Genetic Racial Profiling
Extended DNA Analyses and Entangled Processes of Discrimination

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Abstract

Over the last two decades, the analysis of DNA traces found at a crime scene have expanded the already established forensic DNA analysis for identification to include new techniques intended to predict a criminal suspect's externally visible characteristics, such as eye, hair and skin colour ('forensic DNA phenotyping'), or his or her ethnic, continental or regional origin ('biogeographical ancestry'). In this paper, we conduct a dispositive analysis to investigate how extended DNA analysis in forensics catalyses inherent processes of racialization at three different levels: 1) in the categorizations that are integral to this technology, 2) in the images of the 'dangerous other' combined with inflated expectations regarding these technologies' effectiveness that have framed discourses regarding the legalization of this technology, and 3) in the biases and stereotypes which often guide investigative practices using these technologies. We demonstrate that this is an example par excellence of how the interaction between different practice dimensions can exacerbate unintended discriminating, racialising and racist effects.

Keywords: DNA, forensics, racialization, discrimination, minorities, racial profiling

Introduction

Forensic DNA investigation methods have been expanded rapidly over the last two decades. Previously established DNA profiling techniques used DNA samples found at a crime scene in order to *identify* an individual (so-called genetic fingerprinting). In contrast, some newer techniques focus their DNA analysis on characteristics that are shared by whole groups of people in order to *attribute* statistically likely characteristics to an unknown suspect. These newer techniques predict visible characteristics of the suspect – such as the pigmentation of skin, eyes and hair (forensic

DNA phenotyping) – as well as the continental, regional and group-specific origin of the suspect's ancestors (biogeographical ancestry).[1] Since very different and sometimes misleading terms are circulating in scientific literature and the political debate, we follow the practice of some (mainly German) authors and subsume these methods under the term 'extended DNA analysis' (EDNA).[2]

Extended DNA analysis technologies have already been used in countries such as Canada, the UK, the Netherlands and some US states (Sankar 2010, 2012; M'charek et al., 2020; M'charek and Wade, 2020; Wienroth, 2020a). In other countries, particularly in most of continental Europe, the use of such investigation tools in criminal cases is either highly restricted or explicitly prohibited due to data and privacy protection regulations (Koops and Schellekens, 2008; Samuel and Prainsack, 2018). In the last three years, however, certain continental European countries such as Germany, Slovakia and Austria have approved the use of some of these methods for police investigation work, and in some states like Finland, Switzerland and Spain new legal regulations are being considered or under consideration (cf. Schneider et al., 2019).

In this article we will demonstrate how these technologies contribute to the reproduction of racialisations in forensic investigation practices based on DNA. For this purpose we start from the general observation that the concept of biological race is persistent and resilient (cf. Pollock, 2012). What we consider striking in the development of EDNA methods is a renewed explicitness in the use of racial(ising) categories as well as a current reinforcement of biological boundary-drawing to differentiate humans into groups based on typological concepts. This resilience of the biological and now molecularised race concept counteracts the broad scientific consensus that biological race concepts are invalid (Livingstone, 1962; Lewontin, 1972; Marks, 1995; AAPA, 2019; Fischer et al., 2019) and that race needs to be understood as a sociocultural category of othering and selfidentification.

To explore how EDNA-usage contributes to the continuation and re-expansion of a biological understanding of race, we examine the recent debates regarding EDNA legal reforms in Germany and Switzerland and the application of these technologies in prominent cases in different European countries. To this end, we draw on the analytical concept of 'racialization' in order to shed light upon the interdepencies, institutional settings, practices and underlying historically sedimented images which reinforce essentialised categories and create divisions between groups (Hopman and M'charek, 2020; M'charek et al., 2020). Accordingly, with reference to Miles' and Brown's definitional framework, we employ the concept of racialization "to denote those instances where social relations between people have been structured by the signification of human biological characteristics in such a way as to define and construct differentiated social collectivities" (Miles and Brown, 2003: 101).[3]

Even though the concept of racialization has been subjected to numerous criticisms (e.g. Goldberg and Essed, 2002; for an overview see Murji and Solomos, 2005), it seems to us to be most useful for analysing the practices of EDNA technologies because, firstly, the concept "moves research and political argument away from the unproductive debates about whether any particular individuals, propositions, claims, and doctrines are simply 'racist' or 'non-racist'" (Rattansi, 2007: 107). Secondly, it fosters interpretive social research by shifting the focus away from conceptually fixed entities (like race or ethnicity) and directing attention to the particular temporal and local settings in which people are classified local settings and specific processes in which people are classified (M'charek et al., 2014; Balkenhol and Schramm, 2019). In this sense the focus on racialization, that is, on the practices of boundary work, on the processes of constructing, homogenising, and naturalising human group categories, enables us to contribute additional insights to studies on 'scientific racisms' (Carter, 2007), 'racial formations' (Omi and Winant, 1986) or 'groupism' (Brubaker, 2004).

With a focus on biological human classifications, we are not only interested in determining whether and how racializations take place but also in clarifying how this is related to forms of discrimination (Skinner, 2020), stigmatization (Machado and Granja, 2020), criminalization (M'charek et al., 2020), and securitization (Maguire, 2012; Amicelle

et al., 2015) and how these forms became entangled. While several problems related to EDNA forensic practices have already been addressed and investigated in a number of studies (e.g. Bolnick et al., 2007; Duster, 2009; Lipphardt V, 2018; Skinner, 2018, 2020; Zentralrat Deutscher Sinti und Roma, 2018), these have usually focused on particular fields such as law, media discourse or law enforcement agencies. From our point of view, these fields should also be analysed with respect to their relationship to each other, to their similarities, to their mutual stabilization and sometimes even contradictory objectives. For this reason, we centre our analysis on three interrelated dimensions:

1. the racialising procedures already inherent in the design and functioning of these technologies;
2. the racialising and racist substructure of public debates regarding the introduction of EDNA;
3. the potentially discriminatory, stereotyping and racialising effects of criminal investigation practices.

Racializations occur in all three dimensions, but in their own specific heterogeneous forms and modes. To investigate these three dimensions – technology, discourse and practice – we use the methodological tool of dispositive analysis (Foucault, 1980; Jäger, 2001; Jäger and Maier, 2015). Foucault's description of the "strategic function" or "strategic imperative" of a dispositive helps us work out how these three dimensions interact, support and stabilize each other. The first main point is that a dispositive is organised around a common strategy without there being a strategist. This common dominant strategic function arises, according to Foucault, from the response to an "urgent need" in a specific historical moment (Foucault 1980: 194, 195). The second main point is that unintended and unforeseen effects result from the arrangement of "a thoroughly heterogeneous ensemble". For Foucault (1980: 194) such ensembles consist of "discourses, institutions, architectural forms, regulatory decisions, laws, administrative measures, scientific statements, philosophical, moral and philanthropic propositions". The dispositive must therefore be understood as the "system of relations", in the French original "the network" (*le réseau*), which is established between these elements (Foucault 1980: 194).

Dispositive analysis enables us to look at the field of extended DNA analysis from a broad perspective, which we assume will help us perceive the problems related to EDNA more accurately. In addition, it enables us to locate the causes of racialization beyond these technological tools, the discourses surrounding them, investigative practices or even the intention of the actors involved, in order to comprehend these elements' entanglements. From a methodological perspective, a dispositive analysis has to be sensitive to heterogeneous sites, actors and narratives, as well as their potential links, mutual dependencies and/or effects on each other (cf. Jäger and Maier, 2015). Furthermore, the dispositive concept allows us to capture the effects of these technologies at the three levels central to Foucault-inspired power analyses – the levels of knowledge, institutions and individual preferences for action – all three of which we consider useful for this analysis.

We adopt different theoretical and problem-related perspectives for this analysis, drawn from our diverse disciplinary backgrounds – genetics/molecular biology, political science and sociology/STS. Widening the analysis using these different perspectives seems particularly necessary because today's continental European societies describe themselves as 'post-racial', such that technology-driven racialization processes usually remain unnamed and hidden and race thus tends to manifest itself as an 'absent presence' (M'charek et al., 2020; Skinner, 2020). This means that racializations continue to exist, but their presence and their impact become largely invisible. This happens, for example, when scientific technology is represented as neutral and objective in its development, functioning and effects.

Furthermore, we use the term 'racial profiling' as a heuristic tool to understand how the societal acceptance of EDNA has exacerbated racializations in investigative practices and how EDNA can increase the risk, especially for minorities, of becoming the subject of police investigations and possibly associated stereotyping. Using the term racial profiling, we will discuss how images

of the 'dangerous others', as well as emotions and hopes with regard to a "technological fix for fear and anxiety" (Buchanan, 2019), hinder a debate on sufficiently considering the risks and social costs of this technology. As an analytical term, racial profiling has been established in the last three decades as a keyword for a wide range of anti-discriminatory research (e.g. Glover, 2009; Fassin, 2013; Davis, 2016; Plümecke and Wilopo, 2019). While the term is commonly used to describe police activities such as identity checks, monitoring, surveillance and investigation that are conducted on the basis of a person's skin colour or alleged ethnic or religious identity, for the objectives pursued here we understand this more broadly in terms of investigative practices, in which specific racialised population groups are criminalised and particular crimes are racialised (cf. Lee, 2005; M'charek et al., 2012).

In the following, we first provide an overview of the current technologies of extended DNA analysis and reveal the selective and discriminatory procedures inherent in their design and function. In order to reconstruct the historical constitution of technological artefacts and technological practices we refer to a large corpus of relevant history of science and STS studies as well as to primary sources, especially information and research articles by the main scientific developers of EDNA technology. Second, we focus on two case studies (Germany and Switzerland) in order to grasp main aspects of the current legitimising public, political and juridical discourse. We recur here to already existing academic case analysis but also analyse integrated primary sources such as important media articles,[4] parliamentary debates and other political documents concerning the approval of EDNA for police work. Third, we present specific cases, in which EDNA was known to be utilised, and analyse them with regard to their racialising, stigmatising and responsibilising effects by referring to media coverage and existing academic literature on specific cases. As these sources where not enough to fully understand the exact events and motivations surrounding two cases in the Netherlands where bio-geographical ancestry (BGA) was applied, we additionally draw on an interview we did with one of the geneticists responsible. Finally, we will argue that these three dimensions interact to create a dangerous, technologically conveyed racial profiling instrument.

EDNA technology: Classifying humans in a 'post-racial era'

Extended DNA analyses are by no means as new as they are often presented in the media, especially by its proponents. Instead, they reference a historic branch of classical genetics research that has developed categorizations of humans based on race, ethnic group or population.[5] The first EDNA methods were based on insights from population genetics, which since the mid-19th century has repeatedly identified differences in the frequency pattern of genetic variability according to geographical distance (Dobzhansky, 1973). However, until recently, DNA analysis in forensics has been limited to the identification or exclusion of individual suspects and to the determination of someone's chromosomal sex. For the identification of individuals (so-called DNA fingerprinting), the analysis focuses on regions in the human genome that contain so-called 'short tandem repeats' (STRs), patterns of nucleobase repeats that can be found on several regions on each human chromosome and are often highly variable between unrelated people (Lynch et al., 2010; Wienroth et al., 2015). STRs were chosen not only for such methodological reasons, but also because they are part of so-called 'non-coding' sequences of the DNA that in contrast to 'coding sequences' do not store information for the construction of proteins, the body's building blocks. Thus, they were thought to be 'information free', meaning they could not reveal any intimate information about a person. In the 1980s and 1990s there was a broad consensus that the use of DNA profiles should be limited due to general concerns about data protection and the private information in DNA.[6] For example, the German Federal Constitutional Court ruled in 1995 that an analysis of the coding part of DNA would be a violation of the "absolutely protected core area of personality" of the respective person (Bundesverfassungsgericht, 1995). Geneticists have since stated, however, that there is no scientifically clear boundary between coding and non-coding sequences in DNA, and that there are several DNA markers located in so-

called non-coding sequences that are usable to analyse personal traits (Kayser, 2015). Meanwhile, the general public and political consensus on DNA privacy has also been challenged over the last two decades by new political regulations: in 2000 in the Netherlands and in 2003 in the US, regulations permitted the extended application of DNA technologies to predict the probable racial, ethnic or geographic origin of the person whose DNA was found at the crime scene (M'charek et al., 2020; Sankar 2012). In order to reconstruct how powerful group categories have been inscribed and reified within these technologies, we will first give a short introduction regarding the development of EDNA technologies in forensics, highlighting research on genetic ancestry as well as on phenotypical attribution.

The precursors of extended DNA analysis

Probably the most important precursors of current EDNA methods can be traced to the late 1970s, when the geneticists and haematologists Yuet Wai Kan and Andrée M. Dozy researched sickle cell anaemia in the blood of Black people (with and without symptoms of the disease) and non-Black people (without symptoms). As a by-product of that research, they noticed that they might have found a "new class of genetic marker" that could facilitate a "new approach to linkage analysis and anthropological studies" (Kan and Dozy, 1978: 5631). Based on this study, the geneticist Alec Jeffreys (the inventor of DNA analysis for the identification of individuals) examined the blood of 60 people of "North European, Asian, respectively Chinese" descent with symptoms associated with blood-related diseases (Jeffreys, 1979: 9). His study not only revealed differences in the genes related to these symptoms, but also led him to speculate that his methodology would offer possible uses for investigating "population structure and origins of human races" (Jeffreys, 1979: 8). In the 1980s, with the development of new DNA analysis technologies (e.g. polymerase chain reaction) further approaches emerged to process DNA data within the fields of population genetics, medicine and forensic genetics.

It has been widely recognised in genetics, at least since the 1970s, that variations within each human group are much greater than those between them and that the distribution of gene variants is essentially a gradual continuum around the globe (cf. Livingstone, 1962; Lewontin, 1972). Nevertheless, some scientists have continued to define human populations as discrete entities with measurable genetic differences that can be determined by probability calculations (e.g. Baker, 1974; Nei and Roychoudhury, 1982; Rushton, 1995). In this context, it is not very surprising that in a 1989 meeting on *DNA Technology and Forensic Science* the geneticist Kenneth Kidd and the forensic expert Jack Ballantyne discussed "population-specific allele frequencies" and postulated that it could be possible to determine a persons' "precise racial data" or "racial origin" (Track et al., 1989: 344). A few years later forensic experts in the UK proposed that a single marker could be used to classify individuals along racial group categories of "Caucasian" and "Afro-Caribbean" with an 85% match probability (Evett et al., 1992). And, at the beginning of the 1990s, the already mentioned geneticist Jeffreys predicted that "in the not too distant future, it is conceivable that DNA tests yielding information on, for example, ethnicity, hair colour and eye colour might become available" (Jeffreys, 1993: 210).

Bio-geographical ancestry: Defined localisation of gradual frequency distribution

Indeed, as Jeffreys predicted, by the 2000s forensics had developed technologies which analyse DNA traces from crime scenes in order to calculate probability assertions regarding the geographical, racial, and ethnic ancestry of potential suspects. Currently, there are three such technologies, each with their specific limitations and potential: the analysis of genetic variants in mitochondrial DNA, in Y-chromosomal DNA and in the remaining chromosomes (autosomes) (for an explanation of these technologies see Brubaker, 2017). Figure 1 visualizes an example of how the distribution of a particular mitochondrial DNA pattern is presented to investigators.

In the 1990s the biological population differences which forensic scientists sought to capture were still commonly referred to as 'race', 'ethnicity' or 'population', but since the beginning of the 2000s it has become more common to use the

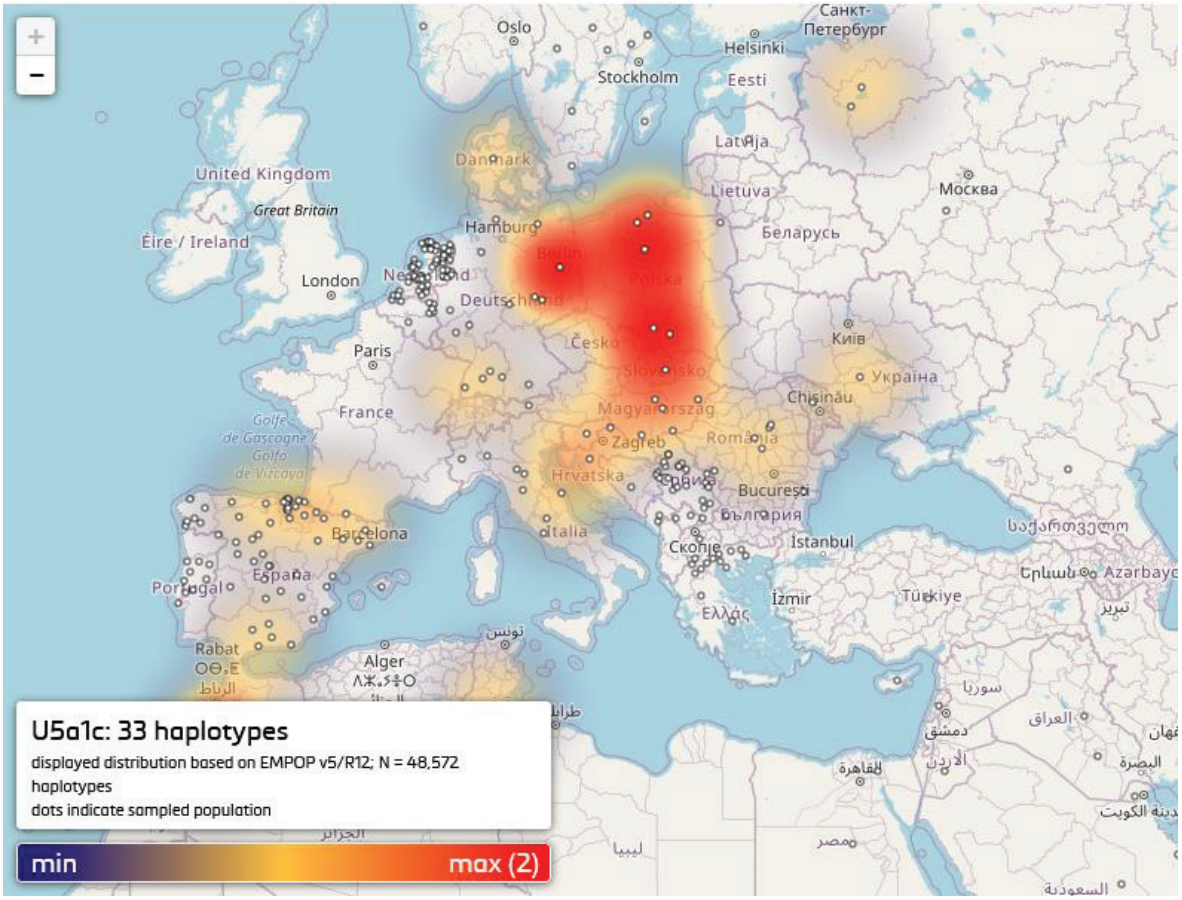

Figure 1. Example visualisation of a specific variability pattern of mitochondrial DNA, called haplogroup U5a1c, taken from the database EMPOP (https://empop.online/hg_tree_browser). As can be seen from the sampling sites (dots), there are large data gaps for many countries and regions. The mtDNA sequences collected in the database are used to make frequency calculations and BGA estimates, as in the case of the "Phantom of Heilbronn".

terms 'ancestry' and especially 'bio-geographical ancestry' (BGA). This shift in terminology has, however, not really reflected a clear differentiation in the underlying meaning, as shown by the usage of the biological anthropologist Tony Frudakis and the population geneticist Mark Shriver, who coined the term BGA, referring to it in a patent application in 2004 as the "heritable component of 'race' or heritage" (Frudakis and Shriver, 2004: 1; cf. Gannett, 2014).[7] It is noteworthy that they use the term race not to refer to the currently hegemonic understanding of it in English-speaking countries as a socio-cultural category, but rather try to highlight its biological foundations.

In its application, however, BGA falls short of a scientifically sound, biological categorization since their analyses are often based upon contemporary US and European race and ethnicity concepts which are actually the product of political debate and negotiation (Gannett, 2014). And in any case, the way in which BGA was operationalised by Frudakis and Shriver cannot be understood as a purely biological specification of human diversity, since their implementation of continental, racial, national, ethnic, religious or language-related group designations always involves categories based on social and cultural classifications (Bowker and Star, 2000). Nevertheless, the term BGA has been used in many contexts – including forensics – to at least create the impression that we now have a concept that reflects the natural measures of human diversity.

Nowadays there are several nationally and internationally operating companies for BGA analysis, which offer everything from DNA analysis to evaluation and the creation of detailed profiles. They, too, have undergone the shift in classification terminology from 'race' to 'ancestry' and 'biogeographical ancestry'. In 2000, for example, the company *DNAPrint genomics* promised the

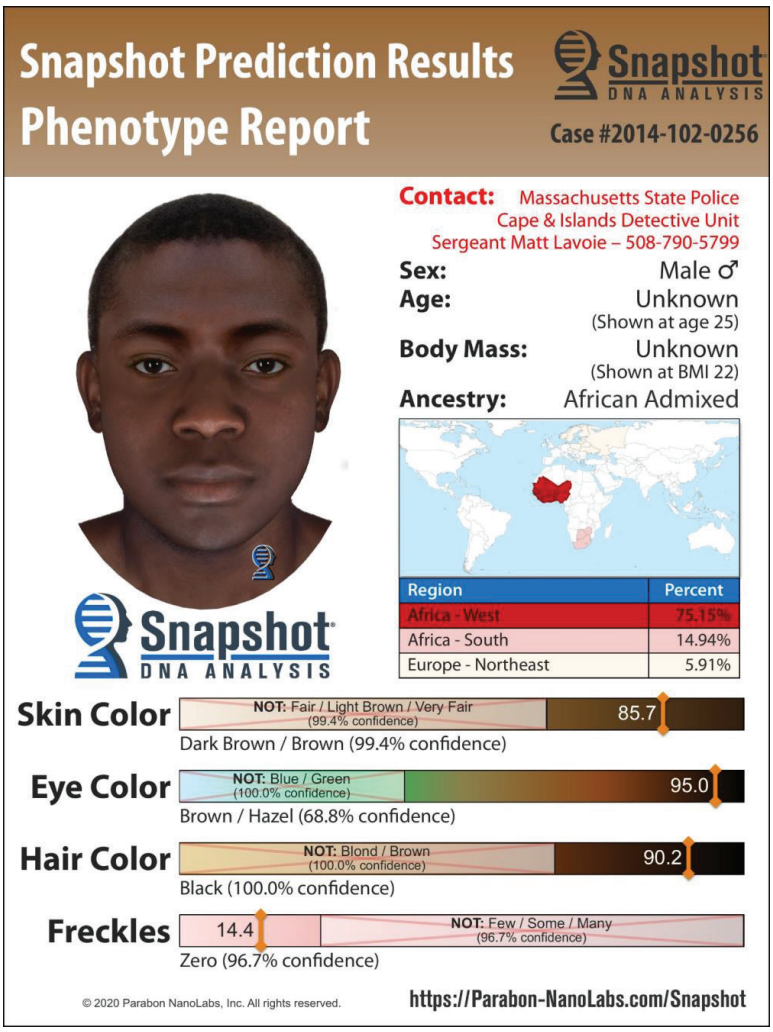

Figure 2. Example of an FDP and BGA estimation as carried out by the US company Parabon NanoLabs. Source: https://twitter.com/ParabonSnapshot/status/1237488967370539008/photo/1 (accessed 3 June 2021).

"deciphering of an individual's race" from crime scenes' DNA traces (Gaskin, 2000), while since 2013 the company *Identitas* (www.identitascorp.com) has been offering its DNA Witness 2.0 to "deduce bio-geographic origin […] from genetic information", and *Parabon NanoLabs* as well as *Illumina* have designated their classification findings as "bio-geographic ancestry", abbreviating this as "ancestry". What is meant by bio-geographical ancestry in this context is shown, for example, in Figure 2, where the "ancestry" of a suspect is projected onto large geographical regions with seemingly high precision, as demonstrated by the two positions after the decimal point.

In addition to private, company-owned and national databases forensic investigators worldwide use two databases located in Germany and Austria, which own today's most comprehensive reference samplings in the world. Both databases are not just a repository for DNA data and sampling locations, but link individual marker data with further classifications, such as ethnic, racial, regional, national, religious, language specific, skin colour-based information. Furthermore, both databases also cluster individual samples into larger groups, which are called 'metapopulations'. In this way the "Mitochondrial DNA Population Database" (EMPOP), operated by the Institute for Legal Medicine of the Innsbruck Medical University in Austria, organizes its data according to the meta-populations "African, Western Eurasia, Asian, American, Oceania", and the residual designation "Admixed", categories which echo classical racial classifications.[8] The database is freely accessible to everyone. Investigators worldwide can therefore enter data obtained from an analysis of mitochondrial DNA into the database, connect the data by means of probability assignments to specific populations and even create a world map which displays how frequently the determined DNA marker combina-

tion occurs in the existing, regionally distributed set of database samples (see Figure 1).

Another important database is the Y Chromosome Haplotype Reference Database (YHRD) at the Charité hospital in Berlin, Germany, which contains the Y-chromosomal genetic information of over 320,000 individuals from 917 sampling locations. The database stores data not only according to these sampling location categories but also to nationally specific classifications such as racial categories in the USA ("European American, African American, Hispanic American" etc.), skin colour categories like in Brazil ("Pardo"), ethnic ones such as those in China ("Uighur, Tibetan", etc.), nationalities such as those in the United Kingdom ("Afro-Caribbean, British Indian, Bangladeshi, Sri Lankan"), language-related group designations (like "Romani, Bulgarian Turks, Basque") as well as religious ones (like "Ashkenazi Jews" or "Druze"). In addition, the various local, ethnic, etc. classifications are grouped into metapopulations (as in EMPOP) – currently in thirty-two (Willuweit and Roewer, 2015; https://yhrd.org). Thus, even though both databases do not primarily aim to provide racial classifications, racial categories are already present in the data.

Furthermore, racializations are also generated as a result of the sampling strategies. Often only a specific selection of persons is included in forensic reference databases for estimating the BGA. The genetic data selected for these reference databases is not collected to represent a cross-section of a region's population, but rather only those individuals with four grandparents born in the same region. While this approach might make sense for research into historical migration and settlement development, it clearly limits forensic application since a large part of the current genetic population diversity (for example those with migration history) is not represented and the differences between the differentiated groups are exaggerated. This problem has also been raised by two of the most prominent proponents of BGA, the above mentioned Mark Shriver and the geneticist Rick Kittles, who see it as a possible concern that in genetic ancestry analysis, "the genetically defined ancestral categories […] could be misinterpreted as indications of 'real' racial divisions, even if they are explicitly acknowledged as being continuous and, to some extent, arbitrary groups" (Shriver and Kittles, 2004: 616).

BGA is therefore not something that can be found in the reality of the current population but is rather the product of how reference databases and the classifications they provide were constructed. Rather than a realistic representation of the population in a geographical location, BGA is the sum of a series of complex and contingent assumptions, not only concerning how the categorizations are developed or which decisions have been made regarding the location of sampling but also in the number of samples considered relevant, what kind of designations of the respective groups are preferred over others, how individuals are assigned to particular groups and how the reference databases are constructed (Pfaffelhuber et al., 2019; Lipphardt V et al., 2021a; Fujimura et al., 2014). In effect, the very technology of databanking and static mapping of a sample in many cases produces an essentialised and homogenised image of human groups.

Forensic DNA phenotyping: Messy categorizations of physical characteristics

Another set of EDNA technologies in forensic genetics is "forensic DNA phenotyping" (FDP), which analyses externally visible features such as facial shape, hair, eye or skin colour as well as further physical features such as biological age (in this case via the analysis of epigenetic markers; see Figure 2 for a visualisation of such an analysis). The FDP analyses of genetic variants statistically associated with pigmentation of hair and iris currently have a higher predictive power than those for age or the pigmentation of the skin. Nonetheless, the degree of accuracy outside the controlled research environment is an object of ongoing scientific debate (Staubach, 2017; Caliebe et al., 2018; Buchanan et al., 2018).

Regardless of which characteristics are being predicted, the accuracy of FDP (as well as BGA) analyses is considerably lower than the predictive value of the established DNA-fingerprinting techniques. For example, in a statement that became central to the German debate on EDNA, the "German Stain Commission" (*Spurenkommission*), an association of German forensic institutes, claimed that hair colour, for instance, can only

be correctly detected in about 75% of the cases (Schneider, 2016). Other scientists have pointed out that even these numbers are misleading (Buchanan et al., 2018; Lipphardt V et al., 2021a) and that this technology's real-life accuracy in the field is significantly lower, since the statistical values called 'area under the curve' describe the performance of the methods under laboratory conditions (WIE-DNA, 2019; Buchanan et al., 2018; Taylor et al., 2021). Even the team of Manfred Kayser, a leading European FDP technology developer and major proponent of the legalization, acknowledged that "since the etiological understanding of FDP-relevant appearance phenotypes is still incomplete, so are the prediction models used" (Caliebe et al., 2018).

While in the context of a criminal case, the goal is to find a specific individual suspect with unique features, FDP is only able to narrow down the possible visible characteristics of the person based on a statistical probability calculation related to groups of people. The result is not an individual set of characteristics but rather a category of the population with a more or less wide range of characteristics. Since a range of possible characteristics is rather unhelpful to law enforcement agencies, scientists and companies offering FDP analyses try to accommodate the needs of practitioners by implementing classifications in the technology that are as unambiguous, mutually exclusive and clear-cut as possible. For example, the system *HIrisPlex-S*[9] by Manfred Kayser's group divides eye colour into three types (blue, brown and intermediary), hair colour into four (blond, brown, red, black) and skin colour is presented as one of five possible options (very pale, pale, intermediate, dark and dark-to-black). The decision to divide skin colours into five types is, of course, arbitrary. Other FDP systems categorize with more, others with fewer divisions. In reality, phenomena like eye colour are much more complex and often not easy to group into a small number of divisions, as evidenced, for example, in the different ways researchers have assigned DNA data to eye colour varieties (Liu et al., 2010).

What further obscures the problems surrounding FDP is that both scientific and media representations of EDNA methods do not sufficiently clarify the differences between BGA and FDP technologies. Although there is a technical overlap between the two forms of analysis (because some gene regions related to physical features are also used for the analysis of BGA), it would be misleading to subsume both technologies under one term, since BGA analysis does not provide information about the appearance of an individual. Doing so would lead to an imagined connection between "ancestry" and "visible characteristics", thus suggesting a traditional, racialised typology.

Unfortunately, the discursive and practical confluence of these two technologies also plays into the political realm's and the public's false and exaggerated expectations about what BGA really offers (cf. Schultz and Bartram, 2017; Lipphardt V, 2018). In both science and in the media, EDNA is often misleadingly referred to as a "DNA composite sketch" or a "composite profile", or it is repeatedly translated in a similar way into another language, for instance into German as a "genetic facial composite" (*genetisches Phantombild*), suggesting that this would have the same accuracy as artist drawings based on eyewitness' memories of a suspect (e.g. VISAGE, 2020; KKWT/ED and Bundeskriminalamt, 2017). The company Parabon NanoLabs also presents its product as a "composite sketch" or a photographic "snapshot" (see Figure 2). Since 2015 this company has offered DNA analyses of unknown suspects that included information on gender, ancestry, skin, eye and hair colour as well as the predisposition to freckles. It should be noted that the image meant to represent the analysis findings is not, as might be the impression, generated from existing DNA data, but from racial-typological stereotypes using a database of images (cf. Wienroth 2020a).

Contextualising EDNA: Debates in Switzerland and Germany

At the time of finishing this article, a parliamentary debate is taking place in Switzerland regarding an amendment to the law concerning the approval of extended DNA analyses for police investigation procedures. Up to now, analyses of DNA traces have only been allowed for identity verification and for the determination of the chromosomal sex of crime suspects. All further analyses were

explicitly excluded in the DNA-Profile Act, which was passed in 2003 and came into force in 2005, stating that the "DNA profile [...] is obtained only from the non-coding sections of the genetic substance DNA" (Art. 2 Para. 1, our translation) and that "no research shall be conducted concerning the state of health or other personal characteristics with the exception of sex" (Art. 2 Para. 2 DNA-Profile Act, our translation).

In the Swiss legislative process concerning the regulation of 2003, all political parties shared in principle the view that DNA data should be given a high protection status, as their analysis and storage would constitute a severe violation of personal rights. In the original draft of the law, the analysis of DNA coding sections was allowed in exceptional cases and by order of a judicial authority, e.g. for the analysis of "genes that determine the colour of eyes, hair or skin" (Schweizerischer Bundesrat, 2000: 37; our translation). However, the opinion that such examinations should not be permitted, not even in exceptional cases, prevailed in the Swiss legislative debate at the time the law was passed. Policy makers attempted to counter the risks of DNA analysis procedures by implementing relatively strict regulations with the aim of preventing the identification of "highly sensitive personal data" as well as "information on ethnic origin" in order to avoid "the public stigmatization of entire communities characterised by their cultural, ethnic or racial identity" (Dardel, 2002; our translation).

In December 2015, however, the existing regulations in the DNA-Profile Law were again put up for debate by Albert Vitali (National Council for the liberal Free Democratic Party, FDP). The aim of Vitali's initiative to revise the law was to allow investigative authorities to use DNA testing methods in order to determine people's phenotypic and further 'personal characteristics', such as their probable 'geographical, racial or ethnic origins' or that of their ancestors. The initiative referred to the rape of a 26 year old woman in Emmen near Lucerne in July the same year. Vitali's text explaining why the law should be reformed was written in a dramatic tone and presented EDNA as a blessing for investigative work. The parliamentary proposal was titled "no protection for murderers and rapists", and claimed that police officers rely on "methods from the last century". Vitali complained: "[...] murderers and rapists must not walk free only because not all scientific options are used." (Vitali, 2015; our translation) One should emphasize here that this particular case was not suitable at all for arguing in favour of allowing phenotypic and ancestry-related investigations based on DNA traces because the severely injured woman was able to make statements about the perpetrator. Among other things, she testified that the perpetrator had black-brown curly hair, spoke broken German and called himself Aaron (SDA and SRF, 2015; SDA and NZZ, 2017). It is at least doubtful that EDNA would have been able to provide additional useful information to facilitate the search for the perpetrator. Given the specific charge of the case with the topos of the 'dangerous foreigner', the question arises whether Vitali would have chosen this as a reference case if the injured woman had given a description had referred to a white Swiss as the alleged perpetrator suggesting that the culprit was a white Swiss man.

One possible explanation why this case triggered the debate on EDNA in Switzerland is that EDNA-technology is quickly linked to historically sedimented images of the 'criminal immigrant' and the 'dangerous' or 'sexually unrestrained other' and, at the same time, it also raises expectations of being able to precisely determine the origin of migrants and refugees. This interpretation is supported by the observation that after the crime case in Emmen, racist associations were quickly voiced in the Swiss debate in the social media and local newspapers. For instance, only two days after the crime, the local police had to remove a call for potential witnesses to come forward on their Facebook page because several "racially discriminatory" comments were made (SDA and bih, 2015). Four days later, Hans Fehrn, National Councillor of the right-wing populist Swiss People's Party (SVP), stated in an interview: "This act is absolutely incomprehensible. That is why we have to control immigration" (DAG and VRO, 2015, our translation). And the next day, posters and stickers of the nationalist party National Orientated Swiss (PNOS) were displayed in Emmen with the slogan "Violence by foreigners is not tolerable! Support the PNOS now" (SAM,

2015, our translation). The crime committed by an individual person was thus generalised in these public commentaries as a problem generally related to immigration or foreigners. While on the surface the discourse is about a crime, these public statements all refer to the racist stereotype of the 'violent other'. Criminality is thereby equated with migration, and genetic tests to determine external characteristics and ancestry are presented in this logic as the supposed solution that will make it possible to identify and prosecute migrants and thereby combat crime.

Very similar discussions took place in Germany, starting at the end of 2016 after the 19-year-old Maria Ladenburger was raped and murdered by an initially unknown perpetrator in Freiburg (see e.g. Vogel, 2018). Step by step this discourse led in 2018 to state-level legalization of BGA and FDP in Bavaria's police law and then in December 2019 to the national-level introduction of FDP as a technical instrument for police investigations in the reform of the German Code of Criminal Procedures. The case of Maria Ladenburger attracted national attention because right-wing social media presented it as a result of the so-called "refugee crisis" of 2015. As in Switzerland, just a few days after the crime a right-wing group expressed their opinion in a leaflet distributed to city households, claiming that "nothing is as easy to determine by DNA analysis as race" and that the criminal prosecution authorities' hesitance to use these investigative techniques is due to their bias in favour of the suspect "because of his race" (Bund gegen Anpassung, 2016). In the following weeks, articles in different newspapers made comparable statements. For example, a comment in the right-wing weekly newspaper *Junge Freiheit* claimed "it would be possible to narrow down the number of suspects through an analysis of DNA for origin, hair colour, eye colour and size. But it is not allowed. Because of falsely understood political correctness." (Krautkrämer, 2016; our translation) The next day the regional daily newspaper *Badische Zeitung* published an editorial titled "Limitations of DNA analysis: a law that protects murderers" (Heidegger, 2016; our translation).

An analysis by Sarah Weitz and Nicholas Buchanan (2017) of the German media discourse on EDNA revealed that the majority of media reports constituted more or less a promotional campaign for the legalization of EDNA. In this debate, an atmosphere was created in which calls to consider these technologies' limitations and social risks were hardly visible at first and then later on presented as complicit with the perpetrators. Strikingly, for a long time even the experts did not regard it as necessary or appropriate to intervene, for example to correct the completely exaggerated hopes and false probability statements circulating in the debate. A more balanced discussion began only after an initiative of a multidisciplinary group of scientists, social scientists and ethicists (WIE-DNA) published a statement against the rapid and unregulated introduction of EDNA, and after civil society organizations further questioned the legislators' positive presentation of this technology, arguing that it would have racist effects (Lipphardt V et al., 2016; Zentralrat Deutscher Sinti und Roma, 2018; Gen-ethisches Netzwerk, 2017, 2019). Nonetheless, exactly one day after the murder suspect had been caught, the Baden-Wuerttemberg Minister of Justice introduced a law reform proposal at the federal level to legalize FDP analysis (Lipphardt V, 2018). The fact that the later convicted perpetrator had been caught using other, already established investigative methods apparently did not matter. Only much later did the geneticist and vehement advocate of FDP Manfred Kayser declare that the case wasn't well suited to argue for a law to allow DNA phenotyping. "It was the wrong case to make that claim" he said (Kayser cited in Vogel, 2018: 842).

Overall, it becomes clear that inflated expectations regarding this technology, quick associations with migration and even blatantly racist images were the guiding principles of these Swiss and German political and media debates. Many people evidently associated EDNA with desires that go far beyond its technical possibilities and fit into current developments on 'crimmigration', in which questions of crime control and questions of migration have increasingly become intertwined (Lipphardt V, 2018; Wienroth, 2020b; van der Woude et al., 2017).

Cases of real-life EDNA-analyses and situation-specific effects

Internationally, there are no data on the scale of this technologies' use, and there is no register, national or international, in which specific cases of EDNA application are recorded. Consequently, no systematic data are available on its outcomes or its broader effects. The information that is available is almost exclusively limited to press releases on specific cases of EDNA use by investigating police or the public prosecutor's office. Some of them have been referenced heavily in the current debate and have been subject to a number of (re) interpretations. In the following, we present some example cases, focusing on the questions of how EDNA has been applied, which discourses framed this usage and which racialising effects can be observed.

The Vaatstra case: The first forensic EDNA investigation and the uselessness of the designation 'white'

Probably the most prominent case in which EDNA has been used in a criminal investigation, is the very first one, that took place in 2000 in the Netherlands. Paradoxically, EDNA proponents often reference it, even though the BGA analysis did not facilitate the search for a suspect. The investigation took place after the rape and murder of 16-year-old Marianne Vaatstra in 1999 in a rural area in the northern Netherlands. Immediately after the crime became public the residents of a nearby home for asylum seekers were placed under suspicion, and the media and politicians justified this suspicion with the murder method, claiming that cutting someone's throat with a knife was "non-Dutch".[10] Soon after, the suspected asylum seekers were all exonerated by a comparison of their DNA profiles with DNA from the crime scene. Due to the lack of further clues, the Attorney General eventually decided to use the DNA traces found at the crime scene for a BGA analysis, even though this was clearly prohibited under Dutch law.[11] In June 2000, the forensic expert and geneticist Peter de Knijff was commissioned to analyse the available traces with a technology that was currently under development using markers on the Y-chromosome to predict the probable ancestry of the person who left DNA at the scene. De Knijff stated that the resulting marker combination was prevalent in Northwestern Europe and rare in the asylum seekers' countries of origin (M'charek, 2008; de Knijff, 2006). This probability statement was translated by law enforcement authorities as a classification of the wanted offender as "white". In this way, a misleadingly homogenised variant of race was created. Many men of colour also have the same markers, especially due to colonial history. While it was possible to use this information to counter the racist propaganda and stigmatization of asylum seekers at the time, it was of little use to the investigating authorities as the Northern European criterion included too many possible perpetrators. The anthropologist of science Amâde M'charek comments in this regard: "Dutchness or whiteness does not make an informative population category for police investigation" (M'charek, 2008: 525).

Nevertheless, the Vaatstra case led to revisions of Dutch criminal law in 2003, which legalised the genetic prognosis of chromosomal sex, externally visible personal characteristics, such as eye and hair colour, and also of race.[12] The case itself was not solved until 2012. Using one of the most extensive conventional dragnet searches conducted in the Netherlands, police were finally able to identify and convict the suspect, a farmer living in the immediate vicinity of the crime scene. As we see, in the Vaatstra case EDNA results were too broad to create more than a vague suspect population and seem to be actionable only when they point to a (supposed) specific and distinct minority.

The British "Night stalker" case: Putting pressure on a whole community

The potential social impact of EDNA in police investigations can be clearly exemplified in the British case referred to as the "Night Stalker", in which entire population groups were placed under suspicion and racialised. This case involved a London citizen of Jamaican descent who broke into mostly elderly women's homes, raped and robbed them; he was eventually held responsible for 203 crimes in the London area between 1992 and 2009 (Dodd, 2011). DNA of the perpetrator was found at several of the crime scenes, but it was not possible to find a match for it, neither in

the British police's DNA database, which had been compiled since 1995, nor in the DNA sampling of several thousand men from the London area.

In 2004, as there were no further clues to narrow down who the suspect could be, the British police decided to call in the US company *DNAPrint Genomics* to perform an EDNA to predict the origin and appearance of the perpetrator based on his DNA (Sankar, 2012; M'charek, 2018). The BGA analysis carried out, called DNAWitness™, produced a quite specific "maximum likelihood estimation" that the perpetrator's ancestry was "82% sub-Saharan African, 6% European, 12% Native American, and 0% East Asian" (Frudakis, 2008: 604). Based on this information, the involved epidemiologist and statistical geneticist Paul McKeigue deduced that the suspect would be of Afro-Caribbean origin, and the detective chief inspector thus concluded that the unknown offender most likely came from an island that was a former British colony (Frudakis, 2008; Sankar, 2012).

This origin estimate was apparently received with such euphoria that the investigating authorities, together with one of the contracted geneticists, considered it realistic to further narrow down the results to a specific island in the Caribbean. Although the technical director of the US company involved stated that this would not be possible, as did the already mentioned geneticist Jeffreys, the investigative authorities "persuaded 200 African-Caribbean officers to submit samples to DNAPrint for comparison". Their "donated" DNA was meant to optimize the tests that had been validated initially for a US population (Adam, 2004). The specified analysis then concluded erroneously that the suspect's ancestors were from the Windward Islands, specifically Trinidad, leading to a suspect population of 21,000 men in the neighbourhoods where the crimes took place. All of these men were asked to give DNA samples, and while this was framed as voluntary, authorities sent "threatening letters to men who refused to take part" (Greenwood, 2009). The actual "Night Stalker", Delroy Grant, was arrested five years later in 2009 – not due to EDNA technology, but to conventional investigation methods such as the evaluation of surveillance camera recordings and the determination of car license plates after he withdrew money from the bank account of one of his victims at an ATM (cf. M'charek and Wade, 2020). What becomes obvious in this case, is how EDNA technology cannot keep its promise to reveal precise characteristics of a suspect, but rather proves to be error-prone in real-world applications outside the laboratory. As a result, a large group of innocent citizens, a whole minority community, were designated suspects via DNA racial profiling and held responsible for helping solve the case.

The "Phantom of Heilbronn": German Neonazis and a contaminated cotton swab

While the problematic effects of EDNA in the Night Stalker case were widely discussed in the British media, a German case of an early BGA analysis in 2007 received inadequate attention, even though in this case racist stereotypes led to false interpretations of the DNA data and to racial profiling. The investigations had started because identical DNA profiles had been analysed from traces in widely scattered locations in France, Germany and Austria, and from various types of offences. The investigative authorities focused on female members of vulnerable groups, such as magazine pushers, homeless people, sex workers or "people with frequently changing residence", the latter being used as an internal code for Roma and Sinti (Lipphardt A, 2021: 231). Since some of the crime scenes were located in Austria, where BGA analysis was allowed, an ancestry analysis was performed using the mitochondrial Database EMPOP, and this suggested that the suspect's ancestors had come from Eastern Europe or neighbouring countries of the Russian Federation. Probability assignments of DNA data to specific geographical and national areas are typically visualised, as in this example in Figure 1, an image from the EMPOP homepage. The haplogroup depicted here is not identical with that of the suspect, since this is confidential according to data protection laws, but it does illustrate how a wide spatial distribution of certain DNA variants is used to attribute a specific origin to a suspect.

The police believed this information confirmed their suspicion that the perpetrator must be of Roma or Sinti ethnicity (Lipphardt A, 2019). An anonymous investigator was quoted in a

newspaper saying "we are also investigating intensely in the Gypsy milieu" (Eißele and Nübel, 2004; our translation). Indeed, racialising and criminalising stereotypes of Roma and Sinti were the basis for the following police investigations, as well as media coverage (Lipphardt A, 2019; Kleffner, 2014). Until 2009, the so-called "Phantom of Heilbronn" was thought to be responsible for around 40 offences between 1997 and 2009, including the murder of police officer Michèle Kiesewetter in April 2007. As the anthropologist Anna Lipphardt reveals in her research, the state criminal investigation office in Stuttgart searched for a woman based on an operational case analysis that included the anti-gypsyistic idioms "vagabonding, parasitising, stealing, and roaming" (see Figure 3) (Lipphardt A, 2021: 228, our translation).

It was not until 2009 that it finally became clear that during the production process, the cotton swabs being analysed had been contaminated with the DNA of a worker at the cotton swabs manufacturer. Until then, the EDNA analysis had given weight to the racialising perspective of the investigative authorities and resulted in resource-intensive investigations and dragnet searches, in which the police had ordered DNA samples from thousands of persons on the basis of these suspicions. While this dramatic error led to a revision of forensic laboratory standards and the adoption of a strict quality management strategy to avoid future contaminations, no comparable measures were taken to prevent the racist dynamics that had let to the wrongful investigative focus (Stenger, 2017). On the contrary, some police representatives are still using the case to claim the alleged usefulness of BGA analysis since the cotton swabs factory worker, in fact, turned out to be of Eastern European ancestry. But the case was not closed at this point. After the self-disclosure of the German neo-Nazi terror group "National Socialist Underground" (NSU) in 2011, it became clear that it was they who had murdered the above-mentioned police officer in 2007. However, it took another five years until this case was also discussed in the German media as an example of the extreme damage that can be done with forensic EDNA analysis. Only then it was discussed how the BGA analysis reinforced the already racist focus of the investigation, contributed to the victim-perpetrator reversal (which characterised the investigation of the other NSU murders) and unjustifiably subjected thousands of minority women from discriminated groups to police investigations.[13]

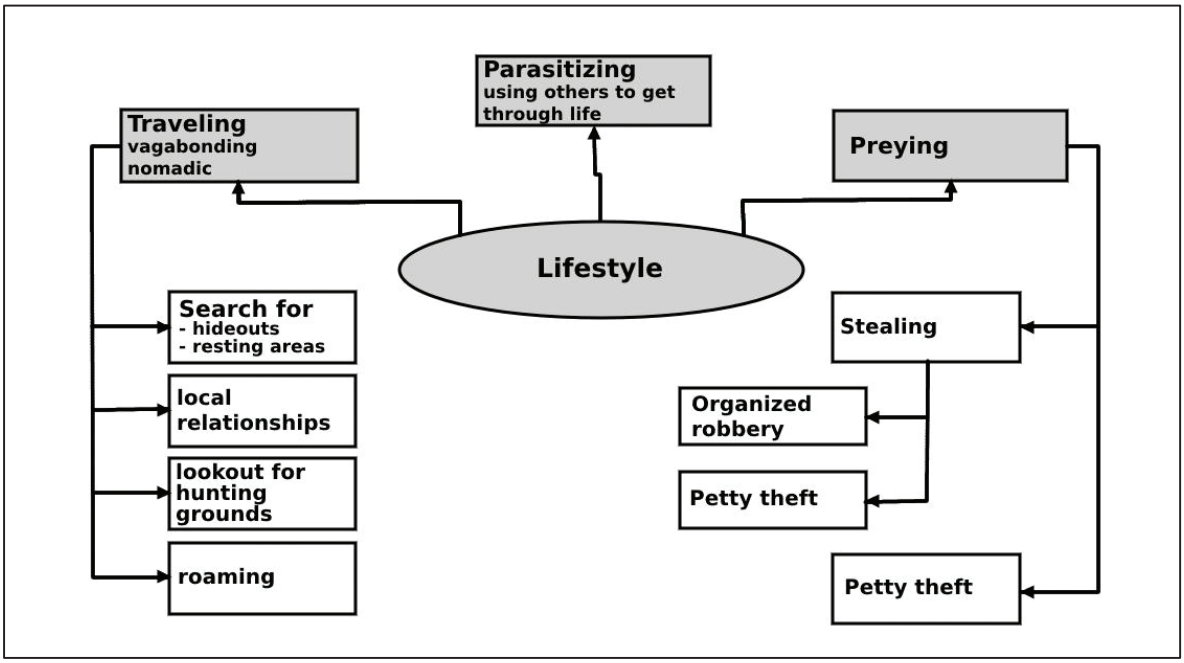

Figure 3. Suspect profile report used by the State Office of Criminal Investigation of Baden Wurttemberg, Germany in the case of the Heilbronn Phantom filled with all kinds of anti-gypsyist stereotypes. Translated and redrawn by us. The German version is in Lipphardt A. (2021: 228).

The Milica van Doorn case: Constructing a suspect population responsible for solving a criminal case

The Milica van Doorn case also took place in the Netherlands, in the municipality of Zaandam near Amsterdam, where the 19-year-old Milica van Doorn was raped and killed in June 1992. In the following years, the police investigation was unsuccessful, because there were no useful clues aside from a witness testimony of a couple who had seen a "Turkish-looking" man on the evening of the crime riding a bicycle near the later crime scene. The DNA profile from the crime scene did not lead to a match in the DNA database of the Netherlands Forensic Institute, and neither did further investigations in 2001 nor voluntary DNA testing from 2002 to 2004 in the vicinity of the victim (Peters, 2018).

Eventually, in 2008, the Procurators General authorised a BGA analysis of the crime scene DNA, revealing that the suspected perpetrator's DNA profile was more common in Turkey and North Africa. Based on this, a group of 75 men of Turkish descent between sixteen and thirty years old at the time of the crime were asked to contribute their DNA to the investigation (Toom, 2010), but this also did not result in a match. Finally, in 2017 a DNA dragnet search was carried out following a change in the law, which allowed so-called familial searching[14] utilising DNA analysis. This time the group who was asked to give their DNA consisted of 133 men of Turkish ancestry who had lived near the crime scene in 1992 or who were family members of these residents. According to the police's statement and the media reports of the time, a comparatively cautious approach was taken (cf. van Oorschot and M'charek, 2021). It involved police communication with representatives of Turkish-Dutch and Kurdish-Dutch religious communities, explaining the goal of DNA testing, asking for support and thanking the participants afterwards in several media posts for their willingness to donate their DNA for the investigation. The result was that only two of the selected individuals did not participate in the dragnet (Stoker, 2020). One of them was finally identified as a suspect via his brother's DNA and by means of a court-ordered DNA identity test. He was sentenced in court in 2018 – and at the time of writing this article a verdict for the case is still pending in a higher court.

Although the investigators tried to be cautious in several respects to avoid racist stigmatization, the case nevertheless demonstrates how EDNA application has inherent problems that do not vanish even in a best practice scenario. Above all, it becomes clear how EDNA results tend to put pressure on ethnically marked persons, grouping them in one seemingly homogenous "community" that is then asked to take responsibility for the investigation. In any case, it is hard to imagine that the search for an offender of Dutch origin would have been conducted with similar pressure on all members of the Dutch ethnic group or that "the Dutch community" would have been addressed as such by investigators. Moreover, the success of the investigation was due to a large extent to the substantial limitation of the group of suspects, which was only possible because of their ethnicity. BGA and FDP that attribute a suspect's DNA trace to minorities are translated as knowledge about a "suspicious population", and the formulations of forensic experts such as "the DNA profile is more common in Turkey and North Africa" are turned into generalising statements such as "the perpetrator is a Turk" (M'charek and Toom, 2011; cf. Cole and Lynch, 2006). A similar approach would probably not be adopted towards a suspect believed to be of so-called autochthonous Dutch origin, firstly because there are far too many people of this population group living in the urban area concerned, and secondly because the search for a single perpetrator of Dutch origin would not lead to all white people being addressed as a "suspect population" or to the demand that they as a population group assume responsibility for helping solve the case. This case is therefore yet another example of how EDNA contributes to the strong structural targeting of minority groups by investigating authorities and, beyond that, how a group framed as "ethnical group" is put under pressure to take responsibility as a "community" only because of a common ethnic or religious background.

First BGA analyses in Germany: No minority characteristics, no investigative use

Meanwhile, since the legalization of BGA forensic analysis in the state of Bavaria, Germany in 2018 for the vaguely defined purpose of "danger prevention" (Rath, 2019), two such cases have drawn public attention. The first EDNA was performed on the DNA of a serial rapist, referred to by the media as the "Allgäuer Triebtäter" (The Sex offender of Allgäu), who had attacked at least six girls and women between 2000 and 2011. The BGA analysis did not elicit the anticipated investigative success, since the ancestry of the perpetrator was predicted to be "European". "For a manhunt this description is simply 'not enough'", a newspaper article quoted the Federal Criminal Police Office in charge of the investigations as saying (Rath, 2019; our translation).

In a second case, Bavarian police commissioned a BGA analysis to find the suspect in a murder case from 2013 referred to as the "Isarmord" (Isar murder). In this case, a male suspect had stabbed the 31-year-old Domenico Lorusso in Munich with no apparent motive. A DNA dragnet search with 6,500 men revealed no matches. At the beginning of 2020, an EDNA was carried out which predicted that the offender was very likely to have brown or light brown hair, brown eyes and medium skin colour. In addition, he would probably come from Europe, and he himself or his male ancestors would come from northern Ukraine, Russia or Belarus (Hans, 2020). While the lead investigator told a newspaper that the DNA analysis "outperformed his expectations", the author of the article points out that "the description more or less applies to the average Munich inhabitant" and "millions of Europeans" (Hans, 2020; our translation). No suspect had been arrested by the time this article was written. This confirms what M'charek already stated for the Vaatstra case and the first EDNA analysis carried out there, namely that in most European contexts 'whiteness' does not constitute an informative finding for a police investigation (M'charek, 2008: 525).

Conclusion: Racializations are incorporated in and reproduced by EDNA

In employing the analytical model of dispositive analysis, we have examined the reality of EDNA in three analytical dimensions – that of EDNA as a technological instrument, EDNA in media discourse, and real-life cases of EDNA application in forensic investigations – revealing different types of racialization in all three dimensions. First, we were able to reconstruct how the development of this technology has been marked by very selective sampling strategies, by homogenising within group categories and overemphasising the differences between them, by classifications based on existing, (culture- and nation-specific) constructed 'race' and 'ethnicity' categories and by the reduction of gradual genetic diversity to a few categories. Second, we examined how public discourse regarding the legal approval of these technologies in Germany and Switzerland is characterised by undue faith in its effectiveness as well as by racialised and often openly racist images about the 'criminal immigrant' and the 'dangerous or sexually unrestrained other'. Third, our analysis of applications of EDNA technology revealed how real-life EDNA analyses can lead to racialising and racist attribution of crimes to particular populations and can thus lead to the consolidation of

Table 1. Overview of the results of the dispositive analysis of the different dimensions examined

Dimension of analysis	Forms of racialization and their outcome and effect
1. Design and operating principles of EDNA technology	• Reduction of gradual variability into distinct typologies • Naturalization of cultural- and nation-specific classifications • Homogenization within groups and emphasis on difference between them
2. Media and political discourse on the introduction of EDNA	• Massive intertwinement between the debate and crimmigration narratives • Use of essentialising group assignments • Racist images of the 'dangerous other'
3. Cases of EDNA application in forensic investigations	• Creation of suspect populations, criminalization of populations • Assignment of responsibility to minority groups and communities • Danger of stereotyping, stigmatization and racial profiling

racist ideas. Our investigation has also shown that EDNA entails the danger of reinforcing stereotypes, can impose a special responsibility for investigations upon minority groups and, above all, makes already often marginalised groups even more vulnerable to racial profiling.

In the cases investigated here, it is quite obvious that the idea of race has by no means been overcome but rather remains very persistent, mobile and mutagenic; it shifts and changes. While the term race has been largely absent in recent years, the concept persists and reappears intermittently in discourse as well as in some praxis fields (cf. M'charek et al., 2020). This can be observed in the case of EDNA technologies, which target not individuals but rather human groups, which therefore have to be constructed using various selection practices. However, EDNA technologies should not be interpreted as an intentionally racist project, and the actors involved, such as politicians, media advocates and police practitioners, do not pursue a common racist strategy. Structurally, however, racialization remains a constitutive force in the problematic process of dividing people into manageable group categories, since researchers and investigators can escape neither the typological classifications of population groups which they were socialised to perceive nor the historically charged connotations associated with particular phenotypic characteristics and geographical spaces. Even if predicting someone's race is not the aim of the analysis, and even if explicit forms of racialization are actively avoided, reinscribing race and a racialising focus on minorities remains intrinsic to EDNA technologies.

Furthermore, we revealed in our study that the three dimensions examined do not stand independent of each other but are interwoven and mutually supportive without a directed causal relationship. To this end, the dispositive concept, as we outlined it in reference to Foucault (1980) and Jäger (2001), served us as a very useful analytical model to grasp the interconnectedness of these technologies, discourses and practices. In addition, this concept allows us to focus on the complexity of the problem, showing clearly that the negative effects of EDNA cannot be eliminated by correcting them only at one level (for instance, only with a more sound police practice, discursive or technological approach). And lastly, we were able to use dispositive analysis to identify how the application of this technology in investigative work can have very different effects in different situations.

Indeed, because the problems related to EDNA technology occur in apparently unrelated fields and because the consequences and effects of its application become invisible behind the inflated expectations regarding their results, these problems can become especially powerful and difficult to avoid. Even in cases in which attempts were made to avoid racist effects of EDNA technology through anti-discrimination measures, the risk of being profiled is mainly carried by members of minority groups.

In order to grasp this complexity of issues we use the term 'racial profiling' as a heuristic tool to highlight the structural problems that cause members of racialised groups, in particular, to be targeted by investigating authorities. The term 'genetic racial profiling' draws our attention to these effects and impacts with regard to EDNA-based police practices, which are inclined to selectively focus on minorities and thus reinforce societal patterns of discrimination and disadvantage. The example of EDNA-based forensics illustrates the paradox that in current post-racial societies biological concepts of race are rarely referred to openly, even as biological attributions to specific, historically categorised groups are all the more interwoven in such technologies, meaning that race- or ethnicity-related discrimination is merely hidden behind supposedly purely technical procedures and discursively legitimised police practices. Race is therefore both absent and present at the same time.

Finally, our analysis demonstrated that EDNA tends to have very unequal effects on majority and minority populations. This is because EDNA is only a useful investigative tool if its DNA analyses reduce the suspect group to a manageable size for investigation. In addition, the search for a wanted person reconstructs a particular minority population as a 'suspicious population' (cf. M'charek et al., 2020). Once again, these effects of EDNA in its forensic application can be linked back to the technological development of the databanks

themselves, not in the past but also in the present. That's why we end this article with two examples of discriminatory practices of data collection. One very problematic development appears to be the research of China's Ministry of Public Security, which has recently been made public. According to critical observers (Wee and Mozur, 2019; Moreau, 2019), DNA samples were taken without proper informed consent and allegedly at times by force from a large number of people belonging to Tibetan and Muslim minorities in China, in order to develop EDNA research to predict external characteristics and origin from DNA. Additionally, companies based in Hong Kong and China are developing facial recognition systems for police authorities that they claim can assess whether a person is a Uighur (van Noorden, 2020). Together these technologies contribute to mass surveillance and human rights abuses of discriminated minorities (Wee and Mozur, 2019). It would be naïve to think that this operation of the Chinese state can be separated from EDNA research in the West. In fact, the studies were conducted partly in cooperation with and financed by Western research institutes, and their results have been published in prestigious international scientific journals and included in the research databases that form the basis for EDNA investigations in the international context.[15] Additionally, some European researchers engage in ethically questionable collection of data from minorities themselves. At the end of 2020 Lipphardt V et al. reported that DNA data of European Roma is frequently used without documented informed consent and often transferred from medical studies into forensic research (Lipphardt V et al., 2021b; Schiermeier, 2021). Such threats are especially prevalent for minorities and already underserved communities (Machado and Granja, 2020).

In conclusion, EDNA exacerbates an already existent structural problem by exposing people from discriminated social groups much more often to the danger of being the object of criminal investigations and criminalising stereotypes. Extended DNA analyses may thereby contribute to casting suspicion on entire population groups. In this regard this profiling not only discriminates against those directly subject to it but also their family members and communities, affecting relationships in society as a whole by creating and stabilising categorical divisions. Not only the consequences of over-policing minority population groups, but also the inflated hopes of solving complex security problems by technological means have not yet been sufficiently considered in public discourse. The effects of the three dimensions of EDNA technologies are interwoven and reinforce each other. Unquestioned, the supposedly neutral classification requirements of forensic applications, accompanied by the relatively uncritical discourse regarding the limits and risks of EDNA technologies, create fertile ground for genetic racial profiling to take place. Scientific research and a broad political as well as societal debate on the problematic social implications of these technologies are therefore urgently needed.

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Notes

1 Furthermore, research is being done on estimating people's height and their likelihood of having freckles. Some companies are also already claiming that they can estimate the age of a person using an epigenetic test procedure. Profiles for other features are in development, such as facial features, early baldness in men, ear shape, etc.

2 See for example Lipphardt et al. (2021a) and Amelung and Machado (2021) or the terms used by the Freiburg Initiative, http://www.wie-dna.de/english/. In most scientific and popular texts on the subject, the technologies investigated here are subsumed under the term 'forensic DNA phenotyping' (FDP). We consider this label to be misleading when used as a catch-all overarching term beyond the DNA analysis of probable phenotypic characteristics. For instance, when biogeographic ancestry (BGA) is subsumed under FDP it is then misunderstood as giving information about phenotypic characteristics. We therefore use EDNA as the overarching term to include both FDP and BGA. Even more misleading are other terms such as 'molecular photofitting' or 'composite sketching' which incorrectly suggest technological capacities which do not currently exist.

3 Our analysis of racialization encompasses different ways of constructing groups and is intended to be sensitive to the European context in particular, as racialising demarcations often function differently here compared to the US – less along the colour line and more linked to nationalisms, origin, migration history, language, religion and culture-related aspects.

4 We can thankfully draw on the data collected by Sarah Weitz, Nicholas Buchanan and Veronika Lipphardt in their media analysis of the debate in Germany (see Weitz and Buchanan, 2017).

5 One early forerunner Francis Galton already tried to determine race and nationalities from fingerprints using statistical methods (Galton, 1892). Furthermore, there are patterns of continuity from early genetic studies of differences between racial groups – such as seroanthropological research on blood samples in the first half of the 20th century and population genetics since the 1930s – to today's attempts to genetically predict the origin and visible features of a person (cf. Spörri, 2014; Roberts, 2011).

6 By pointing to this consensus we do not want to imply that the already established technologies of DNA profiling for identification, e.g. the technologies of dragnets and forensic DNA databanking, are uncontroversial. Data protection and civil rights concerns have been expressed regarding the massively expanded access to this highly sensitive personal data during the last two decades. See e.g. publications of the NGOs Center for Genetics and Society, Gene Watch UK, Council for Responsible Genetics, (Krimsky and Simoncelli, 2011; Lynch et al., 2010).

7 As another earlier source, the philosopher of science Lisa Gannett (2014), cites a poster presentation at a meeting of the American Society of Human Genetics by Mark Shriver and others from 2000, in which BGA was introduced in order to measure the "components of ethnicity that are biologically determined" (Pfaff/Parra/Shriver cited in Gannett 2014: 175).

8 https://empop.online/empop_stats, accessed 2 June 2021.

9 For an explanation of this technology, see https://hirisplex.erasmusmc.nl, accessed 2. June 2021.

10 This was expressed, for instance, by the right-wing populist Pym Fortuyn (de Koning, 2012; cf. M'charek, 2008).

11 Details on this and on the Milica van Doorn case were kindly provided by the Dutch forensic geneticist Peter de Knijff, through personal correspondence and an interview.

12 Following additional reforms in 2012 and 2017, the Dutch government regulation on DNA investigations in criminal cases stated in article 1 b the legalised analysis of: "a. het geslacht [sex]; b. het ras [race]; c. de oogkleur [eye colour]; d. de haarkleur [hair colour]."

13 See the extensive documentation on "Unravelling the NSU complex" at www.nsu-tribunal.de/en.

14 Familial Searching uses DNA analysis to search for partial matches within DNA profile databanks. It is based on the principle that siblings, parents, uncles, aunts and cousins, on average have more in common in their DNA profiles than unrelated persons. If this method reveals partial matches with the DNA of an unknown suspect, it is possible to investigate within the family of the partially matched person in order to search for the perpetrator.

15 One of the scientists responsible for this research is Fan Liu, a professor at the Beijing Institute of Genomics, who often collaborates with the most prominent FDP researcher Manfred Kayser (mentioned above) at the Erasmus University Medical Center in the Netherlands – not only as a member of his research group, but also as a frequent co-author (Pośpiech et al., 2018; Liu et al., 2019).