this group also involves individuals genetically related to those who have uploaded their DNA into recreational DNA databases. Up until this point, the academic debate over long-range familial searches has been mainly focusing on this group of individuals that, without explicit consent and/or awareness, have been involved in long-range familial searches, a scenario posing serious questions in terms of privacy and protection of human rights (Kennett 2019; Murphy 2018).

However, such reflection disregards individuals who have voluntarily opted-in for participating in long-range familial searches for criminal investigation purposes. The notion of the volunteer – a citizen who agrees, based on free and informed consent, to have his/her DNA profile included in a forensic DNA database on their initiative, i.e. without being approached by an agent of the justice system – was already present in some forensic DNA databases regulations. For instance, Helena Machado and Susana Silva explain how the Portuguese regulation of the national forensic DNA database allows volunteers to participate (Machado and Silva 2009):

> A request by a volunteer for their DNA profile to be included in the database may symbolically signify maximization of choice and a sense of individual responsibility toward maintaining social order. In addition, the genetic profile of the volunteer is received by the state as a voluntary gift and as the citizen's contribution toward expanding a database designed to fight crime and ensure public peace and security (Machado and Silva, 2016, 329).

However, the number of volunteers in forensic DNA databases is, up to this point, considerably low (Amelung, Granja, and Machado 2020; Machado and Silva 2016). Nowadays, individual citizens interested in personal genomics and who have already purchased a DTC genetic test have the possibility of choosing to make their data available for law enforcement actions. Such a subject, therefore, illustrates a participatory turn (Prainsack 2011) in forensic genetics that transforms the relations between citizens and law and is linked to the development of novel strategies of subjectivity, involving practices of choice, obligation, relatedness, and identification (Machado and Silva 2008, 2009; Novas and Rose 2000). As outlined by Carlos Novas and Nicholas Rose about the birth of the somatic individual in terms of biomedical risk,

> These new modes of subjectivity produce the obligation to calculate choices in a complex interpersonal field, not only in terms of individuals' relations to themselves, but also in terms of their relations to others, including not only

> actual and potential kin, past and present, but also genetic professionals (Novas and Rose 2000, 488).

Civil engagement with long-range familial searches is being actively promoted by some companies, such as *FamilyTreeDNA*, which asks their customers to help them solve crimes. One example of this is a TV advertisement featuring Ed Smart, father of Elizabeth Smart, a Salt Lake City teen who was abducted in 2002 and later found alive, in which *FamilyTreeDNA* passes the following message: "When a loved one is the victim of a violent crime, families want answers. There is more DNA available at crime scenes than other evidence. If you are one of the millions of people who have taken a DNA test, your help can provide the missing link. *You don't have to buy anything, just participate*"[6].

These types of messages are rooted upon the idea of biological citizenship (Novas and Rose 2000), that is, the notion of the responsible and moral individual that increasingly thinks about and acts upon biological knowledge, therefore supplanting forms of control from "above" by those from "below" (Lemke 2011; Machado and Silva 2016; Tutton and Prainsack 2011). Based upon such a notion, participation is framed as a matter of "free" and informed choice that conveys the notion that the responsible citizen is the participatory citizen, motivated by social solidarity and personal altruism to contribute to the collective good.

However, allocating the decision-making power in each individual also raises other issues. As noted by Natalie Ram when discussing consent and choice in human tissue research:

> Most tissue providers are not medically or scientifically trained, and this limits their ability to grasp subtle nuances in scientific methodologies, to consider the broad range of research for which they may be providing their tissues, or to understand the tradeoffs implied in selecting one set of (…) options over another (Ram 2008, 276).

The participatory turn in forensic genetics, therefore, implies that individuals are making decisions about complex topics, with unfolding implications, that might not be fully known at the present moment. In addition, in the case of long-range familial

[6] Italics added. Transcribed by the author. Video is no longer available.

searches, the topic of choice also goes beyond the individual level, as making DNA profiles available for law enforcement searches implicates not only the individual but also his/her extended family (Arnold 2020; Murphy 2018). It is, therefore, important to understand how such decisions intersect with and become allied to new modes of subjectivity that stress autonomy, responsibility, and choice (Rose and Novas 2005).

In line with initiatives that increasingly call for the participation of citizens in long-range familial searches, in the public announcement of the partnership between *GEDmatch* and *Verogen*, the company CEO, Brett Williams stated: "Never before have we as a society had the opportunity to serve as a molecular eyewitness, enabling law enforcement to solve violent crimes efficiently and with certainty"[7]. Individuals are, therefore, being invited to participate as "molecular eyewitness", a notion anchored on the alleged "certainty" of DNA to solve crimes that has been deeply criticized over the years (Lynch et al. 2008). However, such framing omits the role of the growing industry and markets commercializing specialized genetic services and how the engagement of users in value co-cocreation is an integral feature in the co-production of biovalue.

Law enforcement access to recreational DNA databases and the co-production of biovalue

Long-range familial searches highlight the several forms by which the commodification of genetic knowledge and the marketization of science intersect with forensic genetics. More particularly, the potential attributed to this technique has sparked interest among several companies that currently commercialize advanced DNA analysis services. Consequently, the fourth wave of forensic genetics is shedding new light on the commercial value associated with forensic science and harboring creative combinations between scientific imperatives, judicial priorities, and commercial interests in ways that further compound the political economy of forensic genetics (see also Lawless, 2011; Wienroth, 2020).

The concept of biovalue is thereby extremely useful to interrogate this evolving trend. It was originally developed within the framework of biobanks and it tends to be associated with economic value, as its production is at the center stage of the

[7] https://verogen.com/gedmatch-partners-with-genomics-firm/?mrksrc=social&utm_campaign=forensicgenealogy&utm_content=107158419&utm_medium=social&utm_source=twitter&hss_channel=tw-900437789077946368

development of bioeconomies (Mitchell and Waldby 2010; Waldby 2002b). According to Catherine Waldby,

> Biovalue refers to the yield of vitality produced by the biotechnical reformulation of living processes (…). The process of producing biovalue is also the process of technical innovation that enables the patenting of cell lines, genes and transgenic organisms as inventions, securing their status as intellectual property and possible sources of profit for their inventors (Waldby 2002b, 310).

However, as noted by David Skinner and Matthias Wienroth, the concept is also useful to reflect upon the particularities of forensic genetics. As outlined by the authors, biovalue is "dependent on the negotiation of ethical worth expressed in terms of cultural, societal, institutional and individual values, norms, rights, obligations and interests" (Skinner and Wienroth 2019, 5).

Waldby argues that there are two incentives for the co-production of biovalue. The first regards the public incentive, foregrounded by the technology's advocates. In the case of long-range familial searches for law enforcement purposes this value derives from the potential to solve complex criminal cases (Katsanis 2020). The second incentive for the co-production of biovalue "is the production of exchange value, of biological commodities that can be bought and sold" (Waldby 2002a, 310). In the case of long-range familial searches, this kind of biovalue co-production entails several facets through which biological materials can be marketed, by different or similar companies.

As already explored by Anna Harris, Sally Wyatt, and Susan Kelly (2012), through their work on the field of personal genomics and in particular of the company *23andMe*, the initial commercial exchange, in which laboratories analyze the genetic and return the results to the paying customer, is followed by other profitable endeavors, such as growing a research database which can be sold to third parties. See, for example, Glaxo Smith Kline partnership with *23andMe* aimed at developing new drugs and therapies based on the *23andMe* database[8]. Users of DTC companies, by engaging with "free clinical labor", are therefore involved in the co-production of biovalue, providing the company with information from which it has established a valuable database (Harris, Wyatt, and Kelly 2013).

[8] https://www.gsk.com/en-gb/media/press-releases/gsk-and-23andme-sign-agreement-to-leverage-genetic-insights-for-the-development-of-novel-medicines/

The advent and consolidation of long-range familial searches create two additional forms of biovalue. The first is also economic: by voluntarily making their DNA available to law enforcement searches, individuals are also creating the conditions for the establishment of a new market, specialized in forensics. In this sense, individuals who voluntarily participate in databases available for law enforcement searches are lending their genetic information to create a resource with significant commercial potential that is going to be marketed by several specialized companies. In this sense, although they participate under a rubric of social solidarity and personal altruism, their participation is formulated in several profitable ways. In this regard, it is important to recall that profiles once uploaded to *GEDmatch*, as a non-profit website, are now being managed and used by *Verogen*, a profit-oriented forensic genomics company interested in maximizing the potential of such profiles for commercial purposes.

The second form of biovalue created by the advent and consolidation of long-range familial searches is biolegal value. By making their genetic data available for law enforcement searches, either voluntarily or involuntarily, the participation of donors constitutes biolegal value. The concept of biolegality, proposed by Lynch and McNally, outlines how policing and technoscience interact to create new sets of active "suspects" (Lynch and McNally 2009). Up until this point, biolegality was restricted to forensic DNA databases and forensic technologies (Granja and Machado 2020; Lawless 2012). However, the advent and consolidation of long-range familial searches show how individuals are co-producing biolegal value by making genetic data available for law enforcement searches. In this sense, the genetic material originally submitted to know more about health conditions and/or ancestry, also becomes an asset to several profit-lead companies, able to market it, and can take part in genetic collections that are going to be used to criminal investigation purposes.

Final remarks

In this article, I aimed to explore how long-range familial searches conducted in recreational DNA databases reframe the trajectory of forensic genetics. The contribution of this article, therefore, lies in its proposal to extend beyond previous discussions on long-range familial searches conducted in recreational DNA databases that disregard the participatory turn, as well as the increasing commodification of genetic knowledge and marketization of science.

I argue that the advent and consolidation of long-range familial searches in recreational DNA databases represent the fourth wave of forensic genetics. Such wave holds similarities with previous waves but also presents clear-cut distinctions, such as the "journeys" of data from non-forensic to forensic domains and the shift from mandatory involvement with law enforcement searches towards voluntary participation. Overall, I detail three main implications of long-range familial searches, namely, the expansion of affected populations, the participatory turn, and the co-production of biovalue.

By enlarging the datasets and data subjects that can be used to search for criminal suspects, long-range familial searches end up targeting more distant genetically related individuals and an economically privileged and European-descent population. This is very different from forensic DNA databases that usually overrepresent certain groups and social categories that are most affected by the actions of the criminal justice system, such as racial and ethnic minorities (Duster 2003; Skinner 2013).

In addition to expanding the affected population, I also explore how long-range familial searches frame citizens' participation in law enforcement genetic searches as a matter of "free" and informed choice. This conveys the notion that the responsible citizen is the participatory citizen, a very prominent issue that has received very little attention. The use of recreational DNA databases, therefore, reconfigures how citizenship is perceived and acted upon concerning law enforcement as it also outlines the choice-enhancing character of being included in a database used for forensic purposes. By shifting the *rationale* of participation into databases accessible by law enforcement towards voluntary, long-range familial searches end up marking a participatory turn into forensic genetics. Such re-framing is, nonetheless, still anchored on longstanding structures of power and inequality. Underprivileged and racialized communities, more prone to the surveillance and action of the criminal justice system, continue to have their profile mandatory included in forensic DNA databases. The economically privileged population of European-descent individuals have the option of choosing to altruistically make their profiles available (Machado and Silva 2009). Although it is beyond the aims of this particular article to explore the motifs and meanings attributed by individuals to the choice of making their genetic data available for law enforcement purposes, this is a very pressing issue to explore as it relates to issues of scientific and judicial legitimacy, public trust, and citizenship.

Finally, the fourth wave also consolidates trends anchored on the marketization of science, as there is an increasing number of companies offering specialized forensic services. It is, therefore, clear how the still-evolving fourth wave of forensic genetics has, therefore, formed and consolidated interactions between the forensic and the recreational markets, which have harbored creative combinations between scientific imperatives, judicial priorities, and commercial interests in ways that further compound the political economy of forensic genetics (Wienroth 2020). Such transformation thus outlines different types of biovalue that are being engendered by long-range familial searches, namely economic and biolegal value.

The increasing relevance of commercial companies in the forensic genetics field, as well as the importance attributed to genealogists, also brings into focus a topic deserving further attention: the reconfiguration of epistemic authority implied in the fourth wave of forensic genetics (in this respect see Machado and Granja 2019; Wienroth 2020). As long-range familial searches gain importance in law enforcement actions, there might a movement of the centers of epistemic authority away from forensic geneticists towards genealogists. It is, therefore, important to address how those changes are perceived by new and old actors involved in the production, analysis and, interpretation of genetic data within criminal investigations while addressing how issues of validity, accountability, legitimacy are negotiated as part of the scientific conduct.

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