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Governing expectations of forensic innovations in society: the case of FDP in Germany

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This article is about the governance of expectations of forensic DNA phenotyping (FDP) innovations in Germany used for the prediction of human externally visible traits such as eye, hair, and skin color, as well as biological age and biogeographic ancestry. In 2019, FDP technologies were regulated under the label “extended DNA analysis”. We focus on the expectations of members of the forensic genetics’ community in Germany, in anticipation and response to those of regulators who advocated for such technologies. Confronted with regulators’ expectations of omnipotent technologies and the optimistic promise that they will enhance public security, forensic geneticists responded with attempts to adjust such expectations, specifying limits and risks, along with a particular logic sorting matters of concern. We reflect on how forensic geneticists’ govern expectations through forms of *distributed anticipatory governance*, delimiting their obligations, and distributing accountability across the criminal justice system.

Keywords: forensic geneticists; sociology of expectations; forensic DNA phenotyping; anticipatory governance; accountability

Introduction

Forensic DNA phenotyping (FDP) is a bundle of DNA analysis technologies that have emerged for the prediction of human physical characteristics, including externally visible traits such as the color of eyes, hair, and skin, as well as biological age and biogeographic ancestry. These technologies aim to provide typological information about common, but varying, personal features by drawing on population-based probabilities. In the realm of criminal investigation, this set of technologies is applied to unidentified DNA stains found at crime scenes. FDP’s overall promise is linked to the ability to narrow down groups of criminal suspects and thus improve criminal investigations and increase public security.

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Already for some time transnational networks of forensic geneticists have been researching and debating the aforementioned FDP technologies (Wienroth 2020). Yet, the technologies have entered the regulations of criminal law in only a few countries (Samuel and Prainsack 2018a, 2019). By the end of 2019, FDP became regularized in Germany in the aftermath of a particularly high-profile criminal case¹ that took place in Freiburg in the regional state of Baden-Württemberg in October 2016, after intense debate about their legitimacy, proportionality, and adequate solutions to regulate them (Lipphardt 2018).

The Freiburg criminal case received overwhelming media interest in the context of debating for and against new forensic technologies able to predict externally visible characteristics and biogeographic ancestry (Lipphardt 2018). An asylum seeker turned out to be the perpetrator whose outward appearance was different from that of the German majority population. The subsequent media attention predominantly represented views of an unsafe society using outdated forensic technologies and raised highly optimistic public expectations around forensic DNA technologies, suggesting that FDP provided an easily available solution to enhance public security (Weitz and Buchanan 2017).

The criminal case and the subsequent discussions gave rise to proposals for using FDP and such proposals entered the policy debate in using the label of “extended DNA analysis” to refer to FDP technologies. While the term FDP circulates among the forensic genetics community, the term “extended DNA analysis” was established in the policy debate in Germany to describe the political project to regulate a specific selection of FDP technologies available for use in the criminal investigation. The following sentence was added to the existing legislation (German Code on Criminal Procedure (StPO) § 81e) which regulates the use of forensic DNA analysis: “If it is unknown from which person the trace material comes, additional determinations about the eye, hair, and skin color, as well as the age of the person, can be made” (Bundesministerium der Justiz und für Verbraucherschutz 2019a).

Before the draft law’s finalization, the Federal Ministry of Justice and Consumer Protection initiated a consultation process and invited a range of stakeholders’ advisory opinions on the draft law which were made public through the Ministry. Advisory opinions of diverse stakeholders were received articulating diverse supportive or critical responses (Bundesministerium der Justiz und für Verbraucherschutz 2019a). Claims of stakeholders gathered around the technological potential of FDP, its readiness, and its application possibilities in criminal investigation versus its potential harm to fundamental rights. In the reasoning which accompanied the draft law for amending the StPO to incorporate FDP, the governmental parties proposing the draft stated:

According to current scientific knowledge, the externally visible body characteristics can be determined by examining genetic information with *sufficient predictive*

accuracy [own translation and own emphasis]. (Bundesministerium der Justiz und für Verbraucherschutz 2019b, 30)

Federal regulators agreed on the assessment of sufficient accuracy for a specific set of FDP technologies. Yet, the federal and state initiatives to regulate the emergent technologies had included and justified different selections of technologies. Both had incorporated the prediction of eye, hair, and skin color as well as age. Yet, the federal law avoided selecting “biogeographic origin”, unlike the Bavarian Police Law. The motif for excluding biogeographic ancestry was justified by policymakers by its apparent potential to discriminate against certain population groups (Rath 2019). The minister of justice, Christine Lambrecht, explained its exclusion by warning of the potential harm against minority groups: “However, it can result in larger groups being pilloried, such as all Africans or all Asians” (Rath 2019, 2, own translation). While the prediction of biogeographic origin was not included in the federal law, prediction of skin color was incorporated. The argumentation of the minister to include skin color followed the logic of classifying skin color as the outer appearance which likewise might be reported by an eye-witness: “If a witness says that the perpetrator was dark-skinned, the police are already looking for a dark-skinned perpetrator” (Rath 2019, 2, own translation).

The general use of FDP technologies in law enforcement for solving crimes in the responsibility of the federal level followed once a single state – out of sixteen states in Germany – already had surged ahead and created precedents in terms of regulation in the context of preventive policing. Already in 2018, the Police Law in the South German state of Bavaria had included FDP technologies in the context of preventive police actions (Bayerische Staatskanzlei 2018) averting “imminent danger”. The amended Bavarian state law authorized the use of the following FDP technologies, the prediction of eye, hair and skin color as well as age and biogeographic ancestry, “to investigate people they deem an ‘imminent danger’[,] persons who have not necessarily committed any crimes but might be planning to do so” (Vogel 2018). The Bavarian legislator justified the demand for FDP technologies in a context of counter-terrorism measures to prevent potential mass shootings or terrorist attacks which emphasized a notion of security linked to the requirement of acting “before the formation and identification of a determinate threat” (Anderson 2010, 792).

The introduction of FDP in Germany is an exemplary case of contemporary state security policies focusing on diverse potential future threats and dangers of unpredictable nature as a legitimizing carrier for particular pre-emptive actions and overall “risk group” oriented data-driven surveillance measures (Pavone, Santiago Gomez, and Jaquet-Chifelle 2016). At the same time, the regional state law, as well as the federal law amendments oriented to enhance FDP technologies, were accompanied by the political rhetoric of security enhancement along with tremendous expectations about their availability, capabilities, accuracy, and efficiency. In this paper, we focus on the expectations of members of the forensic genetics’

community in Germany, in anticipation and response to those of regulators who advocated for such technologies. Confronted with regulators' expectations of omnipotent technologies forensic geneticists responded with attempts to adjust such expectations, specifying limits and risks, along with a particular logic sorting matters of concern. Our focus is to explore how forensic geneticists managed expectations within their community of practice as an attempt to lower and adjust expectations around seemingly omnipotent technologies, but also contributed to the governance of expectations with proposals of (self-)regulation to prevent potential harm.

Previous works on the views about FDP by the members of the European community of forensic geneticists have shown that this professional group carve out notions of risks emerging from the uses of these technologies in the criminal justice system, and claim that strict accountability is needed (Wienroth 2018, 2020; Granja and Machado 2020). This paper aims to contribute to deepening the understanding of forms of assigning and distributing accountability, and the specific role of the community of forensic geneticists in governing expectations of FDP innovation in German society. One of these studies, conducted by Wienroth, proposed the notion of "anticipatory (self)governance" to focus on "the role which researchers and users of technologies have in the framing of emerging technologies as responsive to specific operational challenges, and eventually the adoption of technology into practice" (Wienroth 2018, 12).

We take inspiration from Wienroth's work on anticipatory (self)governance, but we also will assess as much this notion allows for a critical consideration of the discursive articulations of forensic geneticists' attempts to govern expectations of FDP. In this article, we propose to make use of the analytical repertoires from the sociology of expectations, sociology of innovations, and critical security studies that together contribute to expanding and deepening the understanding of the interrelations between expectation management within the epistemic community of forensic geneticists, the governance of expectations of security innovations, and policymaking in the context of emergent security technologies. We will suggest the term *distributed anticipatory governance* which goes beyond self-governance to look at what matters of concerns evolve in discursively articulated expectations of forensic geneticists and how governance accountability for FDP technologies is assigned in a distributive manner.

Governing expectations of forensic genetic innovations

The sociology of expectations is an account that has explored future-oriented discourses together with new and emerging technology innovations. Its interest lies in studying rhetorical visions and how they are performative in the way of how they serve to enable some technoscientific worlds and to disable others (van Lente and Rip 1998; Borup *et al.* 2006). While lots of attention has been paid to expectations and hypes (Borup *et al.* 2006), some attention has been paid to low expectations

(Gardner, Samuel, and Williams 2015). Little attention has been paid to how expectation management of lowering expectations to maintain credibility and legitimacy for technologies takes place. Yet, a small, nascent body of work on low expectations has drawn attention to the less-promissory visions of the future that accompany biomedical innovation projects. This work has examined the nature of “low expectations” and what role they might play in innovation projects as a whole (Gardner, Samuel, and Williams 2015). Tutton (2011, 419) for instance studied the biotech industry tackling back and forth between pessimistic and optimistic forecasts of equally conditional futures.

Critical security studies have explored how the reference to security moves matters from regular politics into the realm of security thereby enabling extraordinary measures to be considered as proportionate measures. Studies on the securitization (Buzan, Wæver, and Wilde 1998) of specific technologies (Amicelle, Aradau, and Jeandesboz 2015) have looked into how security practitioners engage politically to garner support for the countermeasures and actions which already need to be taken in the present (Kester *et al.* 2020). In this article, we explore the security technologies of FDP which forensic geneticists problematize themselves to adjust and redirect overly enthusiastic political support for seemingly omnipotent technologies. By doing so we also study how they respond to dominant normative security visions increasingly demonstrating the seemingly inevitable tradeoffs with restricting civic rights and freedom (Pavone, Santiago Gomez, and Jaquet-Chifelle 2016) and producing discriminatory pitfalls deriving from value-loaded categorizations of suspicion/non-suspicion population groups (Leese 2014).

Kester *et al.* (2020) have provided an important attempt to bring together insights from theories of sociology of expectation and critical security studies which provide an important foundation to our article. They characterize both scholarly traditions as follows:

one logic [is] detailing the performativity of desirable futures with its desire to change certain aspects of the present [sociology of expectations] and one [is] detailing the performativity of undesirable futures to preserve or stabilize the present [critical security studies]. (Kester *et al.* 2020, 89)

Professionals developing and working with security technologies tend to normalize and take securitization demands and a “focus on futures through threats, dangers, catastrophes, or other perceived events” (Kester *et al.* 2020) that negatively impact futures rather for granted. The way they mobilize expectations about technologies may follow different logics deriving from the respective epistemic communities’ frame of reference and in response to regulators’ mobilized expectations and potential hypes featuring security technologies to prevent undesirable futures.

As we will show in our analysis, the community of forensic geneticists in Germany actively participates in *reactive management of expectations*, or what Brown and Michael (2003) in their seminal work have called deploying prospects

of futures of the new technology at stake, which derive from retrospected futures linked to forensic genetic technologies in general which have been overly enthusiastic in the past (Amelung, Granja, and Machado 2020).

Hielscher and Kivimaa (2019) building on Konrad and Alvia Palavicino (2017, 190) have approached the dynamics of “governance by expectations” which they understand as the intentional use of expectations to legitimize the implementation of policy and technology innovation. In the German regulation process of FDP, we may see governance of security technologies by expectations, regulators envisioning threats such as severe crimes like the Freiburg murder case, to justify the demand, necessity, and relevance of forensic technologies in the present as means of prevention. At the same time, forensic geneticists as we will see in the analysis, seem to contribute to what Hielscher and Kiviima called “governance of expectations” towards FDP technologies. They respond to overly optimistic expectations towards technologies by proposing particular regulatory setups for technological configurations and fixing expectations towards specific enactments of technologies. They do so by considering selected matters of concern relevant to create legitimacy in the epistemic community of forensic genetics and the wider publics of security policies.

Wienroth proposed the notion of “anticipatory (self)governance” in order to focus on “the role which researchers and users of technologies have in the framing of emerging technologies as responsive to specific operational challenges, and eventually the adoption of a technology into practice” (Wienroth 2018, 12). He identified distinct types of anticipatory ordering devices which together prepare the adoption space for the uptake of technologies: (a) aspirational regimes to orient rationalizing and operationalizing research and technology, (b) standard standard-setting to harmonize training and methodologies for testing, analysis, and interpretation of FDP technologies and (c) projected applications and trainings for such applications. We take from Wienroth the focus on anticipatory (self)governance and selected ordering devices, but also will critically assess as much they allow for a critical consideration of the discursive articulations of forensic geneticists’ attempts to govern expectations of FDP technologies.

Methodology

This article is based on a qualitative interpretative methodology analyzing semi-structured interviews and selected journal publications of forensic geneticists. The data collection was conducted before the finalization of the bill which passed by the end of 2019. The interviews were conducted between June 2017 and May 2018 with nine professionals from eight institutions developing or working with forensic genetic technologies in Germany distributed across six states in Germany. The interviews were conducted under the protocols and procedures of the European Research Council’s ethics regulations. We selected interviewees based on the search of German authors of scientific articles in the area of

forensic DNA phenotyping, additional contacts with professionals participating in conferences and other events relevant to the field, and complemented the selection with the snowball method applied among interviewees asking for forensic geneticists with a known (potentially diverging) viewpoint on the matter of the “extended DNA analysis” in particular and the regulation of FDP in Germany in general. Interviewees were recruited by e-mail and telephone. The script of the interviews covered the following themes: the organization of the provision of forensic genetics services in the country, views, and experiences about technological development and innovations of DNA technologies such as FDP, as well as the public perceptions and regulatory process related to technological forensic genetic innovations. All interviewees signed a written informed consent form and agreed to be audio-recorded. The interviewers took notes to help to guide questions in the interview and for reflection after the interview. When the interview was completed, the interviewers reviewed their notes and made annotations about issues and items that could be addressed in the analysis. Whenever necessary, an editing process was carried out after the initial transcription. The editing was performed without ever undermining the original meaning of the narratives or suppressing the individual voice of the narratives of each interviewee (Poirier, Clapier-Valladon, and Raybaut 1983, 65). Quotations relevant to the different uses, meanings, and regulation of FDP were coded and subjected to multiple readings to develop an in-depth understanding of the prevalent notions of expected benefits and risks of FDP technologies. These quotations were systematically compared, contrasted, synthesized, and coded by theme and by thematic category following the principles of grounded theory (Charmaz 2006) and interpreted using a qualitative content analysis approach (Mayring 2004). In this paper, we analyze the replies that were considered by the two authors as illustrating the thematic categories that emerged from the content analysis.

Taking into account previous research (Samuel and Prainsack 2018a, 2018b) on professional views of actors involved with FDP by building on interviews with European police, scientists, and representatives of governmental agencies demonstrating the heterogeneity of views, even across the same professional group, we considered the aspect of heterogeneity of views when selecting our interviewees, while assuming that the group overall shares understandings which tend to welcome the legalization of FDP technologies in Germany. The sample is assumed to be sufficiently diverse to represent a characteristic variety of views across the community of forensic geneticists because interviewees confirmed throughout the snowball method the same protagonists as representing converging viewpoints among the forensic genetics’ community.

Additionally, three journal publications published between 2018 and 2019 complement the data corpus for the analysis as they provide written articulations of forensic geneticists’ viewpoints on FDP technologies and/or on the extended DNA analysis as the regulatory project in Germany from a forensic genetic viewpoint in international and German journals considered key journals for the forensic

community. By incorporating these publications data is considered which allows us to assess how forensic geneticists attempt to the scientific and policy dialogue regarding the regulation of FDP. The sample includes the correspondence in scientific debates found in one of the community's most prominent journals, *Forensic Science International*, and one article in the *Deutsches Ärzteblatt*, and one article in *Rechtsmedizin*. We included those articles (co-)authored by forensic geneticists which were produced while the regulation process was on its way. To our knowledge, there are no additional articles that fit these criteria. We analyze the recommendations for regulatory solutions of FDP technologies and how they respond and incorporate specific matters of concern.

Regarding the different type of data collected, analyzed, and interpreted in this article, we assume that forensic geneticists as a specific epistemic community perform and articulate themselves on matters related to FDP and its regulation differently either as authors of publications addressing audiences of expert publics of forensic genetics or in semi-structured anonymized expert interviews. Both of them provide relevant carriers of meanings of expectations about desired and undesired futures and specific matters of concern related to FDP and its regulation of the epistemic community, however, differing with regards to the type of language and symbolic representation of meanings (values and beliefs) (Yanow 2000).

Results

Matters of concern orienting forensic geneticists' expectations towards FDP

When we began collecting our interview data the regulatory process had been accompanied already by numerous events involving forensic geneticists, legal and data protection experts, social scientists, and practitioners from the criminal justice systems. These included a symposium held by the ministry of justice and consumer protection on 21 March 2017 which was documented on the ministry's website, and a press briefing with various expert opinions held by the Science Media Center Germany on the same day likewise documented on the host's website. Another interdisciplinary and transdisciplinary symposium was held by the Freiburg Institute for Advanced Studies (FRIAS) on 9 and 10 June 2017 which all dealt with the matter of regulating the "extended DNA analysis" (STS Freiburg Group 2017). Additionally, notable media attention has shaped the general publics' and expert publics' views as well as the regulatory debate. According to Weitz and Buchanan (2017) who analyzed the media coverage related to the political project of the "extended DNA analysis", there were 171 related media reports published between January 2016 and June 2017. The forensic geneticists in Germany we talked to were informed about a certain range of views and supportive or skeptic positions regarding FDP technologies represented in the media and in such events which they either had attended or heard of. We assume to some degree shared anticipated expectations of forensic geneticists shaped by the public discourse accompanying the regulatory debate. Thereby, our interviewees

referred to the supposed high potential to advance criminal justice of such technologies assumed by proponents in policy-making, but also confirmed their awareness of claims about issues of privacy and discrimination had been repeatedly raised by data protection experts, social scientists, and legal scholars.

Our interviewees demonstrated an overall interest and curiosity in technological innovations in the field of forensics, welcomed FDP as a set of technologies and had optimistic expectations that they could make an impact and progress in the forensic field. However, in response and reflection of the regulatory debate about the “extended DNA analysis” forensic geneticists adjusted and sorted their expectations along with specific matters of concern as we demonstrate in this section.

Forensic geneticists considered novel technologies as proof of possibility and the creation of impact in the forensic field, as the following quotation, referring to FDP and the 1990s when DNA analysis slowly became the “gold standard” (Lynch *et al.* 2008) in forensic science, demonstrates. In the words of one of the interviewees:

[DNA] phenotyping is also a new phase and logic for us, who are scientists in forensics, that we are interested in. Yeah. We start to be interested in new technologies when [they] arrive or even try to differentiate a little bit the new technology whether in terms of why now, what is the context in Germany? (...) what is the impact of a new method? (interviewee O06)

Among forensic geneticists exists a certain taken-for-granted belief in the utility and relevance of innovation and technological progress which help to predict the outer appearance of unidentified individuals per se in their field:

Being able to generate a genetic photofit image from an unknown person, that would be a true innovation of course. But I think it will take more like 5–10 years until we get there. (interviewee O01)

The trust in innovation goes without referring to greater claims about its contribution to increasing security, which in contrast plays a major role in the regulatory debate to make claims about the innovation’s legitimacy.

Our interviewees manage their own and others’ expectations towards FDP technologies in a manner that they tend to lower and adjust expectations regarding such technologies along with specific matters of concern, in response to expectations raised in the public regulatory debate. They aim to reduce and to alter expectations regarding matters of the *accuracy of prediction, readiness, and preparedness* of the forensic field and *investigative value* in the criminal investigation.

Demands for further research and development to meet expectations about the accuracy

In the German context of research development, a reoccurring concern evolved along with matters of the *accuracy* of FDP technologies which refers most often to the accuracy of prediction. Hopman (2020) described the accuracy of the technology as being in the focus in particular in the context of the development of the

FDP technologies in the Dutch research laboratory she investigated to help the search for the genetic phenotypical uniqueness of the individual, and what differentiates one from another. Forensic geneticists distinguished between the different characteristics of appearance and age, as well as biogeographic ancestry to consider varying degrees of accuracies of prediction. The forensic geneticists' understandings related to the separate technologies are based on different scientific methods and probabilistic values and, therefore, vary regarding their accuracy and reliability of their prediction. Genetic information used for predicting EVC's and epigenetic information used for age estimation play one important difference between the methods differently influencing the accuracy of prediction. As one interviewee said:

I think that the best predictive phenotype at the moment is eye color. I think there's no way of denying that. The second best is the hair color. We also have a special kind of age prediction. It is relatively advanced now, but this is a kind of a different model: it doesn't use genetic information but epigenetic information, so it uses other kinds of markers. (interviewee O08)

Aiming at better and accurate prediction results is considered the major achievement which needs to be gained in forensic genetic research. Accuracy as part of technology development is also considered as a normative neutral scientific ideal, while the further transfer and use of FDP technologies in a criminal investigation are decoupled as to be deliberated societally:

For most EVCs, externally visible characteristics, one can expect a polygenic component, where we do not yet know many factors. To improve the accuracy of the prediction that in itself is neutral. How to use it then is a societal discussion. But if I can make an accurate prediction that may be methodologically interesting, I think more genetic research needs to be done to detect genetic factors. We need sample sizes large enough to provide these studies with enough statistical power. (interviewee O10)

A slightly different concern regarding accuracy derives when taking the prediction of biogeographic ancestry into account. While the prediction of EVC's relies on genetic information, and age prediction additionally relies on epigenetic information, biogeographic ancestry furthermore only can be analyzed with supplementary insights from population studies. Forensic geneticists assume that predicting biogeographic ancestry is scientifically feasible in forensic testing, at least at the continental level (Vidaki and Kayser 2017). Yet, they also specify, that genetic geographic population substructures are influenced by human migration and differ across the globe (ibid). On these grounds the following quotation illustrates what influences the accuracy of prediction of biogeographic ancestry:

About biogeographical ancestry, we need more studies to more accurately determine the prevalence of different characteristics in different parts of the world, in different population groups, because so far very, very little data exists. (interviewee O10)

The need for investment in research and development is emphasized in the following quotation, which argues that it must be accommodated alongside casework. The distinction between different forensic cultures, for example, research science and forensic science, as characterized by a substantive divide between research and casework (Cole 2013) is problematized here. Thus, the current forensic community is perceived as being confronted with a big but inevitable challenge if FDP is to become established over time. In the words of one of the interviewees:

I guess that many of my colleagues (...) don't have the chance to do research. If you want to do phenotyping you do have to spend a lot on research and development of course. In Germany, if you think of implementing, it must be tested and now it's prohibited. We're not allowed to do it in cases only. Research then doesn't make real sense, it should be also done in combination with casework. (interviewee O09)

Although most geneticists consider the levels of accuracy of prediction sufficient to be used in a criminal investigation, they tend to argue in favor of further research and development of FDP technologies and generating more data to strategically increase its relevance in forensic contexts (Hopman 2020, 7). Additionally, interviewees emphasized the combination of forensic research and testing technologies in casework as a prerequisite to prepare the implementation of FDP.

Reconfiguring expectations about the preparedness and readiness of the forensic field

Forensic geneticists are concerned about the transfer of FDP from the research and development stage to the implementation stage in forensic labs. They shared cautious expectations regarding the *preparedness and readiness* of the field of forensic labs to implement these still emergent technologies on a large scale. The following quotation addresses a central concern linked to the forensic validation of the technologies which is seen as a prerequisite before applying this set of techniques in forensic laboratories:

The scientific proof of concept is something very different from the forensic validation that we need to perform before we can actually use these kinds of methods. I think most people working on forensic genetics in Germany are waiting to see what comes. [They are] a bit anxious maybe because there is a huge expectation that at the moment simply cannot be fulfilled. And they're thinking about (...) how do they get the information they [will] need, and how can they do the forensic validation. (interviewee O13)

The following quotation from a forensic geneticist working in a police lab reveals a pragmatic view on the transfer process of new technologies from the research and development stage to the implementation stage:

We are now in a process that we need to take the things from the universities into practice. And therefore, we have to re-validate everything, to see what we can do with it, where are the limitations, and this process needs a while. (interviewee O02)

The interviewee considers the technologies' research development as sufficiently mature but emphasizes that the process of re-validating technologies for their actual implementation in the forensic policy lab is a prerequisite before being able to use it. This partially refers to what Hopman (2020, 10) has reflected on the use of FDP technologies in forensic labs where forensic analysis tools need to be adjusted to produce "useful" results under conditions of limited resources. In the forensic lab, the focus lies on the commonalities and to situate the commonalities in the context of the countries' major population to identify how common a result is.

Lowering expectations about the investigative value in the criminal investigation

Other central matters of concern along with the translation of FDP technologies into the context of a criminal investigation assemble around the issue of the *investigative value* of FDP. That relates closely to what Hopman (2020) called the logic of valuing as guiding rationale in a police investigation when results of FDP forensic analyses translate into a criminal investigation, e.g. the weighing pieces of forensic intelligence and narrowing down attention to specific population groups. The *regulatory* promises enacted by policymakers, which serve public goals of contributing substantially to a securer society, are re-assessed by forensic geneticists. Forensic geneticists readjust and specify expectations about the utility of FDP in criminal investigation raised in the regulatory debate.

Our interviewees recommended that the technology be used initially "only for special situations, so for kind of serious crimes" (O08 – forensic geneticist), or expected its use to be minimal: "We all think we don't really need to be so very excited because it will only be used in very, very limited number of cases and very specific kinds of samples" (interviewee O13) Against high public demand for a suitable and feasible solution, many forensic geneticists suggest that the prediction of EVCs and age are legitimate techniques in specific and limited situations of a criminal investigation. The prediction of biogeographic ancestry is occasionally problematized regarding its added investigative value considering its contribution to narrow down a pool of potential suspects (Hopman 2020, 12).

How biogeographic ancestry orients criminal investigation depends on various contextual information and processes of considering and weighing investigative leads. FDP predicting biogeographic ancestry then can be used to prioritize certain suspect groups of people over others (Hopman 2020, 12). To narrow down the group of suspects the indication of a European genetic background is considered "useless" as it does not narrow down the pool of suspects. Instead, a result is considered "useful" if it leads to minority groups as the following quotation illustrates:

It [biogeographic ancestry] may be useful, but it may also be useless. For example, if the investigation results that this is a typical European genetic background, what do

you know? You know that the person is European. So maybe you can exclude some Africans and some people from the Middle East or some other areas, but that is about it. On the other end, if you know that somebody came from South Asia or Afghanistan [...] then you might look more into a particular group of people. (interviewee O01)

A different matter relates to biogeographic ancestry to its visibility. It does not necessarily translate into phenotypic externally visible characteristics as the following quotation illustrates with regards to the Bavarian legislation which included biogeographic ancestry into the set of allowed technologies:

If now in the Bavarian law, this bio-geographical origin is to be determined, then you can do that, but that would be I say to a large extent a waste of money because as I said that is only a representative feature that is not necessarily externally visible. That said, I can say this person is probably from Syria, but I cannot tell what they looked like. But then all of a sudden, cliché images and prejudices and perhaps racist ideas come in place. So, I think you can determine the bio-geographical origin, but it hardly has any added value. It has to be incorporated sensibly into the prediction, but on its own, it does not have much added value. (interviewee O10)

This interviewee problematizes biogeographic ancestry with regards to the moment in a criminal investigation when the forensic result – which does not provide predictions about specific visible characteristics – mixes with stereotyped images of investigators about specific population groups. Some forensic geneticists engage with concerns actively argued by social scientists about how such differences correspond with socially constructed categories used to classify and describe population groups, which may have a discriminating effect (Granja, Machado, and Queirós 2020; Toom 2016).

A few forensic geneticists state clearly – beyond the matter of the investigative value – that they anticipate fundamental social and ethical problems with selected technologies of FDP. As the following quotation demonstrates, taking the recent influx of migrants during the so-called refugee crisis into account, the interviewee even opposes the prediction of skin color fundamentally:

I think [...] I don't want to have it in Germany. My statement is maybe not the most profound and not most important, but at least I'll not see a test in Germany for our skin color. I don't want to have it. I don't want to have mass screening that is based on skin color. And yeah, I think that this is a very clear statement, which has to do with stereotypes about migrants, and the relation to the refugee crisis in question, as you want to call it. But from the forensic point of view and the societal and ethical point of view, I think I don't want it because of the possibility of creating stereotypes [...]. Maybe this may change, but I'm not sure. (interviewee O06)

If interviewees problematized particular features of FDP for the risk of discrimination and racism they either referred to predicting skin color or bio-geographic ancestry. The slippery nature of race (M'charek 2020) in the German case is evident: race is an absent presence because it is a taboo subject, often removed

and excluded from discourse and viewed as something that belongs to the problematic past of scientific racism and Nazi genocide (M'charek, Schramm, and Skinner 2014, 462).

Forensic geneticists reflect and respond in their understandings of FDP technologies to “the promise of the new science while managing expectations about its capacities” (Skinner 2020, 3). Forensic geneticists try to lower and reconfigure expectations by addressing specific matters of concern: concrete scientific limits in differences of accurate prediction, limited preparedness of the forensic field, or limited and specific investigative value in the criminal investigation.

Forensic geneticists’ proposals for regulating FDP and the governance of expectations

While the previous section was dedicated to forensic geneticists understandings and expectations towards FDP as analyzed based on interview material, this section analyses how selected forensic geneticists actively engaged in the governance of expectations by publishing their positioning on the ongoing regulatory process of the “extended DNA analysis” in Germany in dedicated professional journals. Some forensic geneticists intervened in the scientific and regulatory debates on matters of how to govern FDP and proposed different models of proportionate implementation that make use of particular technical or regulatory fixes to overcome scientific, social, and ethical ambiguities. Thus, while speculating about the potential of innovative technologies related to the prediction of appearance, age, and biogeographic ancestry, forensic geneticists engage in the governance of expectations (Hielscher and Kivimaa 2019). They attempt to counter and adjust expectations around seemingly omnipotent technologies by making concrete proposals about what they perceive as proportionate forms of regulation.

We consider three pieces of public articulations as described earlier. In all three cases, the major audience is the expert public of forensic genetics interested in the German process of regulating FDP, but obviously, the publications are also available for a wider interested public.

The correspondence in *Forensic Science International* reveals how the regulatory debate in Germany feeds back into the experts’ debate about the accurate development and proportionate use of FDP. By referring to FDP, the scholars involved explicitly excluded biogeographic ancestry. A group of forensic geneticists had published an article about the conditional probabilities of FDP that argued in favor of advancing with FDP development and research to implement it (Caliebe *et al.* 2017). As a response, another group of forensic geneticists and scholars of the social and legal aspects of forensic genetics expressed their skepticism about the utility, accuracy, and readiness of FDP for legalization. They explicitly situated the debate in the context of the ongoing German regulatory debate: “First, we would like to clarify the relevance of this dialogue for the ongoing public and political debate over Forensic DNA Phenotyping (FDP) in Germany”

(Buchanan 2018: e13). After having claimed the significance for the ongoing legislative process in Germany, in further response, Caliebe, Krawczak, and Kayser (2018) differentiated the requirements that would need to be in place before the techniques could be legitimately applied in forensic casework:

The above notwithstanding, since the etiological understanding of FDP-relevant appearance phenotypes is still incomplete, so are the prediction models used – and the corresponding predictive values vary to a certain degree. In consequence, these measures have to be determined empirically for each appearance phenotype, prediction model, and target population of interest before they can be applied sensibly in criminal casework. (Caliebe, Krawczak, and Kayser 2018, e7–e8)

This proposal argues that prerequisites of empirical validation should be in place before implementation of FDP could be considered, reveals the forensic geneticists' cautious expectations of the emergent technology, but it also resonates with the previously analyzed matters of concerns regarding improvable accuracy of prediction and readiness of the forensic field. With regards to its governing ambition, it aimed at reducing public expectations about the immediate availability and applicability of FDP in casework, and consequences in the criminal investigation. The commentary includes a call for anticipatory practices of advancing validation which Wienroth (2018, 11) also called an anticipatory ordering device.

Schneider, Prainsack, and Kayser (2019) proposed the use of all technologies at stake in conjunction with each other – the prediction of hair, eye, and skin color as well as of age and biogeographic ancestry – by referring to their sufficiently high accuracy. However, they argued that “[e]ven those who support the use of forensic DNA phenotyping in specific cases emphasize that these methods should not be used in police investigations until appropriate measures have been taken to ensure that they are used transparently and proportionately” (Schneider, Prainsack, and Kayser 2019, 879). They referred to empirical social-scientific research on forensic DNA phenotyping which identified preserving privacy and protecting against discrimination as major ethical and regulatory considerations. They emphasized in a dedicated section the specifics of biogeographic ancestry and try to decouple biogeographic ancestry as a genetic concept from concepts such as “ethnicity” and “race” as cultural concepts by arguing that “it solely concerns the geographical region(s) from which a person’s biological ancestors originated” (Schneider, Prainsack, and Kayser 2019, 877). They called for steps to be taken which minimize the risks of violation of privacy and ethnic discrimination (Schneider, Prainsack, and Kayser 2019, 878). As concrete safeguards, they proposed that the “training of forensic DNA experts and investigators is essential to ensure that the laboratory findings are correctly generated, interpreted, documented, and transmitted to the investigating authorities and that the authorities understand them correctly and use them properly” (Schneider, Prainsack, and Kayser 2019, 879).

The authors referred to the comparably high predictive accuracy – and thereby did not confirm some concerns about the contested sufficiency of accuracy

which were raised in some of our interviews. Yet, they mobilized the logic of accuracy (Hopman 2020) to stabilize claims about the scientific legitimacy and trustworthiness of FDP technologies. They call for anticipatory practices of training of all actors involved in the adoption of FDP technologies to ensure its “correct” use. We assume that “correct” can be understood as a reference to agreed-upon rules and standards of what correct practices are and then seems to correspond to what Wienroth identified as a separate anticipatory ordering device. With regards to biogeographic ancestry and its public problematization in the regulatory debate to come along with discriminatory or racist potential, the authors try to argue in a conceptual and ontological manner. By distinguishing a genetic concept from a cultural concept they aim to purify the prediction of biogeographic ancestry into “neutral”, unbiased and apolitical technology which only becomes problematic if its use in criminal investigation meets ethnic discriminatory prejudices. With this separation, the authors distribute and delegate the accountability for discriminatory risks to other actors in criminal investigation translating analysis results into investigative leads.

The forensic geneticists Zieger and Roewer (2019) reflected on the introduction and regulation of the so-called “extended forensic DNA analysis” in Germany (and Switzerland). Zieger and Roewer (2019, 417) argued for a regulation that “should avoid a too narrow restriction to [the prediction of, the authors] certain characteristics and at the same time should protect the fundamental rights of the persons concerned as far as possible”. In their view, the prediction of eye and hair color seemed to be the less controversial candidates among the forensic genetic community, while the prediction of age, skin color, and biogeographic ancestry are for one reason or another more contested. They acknowledged that this is “a task that is difficult to solve” as a “rigid definition of the legally permissible spectrum of analyses will inevitably lead to an unsatisfactory result, whether from the perspective of fundamental rights or the perspective of criminal prosecution” (Zieger and Roewer 2019, 417, own translation). They mobilized a framing of a seemingly inevitable tradeoff and conflict between security and individual liberty, privacy, and civic rights overall (Pavone, Santiago Gomez, and Jaquet-Chifelle 2016). In conclusion, they made a regulatory proposal in favor of a national ethical commission which should decide on a case-by-case basis regarding efficiency and proportionality of the use of the extended DNA analysis. They referred to the Dutch example of a special committee but proposed to expand such a body beyond police and criminal prosecution staff and to include forensic geneticists and ethicists. Instead of the specific determination and selection of technologies via law, they suggested establishing definitions of guiding rules together with an ethics committee aiming at a flexible solution which mediates between scientific and technological progress and intrusion of privacy rights (Zieger and Roewer 2019, 417).

The last proposal seems to be most far-reaching with regards to the elaboration of institutionalized regulatory safeguards and procedural assessments permanently accompanying the technology development. It reminds of models developed

in the literature on ethical and constructive technology assessments (Rip and Robinson 2013). By clearly naming ethical and civil rights dimensions of the regulation it goes beyond the logic inherently applied in the contexts of forensic geneticists which we identified in the analysis of the interview material. They aim to balance scientific-technological progress and societal potential harm and do so in a way to assign distributed responsibility to a heterogeneous actor set that goes beyond anticipatory self-governance.

Syndercombe-Court *et al.* (2016) observed that privacy issues and privacy rights have been at the center of ethical interrogations of forensic genetics from its first appearance in the mid-1980s. Due to the conceptual looseness of privacy and the manifold conditions under which privacy rights maybe be breached caused in the past complex and extensive legal and ethical deliberations (*ibid.*). For that reason, “privacy” as well as “ethnic discrimination” seem to remain approached in a simplified manner, in particular taking into account that training of forensic DNA experts and investigators – holding forensic geneticists and criminal justice actors accountable – might be one out of several anticipatory governance practices as Wienroth (2020) suggests. Efforts of responsible forms of standardization could apply here and add to ways of how forensic geneticists may hold themselves and other criminal justice actors’ accountable. This could be part of general “efforts to harmonize training and methodologies for testing, analysis, and interpretation of specific phenotyping technologies” (Wienroth 2018, 11) and assign clear responsibilities for who is in charge of these distributed anticipatory practices to be put in place.

Conclusion

The technologies of predicting skin color and biogeographic ancestry provoked some contestation regarding their societal exigency and legitimacy. FDP forensic technologies served for reflections on the ambiguous relationship-making between an individual suspect and specific suspect population groups and were assumed to attract the mobilization of racism and discriminatory potential. Yet, forensic geneticists perceived risks of discrimination and privacy intrusion as decoupled from the technology itself and instead assumed the possibility to resolve considerations of proportionality of the intrusion of fundamental rights by case-by-case decision making. With calls for anticipatory practices, such as training for DNA experts and investigators or institutionalized forms of ethical technology assessments including a range of expertise from police and criminal prosecution staff to forensic geneticists and ethicists, they named the potential for discrimination risks but also propose how to cope with that.

Being overall in favor of the regulation of FDP technologies forensic geneticists also tended to adjust, minimize or redirect the expectations of the criminal justice system, to keep the integrity of the forensic genetics’ epistemic community. These findings correspond to what Brown and Michael (2003, 14) concluded about the

proximity of actors to knowledge production of emergent technologies and the performance of expectations as deploying prospects of futures of technologies that enable specific technoscientific worlds. The closer proximity of forensic geneticists to primary research relates to being equally cautious of the ambitious promises of technologies as “lessons learned” from the overall enthusiastic public reception of forensic DNA technologies (Amelung, Granja, and Machado 2020).

However, what our findings show beyond confirming key parameters for the variation of expectation is that selected advocates from forensic genetics also applied modes of “governing expectations” by proposing regulatory solutions. They can also be understood as attempts of (self)regulation of expectations towards the uptake in the criminal justice system and its epistemic community of forensic genetics and thereby as a contribution to the actual governance of technologies.

Some forensic geneticists actively engaged in the governance of expectations by contributing with their own proposals of (self)regulation of technologies. With the latter, our article also speaks to debates on forensic geneticists’ anticipatory (self)governance. The study of the German case adds to that debate, that forensic geneticist’s attempts of (self)regulation reflect the anticipation of specific matters of concern partially deriving from the public regulatory debate, but mainly reflecting logics aiming to maintain and expand credibility and legitimacy of forensic genetics in the criminal justice system and to wider publics of security policies. They pick up matters of concern evolving inherently from forensic genetics’ logics and rationalities around the predictive accuracy, the preparedness of the forensic field, and the investigative value for criminal investigation. Additionally, some forensic geneticists responded to dominant concerns deriving from the public regulatory debate regarding privacy and discrimination potential. By proposing regulatory models they addressed anticipated optimistic regulator’s expectations and translated their technologies approving but more cautious expectations into interventionist practices aiming to influence the technologies’ trajectory.

As much as we believe that we find in the German case discursive calls of forensic geneticists’ for anticipatory self-governance practices, we also argue that in particular, the regulatory proposals analyzed in this article to configure FDP technologies contributed by forensic geneticists indicate the attempt to hold a set of heterogeneous actors including forensic geneticists and other actors of the criminal justice system accountable for legitimate and proportionate uptake of FDP technologies. In line with previous findings, we can identify at least two forms of distributing and assigning accountability (Granja and Machado 2020, 8). First, forensic geneticists held themselves accountable regarding the concerns along with the accuracy and validity of technologies that influence the preparedness of the forensic field. Second, some of them distributed and delegated accountability and responsibility for harm prevention when for instance suggesting training for the actors involved in a criminal investigation when interpreting the investigative value and interpreting the FDP results into account as investigative leads. We refer to

distributed anticipatory governance to emphasize the segmentation of logic sorting those matters of concern along work practices from technology development to implementation and the assumed fragmented accountability. In consequence, assigning concerns to distinct sites of forensic work with different work practices allowed forensic geneticists to apply differentiated boundary work (Granja and Machado 2020), attributing own obligations, responsibilities, and accountabilities, but also delegating and distributing obligations, responsibilities, and accountabilities and governing expectations towards other actors' roles in shaping the trajectory of FDP technologies in Germany. Acknowledging the limits of a small data set available for this study we also wish to emphasize that there is more work required to reflect the wider state of play and views of the German forensic genetics' community. Further research may help to make more specific claims about boundary work, accountability, and responsibility assigning distribution between the forensic genetic scientists' social world and the criminal justice system's social world.

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Note

1. Although two murder cases in the regional state of Baden-Württemberg occurred and stimulated the media and policy debate initially, it was the Freiburg case that triggered the public outcry.

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References

- Amelung, N., R. Granja, and H. Machado. 2020. "Communicating Forensic Genetics: 'Enthusiastic' Publics and the Management of Expectations." In *Exploring Science Communication*, edited by S. Davies and U. Felt, 209–226. London: Sage.
- Amicelle, A., C. Aradau, and J. Jeandesboz. 2015. "Questioning Security Devices: Performativity, Resistance, Politics." *Security Dialogue* 46: 293–306. doi:10.1177/096701061558696.
- Anderson, B. 2010. "Preemption, Precaution, Preparedness: Anticipatory Action and Future Geographies." *Progress in Human Geography* 34 (6): 777–798.
- Bayerische Staatskanzlei. 2018. "Gesetz über die Aufgaben und Befugnisse der Bayerischen Staatlichen Polizei (Polizeiaufgabengesetz – PAG) [Law on the Tasks and Competences of the Bavarian State Police]." Accessed August 15, 2019. <https://www.gesetze-bayern.de/Content/Document/BayPAG/true>.
- Borup, M., N. Brown, K. Konrad, and H. Van Lente. 2006. "The Sociology of Expectations in Science and Technology." *Technology Analysis & Strategic Management* 18 (3/4): 285–298. doi:10.1080/09537320600777002.
- Brown, N., and M. Michael. 2003. "A Sociology of Expectations: Retrospecting Prospects and Prospecting Retrospects." *Technology Analysis & Strategic Management* 15 (1): 3–18.
- Buchanan, N. 2018. "Forensic DNA Phenotyping Legislation Cannot Be Based on 'Ideal FDP' – A Response to Caliebe, Krawczak, and Kayser (2017)." *Forensic Science International: Genetics* 34: e13–e14.
- Bundesministerium der Justiz und für Verbraucherschutz. 2019a. "Gesetzgebungsverfahren – Gesetz zur Modernisierung des Strafverfahrens." Accessed September 14, 2020. https://www.bmjv.de/SharedDocs/Gesetzgebungsverfahren/DE/Modernisierung_Strafverfahren.html;jsessionid=9E9A209731071CBEB4E784B5CD101636.2_cid289?nn=6705022.
- Bundesministerium der Justiz und für Verbraucherschutz. 2019b. "Geszentwurf der Bundesregierung: Entwurf eines Gesetzes zur Modernisierung des Strafverfahrens." 1–61.
- Buzan, B., O. Wæver, and J. Wilde. 1998. *Security: A New Framework for Analysis*. Boulder: Lynne Rienner Publishers.
- Caliebe, A., M. Krawczak, and M. Kayser. 2018. "Predictive Values in Forensic DNA Phenotyping are Not Necessarily Prevalence-Dependent." *Forensic Science International Genetics* 33: e7–e8.
- Caliebe, A., S. Walsh, F. Liu, M. Kayser, and M. Krawczak. 2017. "Likelihood Ratio and Posterior Odds in Forensic Genetics: Two Sides of the Same Coin." *Forensic Science International: Genetics* 28: 203–210.
- Charmaz, K. 2006. *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis*. Thousand Oaks, CA: Sage Publications.
- Cole, S. 2013. "Forensic Culture as Epistemic Culture: The Sociology of Forensic Science." *Studies in History and Philosophy of Biological and Biomedical Sciences* 44 (1): 36–46.
- Gardner, J., G. Samuel, and C. Williams. 2015. "Sociology of Low Expectations." *Science, Technology, & Human Values* 40 (6): 998–1021.
- Granja, R., and H. Machado. 2020. "Forensic DNA Phenotyping and Its Politics of Legitimation and Contestation: Views of Forensic Geneticists in Europe." *Social Studies of Science*. doi:10.1177/0306312720945033.
- Granja, R., H. Machado, and F. Queirós. 2020. "The (De)Materialization of Criminal Bodies in Forensic DNA Phenotyping." *Body & Society*. doi:10.1177/1357034X20919168.

- Hielscher, S., and P. Kivimaa. 2019. "Governance Through Expectations: Examining the Long-Term Policy Relevance of Smart Meters in the United Kingdom." *Futures* 109: 153–169.
- Hopman, R. 2020. "Opening up Forensic DNA Phenotyping: The Logics of Accuracy, Commonality, and Valuing." *New Genetics and Society* 39 (4): 424–440.
- Kester, J., B. Sovacool, L. Noel, and G. Zarazua de Rubens. 2020. "Between Hope, Hype, and Hell: Electric Mobility and the Interplay of Fear and Desire in Sustainability Transitions." *Environmental Innovation and Societal Transitions* 35: 88–102. doi:10.1016/j.eist.2020.02.004.
- Konrad, K., and C. Alvia Palavicino. 2017. "Evolving Patterns of Governance of, and by, Expectations: The Graphene Hype Wave." In *Embedding New Technologies into Society: A Regulatory, Ethical & Societal Perspective*, edited by D. Bowman, E. Stokes, and A. Rip, 185–215. Singapore: Pan Stanford.
- Leese, M. 2014. "The New Profiling: Algorithms, Black Boxes, and the Failure of Anti-Discriminatory Safeguards in the European Union." *Security Dialogue* 45 (5): 494–511. doi:10.1177/0967010614544204.
- Lipphardt, V. 2018. "Vertane Chancen? Die Aktuelle Politische Debatte Um Erweiterte DNA-Analysen in Ermittlungsverfahren." *Berichte zur Wissenschaftsgeschichte* 41 (3): 279–301.
- Lynch, M., S. Cole, R. McNally, and K. Jordan. 2008. *Truth Machine: The Contentious History of DNA Fingerprinting*. Chicago: University of Chicago Press.
- Mayring, P. 2004. "Qualitative Content Analysis." In *A Companion to Qualitative Research*, edited by U. Flick, E. von Kardorff, and I. Steinke, 266–269. London: Sage.
- M'charek, A. 2020. "Tentacular Faces: Race and the Return of the Phenotype in Forensic Identification." *American Anthropologist* 122 (2): 369–380.
- M'charek, A., K. Schramm, and D. Skinner. 2014. "Topologies of Race: Doing Territory, Population, and Identity in Europe." *Science, Technology, & Human Values* 39 (4): 468–487.
- Pavone, V., E. Santiago Gomez, and D.-O. Jaquet-Chifelle. 2016. "A Systemic Approach to Security: Beyond the Tradeoff Between Security and Liberty." *Democracy and Security* 12 (4): 225–246. <https://www.tandfonline.com/doi/full/10.1080/17419166.2016.1217776>.
- Poirier, Jean, Simone Clapier-Valladon, and Paul Raybaut. 1983. *Les Récits de Vie. Théorie et Pratique*. Paris: PUF.
- Rath, C. 2019. "Justizministerin zur DNA-Strafverfolgung: Das ist keine Stigmatisierung! [Justice Minister about DNA-criminal Prosecution: This is No Stigmatization!]." *taz*. <https://taz.de/Justizministerin-zur-DNA-Strafverfolgung/!5625314>.
- Rip, A., and D. K. R. Robinson. 2013. "Constructive Technology Assessment and the Methodology of Insertion." In *Early Engagement and New Technologies: Opening up the Laboratory. Philosophy of Engineering and Technology*, edited by N. Doorn, D. Schuurbijs, I. van de Poel, and M. Gorman. Dordrecht: Springer. doi:10.1007/978-94-007-7844-3_3.
- Samuel, G., and B. Prainsack. 2018a. "The Regulatory Landscape of Forensic DNA Phenotyping in Europe." VISAGE. Accessed August 15, 2019. http://www.visage-h2020.eu/Report_regulatory_landscape_FDP_in_Europe2.pdf.
- Samuel, G., and B. Prainsack. 2018b. "Forensic DNA Phenotyping in Europe: Views 'on the Ground' from Those Who Have a Professional Stake in the Technology." *New Genetics and Society* 38 (2): 119–141.
- Samuel, G., and B. Prainsack. 2019. "Civil Society Stakeholder Views on Forensic DNA Phenotyping: Balancing Risks and Benefits." *Forensic Science International: Genetics* 43: 102157. doi:10.1016/j.fsigen.2019.102157.
- Schneider, P., B. Prainsack, and M. Kayser. 2019. "The Use of Forensic DNA Phenotyping in Predicting Appearance and Biogeographic Ancestry." *Deutsches Aerzteblatt Online* 51–52: 873–880.
- Skinner, D. 2020. "Race, Racism and Identification in the Era of Technosecurity." *Science as Culture* 29 (1): 77–99.

- STS Freiburg Group. 2017. "Symposium Erweiterte DNA Analyse in der Forensik: Möglichkeiten, Herausforderungen, Risiken." Accessed December 2, 2020. <https://stsfreiburg.files.wordpress.com/2016/12/symposiumsinfos5.pdf>.
- Syndercombe-Court, Denise, Kristiina Reed, Robin Williams, and Matthias Wienroth. 2016. *A Guide to Legal and Ethical Principles and Practices in Forensic Genetics*.
- Toom, V. 2016. "Approaching Ethical, Legal and Social Issues of Emerging Forensic DNA Phenotyping (FDP) Technologies Comprehensively: Reply to 'Forensic DNA Phenotyping: Predicting Human Appearance from Crime Scene Material for Investigative Purposes' by Manfred Kayser." *Forensic Science International: Genetics* 22: e1–e4.
- Tutton, R. 2011. "Promising Pessimism: Reading the Futures to Be Avoided in Biotech." *Social Studies of Science* 41 (3): 411–429.
- van Lente, H., and A. Rip. 1998. "Expectations in Technological Developments." In *Getting New Things Together*, edited by C. Disco and B. J. R. van der Meulen, 195–220. Berlin: Walter de Gruyter.
- Vidaki, A., and M. Kayser. 2017. "From Forensic Epigenetics to Forensic Epigenomics: Broadening DNA Investigative Intelligence." *Genome Biology* 18 (1): 238.
- Vogel, Gretchen. 2018. "In Germany, Controversial Law Gives Bavarian Police New Power to Use DNA." *Science*. <https://www.sciencemag.org/news/2018/05/germany-controversial-law-gives-bavarian-police-new-power-use-dna>.
- Weitz, S., and N. Buchanan. 2017. "Eine Technologie der Angstkultur." *Freispruch* 11: 20–21.
- Wienroth, M. 2018. "Governing Anticipatory Technology Practices. Forensic DNA Phenotyping and the Forensic Genetics Community in Europe." *New Genetics and Society* 37 (2): 137–152.
- Wienroth, M. 2020. "Socio-Technical Disagreements as Ethical Fora: Parabon NanoLab's Forensic DNA Snapshot™ Service at the Intersection of Discourses Around Robust Science, Technology Validation, and Commerce." *BioSocieties* 15: 28–45.
- Yanow, D. 2000. *Conducting Interpretive Policy Analysis*. Thousand Oaks, CA: Sage.
- Zieger, M., and L. Roewer. 2019. "Plädoyer Für Eine Nationale Ethikkommission Für Die Erweiterte Forensische DNA-Analyse." *Rechtsmedizin* 29 (5): 415–418. doi:10.1007/s00194-019-0328-0.