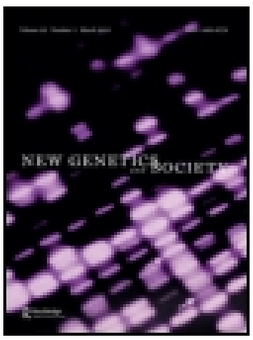

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Opening up forensic DNA phenotyping: the logics of accuracy, commonality and valuing

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Forensic DNA Phenotyping (FDP) encompasses an emerging set of technologies aimed at predicting physical characteristics of unknown suspects from crime scene DNA traces. In its application FDP involves a variety of settings: research laboratories where FDP tests are developed, forensic laboratories where FDP technologies are used to analyze crime scene DNA traces, and finally the criminal investigation, where results of tests are applied towards finding suspects. In this paper I show that the practices in each of these settings work by a different set of concerns, which I articulate by adopting the notion of "logics" as developed by Annemarie Mol. I ethnographically trace FDP from research lab to investigation, identifying three different logics along the way: those of *accuracy*, *commonality*, and *valuing* respectively. Taken together, I show that these practices do not linearly accumulate but form a heterogeneous assemblage, adding nuance to discussions surrounding FDP.

Keywords: forensic DNA phenotyping; logics; practices; heterogeneous assemblage

Introduction

Over twenty years ago, Kathleen Jordan and Michael Lynch set out to "follow" the then "recent innovation" that was the polymerase chain reaction (PCR) around the professional contexts in which it was used (1998, 776). At the time, this technique, which is used to copy targeted sequences of DNA, was rapidly developing and being disseminated into an increasing number of fields. This prompted Jordan and Lynch to question the "scientific identity" of the technique, arguing that as it travelled into medical, forensic and public contexts PCR became differently integrated into practices in particular ways (1998, 778), leading them to conclude that PCR is not "a unitary artefact … that forces the hand of the practitioner who uses it" (1998, 795).

Twenty years later, PCR has become a routine technique that is applied in various settings, including forensics. Despite this passing of time, Jordan and

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Lynch's analysis remains relevant in that it demonstrates how a DNA technology can become differently "integrated" in the practices in which it is applied (1998, 776). In this paper I take inspiration from their work on PCR and, like them, follow a molecular biological technique as it moves into different practices. I will focus on forensic DNA phenotyping (FDP), a set of technologies aimed at predicting physical characteristics of unknown suspects from crime scene DNA traces. FDP technologies are developed in research laboratories, applied in forensic laboratories, and finally used to direct criminal investigations. As such, FDP involves a chain of diverse practices in its movements. Even though these are all connected to forensics, I argue that each of these practices works by a different *logic*. In doing so I build upon Jordan and Lynch's suggestion to "follow the technique" from "place to place, to investigate how it becomes integrated into different logics of practice" (1998, 776).

I follow FDP within the Dutch forensic context, which is an interesting case when it comes to forensic DNA. It was the first country to legally regulate the use of DNA as evidence, introducing its first DNA law in 1994. From the early 2000s, DNA legislation in the Netherlands has been expanding rapidly, especially with regards to FDP (see M'charek 2008). In 2003, DNA legislation was expanded to allow for the inference of "externally visible traits" from crime scene DNA traces. At the time, the traits that were included were sex and race.[1] Yet as this was a "raamwet," literally a "framework law", it was set up to allow for the incorporation of potential future tests of visible characteristics (Toom 2010, 160). And indeed in 2012 and 2017 additional tests for eye- and hair color respectively were legalized, with skin color to be added in the near future (Chaitanya *et al*. 2018).

Within the Dutch forensic context, I move from the research lab where researchers are working on the discovery of biomarkers that affect physical appearance, via the forensic lab where selected markers are applied to DNA material retrieved from crime scenes, and finally into the forensic investigation, where results of analyses are used to give face to an unknown suspect. I take the notion of "logics of practice" as proposed by Jordan and Lynch further by building upon the work of Annemarie Mol (2008). She borrows "logic" from philosophy to articulate the different "rationales" she encountered while doing research on diabetes care practices in the Netherlands. That is to say, she sought to find out "what is appropriate or logical to do in some site and situation and what is not" (2008, 13). Through fieldwork in a hospital she found that there are "different ways of dealing with disease" that clash with one another. I take from her praxiographic approach and focus on logics, as they allow for an articulation and critical consideration of the differing concerns that are at work within FDP practices.

In scrutinizing the different logics I take the research laboratory as my starting point. Here, promises are made towards individualized facial composites based on crime scene DNA traces. I argue that this logic revolves around *accuracy*, entailing a focus on data accumulation and a search for the genetic uniqueness of the individual. I compare this logic of accuracy with its accompanying ideal of

individualized composites arising in the research lab to the actual implementation of FDP technologies in the forensic lab and the forensic investigation. As I move into the forensic lab a different logic comes into view. Here, only small amounts of DNA material are available and there is no money and time to sequence large numbers of markers. Individualization is not the goal in the forensic lab. The focus thus shifts away from pinpointing what makes the individual unique and towards shared genetic features. I call this the logic of *commonality*. Common here refers to similarities between genomes, but also on how *common* a trace is within a particular context, signaling the situatedness of forensic practice. Finally, I turn to police investigators. Here, I demonstrate how results of forensic analyses trickle down into a criminal investigation. In the investigation inferences produced through FDP become instrumental in weighing pieces of investigatory information and deciding which groups to direct attention to. I refer to this as the logic of *valuing*.

In following a forensic technique from laboratories to the police I build on a rich body of literature tracing forensic objects through the criminal justice system (see M'charek 2000; Williams and Johnson 2008). Corinna Kruse, in particular, has done so extensively for the Swedish case (2016, 2019). She worked with the notion of "epistemic cultures" (Knorr-Cetina 1999) to point out how different actors (lawyers, forensic scientists, crime scene technicians, police investigators) produce and comprehend knowledge differently. When it comes to the application of FDP in particular, Gabrielle Samuel and Barbara Prainsack (2019), have already pointed out the heterogeneity in professional views of actors involved with FDP "on the ground" by building on interviews with European police, scientists and representatives of governmental agencies. I furthermore take from Amade M'charek (2008, 2016), who through analysis of Dutch and Belgian forensic cases has demonstrated the importance of studying FDP technology as it is applied in practice. Matthias Wienroth (2018), additionally, has drawn attention to how scientists in Europe engage in anticipatory practices, by for example actively framing FDP as forensically relevant.

As I move from development to application of FDP, translations between the practices will become clear: whereas the research lab focuses on the genetically unique individual, the forensic lab takes genetic groups as its starting point, and in the investigation "types" of suspects are looked for. This ties in with the earlier work of Pilar Ossorio (2006), who emphasized that FDP technologies do not produce individual suspects, but rather suspect classes or populations (284). It generates "typological information" as Wienroth, Morling, and Williams (2014, 100) have stressed. Or as David Skinner (2018) has more recently put it, FDP technologies "divine" race from DNA. This relation between the individual and (racialized) collectives implied in FDP technologies is detailed further by Hopman and M'charek (2020), who have drawn attention to the ways in which this relation changes in the different approaches to trait prediction.

The studies above have addressed the different actors drawn in by- and involved in FDP, and the complexities arising from that heterogeneity, being it either through the analysis of particular forensic cases, policy documents, published research, "personal experiences" (Wienroth 2018, 3) or interviews. In this article I explore this heterogeneity further through an ethnographic study of FDP, building for the largest part on fieldwork conducted in a research laboratory and a forensic laboratory. This approach allows me to bring into view the practical particularities of FDP, enabling me to draw out the different logics that inform these practices. The descriptions I give in this paper are specific to the Dutch context, raising the question of their transportability to other settings. Yet the Netherlands has a leading role when it comes to the application of novel forensic genetic technologies: the international forensic community is looking towards Dutch cases to develop protocols for the implementation of new technologies. In the German Claudia Ruf cold case, for example, investigators are taking lessons from the Dutch Nicky Verstappen case.[2]

As I move down the chain from research laboratory to forensic investigation, I show that these practices, although connected, do not linearly accumulate. Different from other studies that have demonstrated how forensic objects travel between settings and "epistemic cultures" (Kruse 2016, 148; see also Cole 2013), FDP practices do not add up. Authors such as Kruse have pointed out that even though differences in forensic practices exist, the disparate epistemic cultures are "mutually dependent" and together contribute to the production of, for example, a coherent piece of evidence (Kruse 2016, 149). The notion of contribution, however, implies an accumulation of expertise: the practices are "diverse" but in the end they do accumulate (Kruse 2016, 3). I take the case of forensic DNA phenotyping to demonstrate that forensic practices do not necessarily add up, accumulate, or accrue. They rather constitute a "heterogeneous assemblage" (Law 2004; Mol 2008, 92).

Methods

In this paper I predominantly draw on fieldwork conducted in two Dutch laboratories. The first, a research lab, was situated in the department of molecular biology in an academic medical center. Over a period of three months during the winter of 2017/2018 I frequented this lab two to three days a week. Additionally, during the spring of 2018 I conducted two months of fieldwork in a forensic lab. During my fieldwork period I furthermore conducted interviews with police investigators and attended an international conference on forensic genetics. Finally, I attended a three-day workshop on the analysis of facial shapes at a German university in December 2018.

The logic of accuracy: approaching 1

"What is acceptable, desirable or called for" in the research lab can be captured by what I call *the logic of accuracy* (Mol 2008, 13). In this first logic, producing

individual-specific facial composites is the ultimate goal. The ideal here is establishing a one to one relationship between the genotype and the phenotype, a relationship that I found is often numerically expressed through AUC (Area Under the Curve) values. AUC values represent the predictive power of a particular model to estimate the facial characteristics of an individual and are often used interchangeably with "accuracy." Ultimately, researchers are striving for an AUC of 1. Like in Donald MacKenzie's work on missile guidance, in the research lab the expansion of accuracy is taken as the logical direction for this technology to develop (1990, 3). In the field of missile guidance, improving accuracy implied moving ever closer to the intended physical target. Similarly, the practices I encountered in the research lab revolved around getting closer to achieving a predictive accuracy of 1, which is why the focus here is on data accumulation and the discovery of new biomarkers.

In the research lab that I studied, activities were centered around "developing forensic tools for the future" as the professor heading the lab explained during our first conversation. This often required them to conduct "fundamental science," he emphasized, as these tools were developed from scratch. The research conducted here could thus potentially be forensically relevant, but sometimes did not work out for that purpose. This professor therefore emphasized that their work "is not forensics *yet*." Rather, it focused on exploring what may be called the "molecular blueprint"[3] of the face and finding openings towards potential forensic applications.

In order to identify biomarkers associated with facial traits the researchers in this lab analyzed large amounts of data: genes sequenced from people from different parts of the world with varying appearance traits. Through this process genes with statistically significant effects on facial appearance could be identified (Kayser 2015, 34). Researchers found many genes with identifiable effects on appearance in this way, but only those with the most significant effects would be included in forensic tools. These "significant effects" are crucial in making FDP forensically relevant, as they feed into the anticipated practical utility of these tools (Wienroth 2018, 3). For, as I will demonstrate below, the forensic lab cannot include a large amount of markers for casework.

An example of a FDP tool is the HIrisPlex-S system, a model that categorically predicts pigmentary traits, developed by the Erasmus MC in the Netherlands in collaboration with the Walsh laboratory of Indiana-University-Purdue-University-Indianapolis (IUPUI), USA. The scope of this tool has expanded significantly over the years. The first version predicted only eye-color, whereas the most recent version predicts eye- and hair, as well as skin color. And this is only the beginning: "it represents one of the first steps forward in the creation of a fully individualised EVC prediction system for future use in forensic DNA intelligence" (Walsh *et al*. 2011, 170).

As this example demonstrates, FDP is a technology that is constantly broadening its scope. The logic of accuracy is a logic of *expansion* that constantly searches for

new genetic "territories" to map (Adams, Murphy, and Clarke 2009, 250). Researchers are continuously working on identifying new markers that could explain part of the genetics behind human appearance. Like the engineers Kathryn Olesko (1996) studied in her work on electrical resistance measurement in nineteenth century Germany and Britain, they are "steadfast in their grasp for accuracy" (126). And this is not a simple task, as "human facial diversity is substantial, complex, and largely scientifically unexplained" (Claes *et al*. 2014, 2). Despite the complexity researchers are optimistic about the future potential of the technology, often mobilizing identical twins as the evidence that the specific individual details of the face are determined genetically: " … we know that a face's uniqueness has to be hidden in the genome – although we don't yet know where" (Kayser in Karberg 2017). As such, the face is taken as "the holy grail[4] of appearance prediction" as a leading professor in the field stressed during a lecture.[5]

In order to get closer to genetically accounting for facial variation, researchers are calling for larger amounts of data, money and time. Differences in human faces are subtle: "You do need lots of data. Facial variations are very small. So to study faces you need lots of faces."[6] This stress on data accumulation resonates with scholarship on data driven technologies, for example in security studies, where expanding databases are employed towards predicting future security threats ever more accurately (see, e.g. Amoore [2006], Amoore and De Goede [2012], and Leese [2014] on this subject). In a lecture on FDP I attended during the summer of 2018, for example, a presenter discussed the accuracy rates of their prediction tools.

> Obviously there are things to improve, also on the eye and hair color, because it's not perfect. We want to have it [AUC values] higher … The thing is, the more of these genes you identify with this type of analysis, the smaller the effect size is … So that also means that the more genes you find, you need many more because they individually have small effects.[7]

As becomes clear from this quote, in order to account for a greater amount of facial diversity the accuracy or AUC values of the model need to be improved, and therefore more markers need to be included. The quote at the same time signals the inherent paradox in this endeavor, as pursuing new markers and higher accuracies implies the need for ever more data. Complexity increases with each new marker that is identified. The search for markers thus has no end: "The tragedy here is the tyranny of optimization," as the "scope of optimization is unlimited" and can therefore never be fully achieved (Adams, Murphy, and Clarke 2009, 256–257). But, as optimistically voiced by Kayser in an interview article: "The more and in greater detail we can retrieve traits from DNA, the closer we get" (Kayser in Vermaas 2018).

Closer, that is, to "composite sketches that are a 100% correct" (Vermaas 2018). Ultimately, the aim of these research efforts would be to completely uncover the uniqueness of the face. Achieving this would entail accurate prediction of

individual-specific faces, meaning that predictions would be in correspondence with the actual phenotypes. In scientific publications, researchers frame this as the eventual aim of FDP. As stated by Kayser (2015), "Clearly, *being able to predict individual-specific faces from DNA* would be the ultimate goal of FDP and the dream of police men and women" [emphasis added] (44).

In the logic of accuracy individuality is thus the ultimate goal, yet it keeps slipping away in the increasing detail of biomarkers. This results in a practice that is ever expanding its scope, grasping for something that is held out as possible but practically probably unattainable. Furthermore, in the end this research relies on linking geno*types* to pheno*types*, an approach that contrasts with the eventual goal of individualization, "as there are therefore no unique individuals: everyone belongs to a class shared by many others" (Amorim 2012, 261). This raises the question whether the emphasis on accuracy and predicting individual faces might be strategically utilized towards making FDP forensically relevant, suggesting that investigators will be allowed to target a particular suspect. After all, an inaccurate prediction model would be: "limited in its practical applications" (Liu *et al*. 2009, R192). A stress on accuracy is thus not a purely scientific one, but might additionally be seen as being strategically employed to prepare FDP technologies for transportation to forensic contexts.

The logic of commonality: producing group specificity

While the work in the research lab is geared towards accuracy, the forensic lab is informed by what I call the logic of commonality. The ultimate good here is not to produce individual-specific results but to navigate the constrictions of forensic practice while still producing useful results. In order to do so, the focus shifts from the genetically unique to the genetically common. We thus move from the logic of accuracy to the logic of commonality. I take "common" in three senses, drawing on its Merriam Webster definition. First, "of or relating to a community at large," second, "belonging to or shared by two or more individuals or things or by all members of a group" and finally, "occurring or appearing frequently, familiar."[8] As I will demonstrate each of these definitions becomes relevant within this logic. First, in the Dutch forensic laboratory, geneticists importantly focus on how a particular trace *relates* to and can be made sense of within the Dutch context. Second, they seek to find out with whom in the population the donor *shares* markers in order to attribute them to a group. Third, the *frequency* with which these markers appear in the population becomes of importance in order to determine how common or rare a result is. Unlike the logic of accuracy, the individual therefore does not occupy center-stage in this logic. Rather, the focus shifts towards genetic similarities shared among *groups*.

In the forensic lab, I learnt about the practical details of forensic analyses. The focus here was less on the development of new tools and open-ended exploration of the "molecular blueprint" of the face, but rather on the routine application of

forensic analyses, or improving these based on experiences with forensic casework. The lab staff consisted mostly of highly skilled technicians. Furthermore, whereas the research lab could be called disorderly (tellingly, upon being reprimanded to "clean up his mess" an intern once exclaimed: "it's not mess, it's data!"), the forensic lab was organized into separated working- and lab compartments and continually cleaned. Their main concern was with performing the forensic analyses correctly without contaminating or wasting the precious forensic samples.

The tools or "kits" that were applied by this forensic lab could not include a large amount of markers. As explained by a geneticist during a presentation on FDP[9]: "Typically we don't have a lot of DNA. So we need to predict few markers that tell us a lot about a person." Crime scene DNA often comes in small amounts, and may furthermore be degraded or mixed with the victim's DNA (Lander 1989; M'charek 2016). These practicalities complicate analyses. Furthermore, lab machinery imposes limitations: "Preferably we would include as many SNPs[10] as possible. But we are limited in our choices by the maximum amount of fragments that we can put in and read from the PCR," as a senior analyst at this forensic lab explained.

Taking this into account, in the lab where I conducted fieldwork the most commonly performed analysis was determination of geographical ancestry[11] (also referred to as "indirect phenotyping," see Koops and Schellekens 2008). With this method analysts sequenced 42 fragments of a donor's Y chromosome where particular polymorphisms (SNPs) were known to be located. They then determined whether this donor had a mutation for these particular locations (loci) or the wild-type, based on which he was allocated to a particular haplogroup. Each haplogroup was thus based on a particular combination of mutations. Because haplogroups are associated with different parts of the world, inferences could then be made about his geographical "ancestry" and, indirectly, his appearance. Through a set of shared genetic markers, the unknown suspect is located in a population. Following the first definition of common, what matters here is thus not establishing a one-to-one relationship between an individual and their phenotype, but rather between the individual and, in this case, the population living in the Netherlands. Unlike the research lab, which developed tools focused on application in the broadest sense possible, results produced by this lab had to produce leads for *Dutch* criminal investigations in particular. The forensic tools were thus adjusted to that: "So with the Y SNP kit that we use you can at least identify the main groups, and it also includes SNPs belonging to subgroups that occur frequently here."[12] What becomes of importance here are the *frequencies* with which they occur within the population, or how *common* a haplogroup is in the population living in the Netherlands. Using this kit, an unknown suspect can be sorted into a category that would make sense in a Dutch investigation.

This method thus did not offer individual-specific appearance prediction: haplogroups do not directly translate into appearance. The method rather gave a rough indication of a donor's "geographical ancestry," sorting them into a broad

category. Ideally, through this method geneticists hoped to obtain results that did not occur frequently within the Dutch population: "Something odd … Something that they [police] could really do something with," as a lab analyst told me when I asked him what kind of result he was hoping for. Within that rationale, uncommon results are logical, as a less common haplogroup reduces the size of the population of interest and is therefore easier to investigate. Yet what counts as "rare" is not straightforward. The below instance demonstrates this. Two senior geneticists working at the forensic lab had just received the results of a Y haplotype determination from their analysts. They were unhappy with the findings. The haplotype they had found was rare but because of its geographical spread, of no use forensically.

> He has a rare Y chromosome, a R1b subgroup. It only occurs in 1.5 percent of people spread out over the whole of Europe. So that does not help at all.

To try and distill useful information from these results, the geneticist explained they would search for "neighboring haplotypes": haplotypes that are not exactly the same, but close enough to potentially tell them something more useful about this individual's geographical ancestry, as the geographical areas they occur in correspond. The geneticists positioned themselves behind a computer and one of them searched the YHRD for "nearest neighboring haplotypes." The website presented her with a geographical map that showed them where these haplotypes occurred. The other geneticist read the results to us out loud.

> It occurs in 197.000 men spread out over Brazil, Mexico, the Middle East, China.. So that does not add anything at all. The only thing we can confidently say now is "it is a man".[13]

In this case I had spoken to the analysts and knew that besides determination of the haplotype (based on variation in length of short tandem repeats) they had also done a Y SNP analysis (the haplogroup method explained above). And so I asked one of the geneticists if it would be possible to combine the outcomes of the haplotype determination with the results of this other analysis.

> The SNPs don't tell us anything either, there we also found a R1b subgroup. R1b runs from Turkey to Ireland. So it tells you nothing. How likely is it that a suspect in a Dutch crime will be from Europe? You would rather find something rare: India, South East Asia, Africa south of the Sahara. That makes it researchable ["rechercheerbaar"].

I asked one of the analysts if it would be possible to compare a suspect's DNA to a larger set of populations to increase the precision of their geographical predictions. She told me that including more populations would indeed add detail to the results. But it would not be possible within temporal and financial constrictions:

> Well yes, but then every time you find an unidentified body or have an unknown suspect you would have to look at thousands of SNPs. That costs a lot of money and time […] so the haplogroup method that we use now is a cheap alternative.[14]

Geneticists in forensic settings do not have the resources to bring into view individual-specific facial characteristics: restrictions imposed by small amounts of crime scene DNA, lab machinery, and time and financial constraints limit the space for analysis. Practices therefore focus on using limited resources to produce "useful" results. As such forensic practice does not aim to get to the genetic uniqueness of an unknown suspect, but within the given constrictions seeks to assort an unknown suspect into a particular *group* instead. What makes sense in the forensic lab is to focus on the commonalities between genomes, to situate these within the context of the Netherlands and to finally report on how *common* a result is. Once such findings are written up, the report is sent to the police, where practices again operate along a different logic.

The logic of valuing: narrowing the pool

The final logic I address is that of *valuing*. In the criminal investigation, different pieces of information are assembled in order to identify an unknown suspect. Here, FDP can be requested to provide additional clues. After the forensic lab completed their analyses of the samples, a report detailing the results and the analyses that were performed was sent to the police. In this context the report provided one piece of information among many. Whereas practices in the research- and forensic labs focused completely on DNA analyses, in the police investigation results produced through DNA research become part of an assemblage of other information. The DNA is a valuable indicator here that is taken very seriously, but it is not the only one. There might be eyewitness statements, and the modus operandi and location of the crime scene may also provide clues. The DNA predictions are weighed against all these other chunks of information investigators have gathered on a case to decide on the course of the investigation. As such, the final logic is one of *valuing.* This valuing work does not lead to particular individuals, as inferences are not specific enough to individualize. What they rather do is direct the investigation towards *groups* of persons of interest.

Besides my fieldwork in laboratories, I conducted interviews with police officers who were involved in the implementation of FDP technologies. Through these conversations I came to learn about the rationales and choices that guide police practice. I got an idea of how inferences produced using FDP tools are put to use in an investigation. The investigators I interviewed pointed at some of the complexities with applying results produced through biogeographical ancestry determination by elaborating on two cases in the Netherlands. Two women had been raped by the same individual, yet the descriptions they gave of the suspect pointed in different directions.

> So one of the victims indicated it was a man of more or less Moroccan origin, let's say North-Africa. While the other witness, the other victim, so raped by the same man, pointed in the direction of India. So an Indian, eh, appearance … And so as a tactical team leader you therefore had to deal with two possible groups that were interesting

> to put on top of your list. To investigate first. When you then use the DNA, and we did that, and you see a very clear indication in the direction of India. And additionally you connect that to the fact that one of those two ladies was a stewardess and spoke of an "Indian type". And then from that you deduce that those people do have a better view, we think, of where some people come from, from which parts of the world. So you attach more *value* to that, and so you focus more on that without losing the others from sight. But you have to make choices in a criminal investigation, and you do that based on the best information you have.[15]

From the above quote the valuing work becomes clear. Here, investigators were dealing with a case where they had information from different sources pointing in different directions. What then became of concern were questions such as: who to investigate first? where to invest resources? which chunks of information to go by? Because the eyewitnesses gave opposing statements, FDP was used here to weigh the statements against each other and decide which one was most valuable to the investigation. In addition, the occupation of one of the witnesses was taken in as a relevant indicator: a stewardess is considered an expert on phenotypic variation.

Investigation of a criminal offence is thus importantly "information work […] it is concerned with the identification, interpretation, and ordering of information" (Innes 2003, 113). Inferences produced through FDP become part of this work and have to be balanced with other pieces of information. To inform this valuing work, investigators build on past experiences with the technology.

> We have noticed that the DNA indication is often more correct than what witnesses declare. We have experienced that multiple times now. That does not mean that when the DNA indication says "blond hair blue eyes" that it can't be any other way, let's put that first, but the DNA indication is more valuable to me than a witness statement.[16]

Additionally, other kinds of information might be drawn in as relevant. Like in the forensic laboratory, context was of great importance here, albeit in a different way. A factory in the vicinity of the crime scene might become of relevance, for example. During one of the interviews investigators sketched a situation where they had received the results of a FDP analysis: the analyzed DNA profile was frequent in a particular part of Morocco. Then, the officers told me, it became relevant that in the past, a lot of Moroccans migrated from that particular area to work at a local factory in the area of investigation. The factory was then linked to a history of labor migration, becoming an indicator used to value the results. The DNA predictions thus do not become instructive to an investigation by themselves, they "enroll" surprising entities: from migration pasts to geographical locales and professions (M'charek 2008). They are highly contextualized.

After weighing the available indicators against each other, investigators could decide on how to proceed. For the DNA analyses to allow investigators to undertake *action* was most important here: a valuable indicator allowed for "the ability to progress" (Samuel and Prainsack 2019, 10), which in practice meant being able to

decide on which groups to focus attention. FDP is not used to steer the investigation towards a particular individual but to *prioritize* certain groups of people over others. Investigators referred to this process as "condensing." In other words: they were working on "narrowing the pool" of suspects (Cole and Lynch 2006, 40). Results do not have to be highly specific to steer the investigation into a particular direction. In fact, investigators I interviewed specifically indicated that what works best for them is rather broadly defined: to hint at a *category* of person. To again take the example of ancestry determination, police would rather receive results that point at "Asian" ancestry than getting a more specified result: "For us, Chinese is not distinguishable from Japanese or Korean. Asian works better. That gives you very clear images immediately." Investigators do not have the expertise, as does a stewardess, to discern the differences between someone with Korean and someone with Japanese ancestry. So what works best in practice are broad categories that can be translated into a *type* of suspect within a particular investigation.

Additionally, the pressures of the investigation play a role in the valuing work. Investigators told me that cases in which FDP is applied are usually severe: most often they are rape or murder cases. There is thus an urgency to solve them as quickly as possible, meaning officers sometimes have to be practical about their leads. An ethnographic study by Martin Innes (2002) on police work in England and Wales is instructive here. Innes shows that in homicide investigations officers have to be pragmatic when going about an investigation, in the sense that they can "allow the work to be done in a reasonably effective and efficient way" (Innes 2002). This also became clear from my interviews: "But, as police you will sometimes have to, yes, you also have to be pragmatic and work with what you have … you are working on solving a crime."[17] Facing the pressures of an investigation, investigators have to make do with the information they can get. Here, the DNA is an indicator used to focus the investigation, to *value* certain chunks of information over others, to guide decisions on where to direct attention.

The logic of valuing thus informs a practice that through relating DNA to other kinds of information seeks to establish on which phenotypic group to focus attention. This valuing work is informed by other leads available in a particular investigation, but also by the context in which the crime took place, for example the proximity of a factory, and finally, by temporal constraints placed upon the investigation.

Concluding discussion

In this paper I have followed forensic DNA phenotyping "from place to place" (Jordan and Lynch 1998, 776), demonstrating the different logics each of the contexts is informed by. While the practices I describe do not accumulate, they do cohere. As Mol notes: "while the various logics that inform our practices clash with one another, they are also interdependent" (2008, 92), forming a

"heterogeneous assemblage" (92). As I have demonstrated, this coherence is "full of tensions" (Mol 2008, 247). Yet I argue that the logics hang together through the anticipated translations between the settings: I have shown, for example, how the stress on accuracy and most significant effects were partially strategically employed as to make FDP forensically relevant. And how forensic scientists anticipated the production of "uncommon" results, as these would be most useful to the investigation. It is in these shifts between the practices that their coherence becomes evident.

Furthermore, in line with M'charek's assertion to attend to practices (2008, 527), my analysis points at the importance of context in the application of forensic technologies. As the logics shifted, context became relevant in disparate ways. The biomarkers researchers sought to identify in the research lab needed to cover as much phenotypic variation as possible, they aimed to find associations between the genotype and the phenotype *in general*. Here, the virtue was exactly not to be particular in order to make sure the technology was transportable to other settings. This contrasts with practices in forensic labs, which are attuned to Dutch investigations in particular. In order to decide on which kit to use, geneticists here sought to apply sets of markers that would cover as many populations living in the Netherlands as possible. Finally, in investigatory practices the particularities of a case became relevant in terms of the persons of interest and the area in which a crime was committed.

Second, my analysis draws out a shifting focus on the individual and the population in FDP practices. As signaled in the introduction, the paper thus furthermore speaks to debates on FDP technologies in relation to race and racism (Skinner 2018; Ossorio 2006; Toom and M'charek 2011). I would argue that it is precisely in the translations between the logics that race becomes of relevance. Practitioners moved from aiming for the genetically unique *individual*, to establishing the genetic *group*, and finally towards interpreting that as a *type* of suspect. We move from biomarkers to haplogroups to race. A forensic report might state that the suspect has genetic markers that are most frequent in South Asia, and in the investigation this might translate into an "Indian" type. Or a R1b haplogroup within the Dutch context might be translated into a "white man" (Jong and M'charek 2018, 358). Furthermore, in my analysis of the forensic lab, I hinted at the utility of *uncommon* results in particular. Here, the reality is that results are most efficient when they point at a minority population. As the forensic geneticist quoted above put it: "India, South East Asia, Africa south of the Sahara. That makes it researchable."

As I have shown FDP builds on an assemblage of practices. In order to understand its implications we should therefore move beyond analyzing academic publications on FDP research and interviews with stakeholders and attend to it as such: as "technology-in-practice" (Timmermans and Berg 2003; Toom *et al*. 2016). Taking practices and the logics they work by into consideration allows for a more nuanced account of FDP technologies. Analyses as done by Skinner and Wienroth have rightfully pointed out how results produced through FDP can be

translated into racialized group-labels when applied in an investigation. Yet by showing its distribution over a set of practices and opening these up it becomes clear that completely different concerns are at work. To take FDP seriously we need to attend to these concerns, allowing for a more generous understanding of FDP and the practitioners involved in its development and application.

Significantly, this has furthermore enabled me to draw attention to a disconnect between research- and forensic practices. The ideal that informs the logic in the research lab, revolving around achieving individuality in DNA-based facial composites, would not be tenable in a forensic practice that faces a set of practical constraints. Furthermore, my analysis has shown that investigatory practices in fact work best through the use of broad phenotypic categories. It is precisely the *unspecificity* of predictions that makes them valuable, as police investigators are not experts on the meticulous variations of human appearance. It is the openness of FDP results that furthermore allows space for diverse publics to be drawn in and engage with an investigation (M'charek forthcoming).

Anticipating a future in which these technologies will be developed further through the addition of biomarkers, and subsequently an expanding legislation that will allow for the prediction of an increasing number of traits, questions about the coherence between forensic, investigatory and research practices grow ever more relevant. In 2018, the Dutch public prosecutor for example published an article on FDP that stated: "Forensic science is accelerating, with a composite sketch based on perpetrator DNA traces on the horizon" (Vermaas 2018). Promises towards the production of individualized facial composites thus do not stay within research contexts but are circulated, resulting in "unreasonable expectations" beyond the lab (Hallgrimsson *et al*. 2014, 2), demonstrating the urgency of studying FDP as it is applied in forensic practice.

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Notes

1. For a discussion on the use of the term 'race' in this legislation, see M'charek (2008).
2. https://nos.nl/artikel/2311768-groot-dna-onderzoek-moet-na-23-jaar-moord-op-claudia-ruf-oplossen.html accessed 16/12/2019
3. As referred to it by a computer scientist during his workshop presentation titled 'Imaging Genetics of the Human Face' at the Freiburg Institute for Advanced Studies, Germany, 18/12/2018.
4. This resonates with the discourse surrounding the Human Genome Diversity Project (see Jordan and Lynch 1998, 775; Rothman 1998, 23).
5. Rotterdam, November 17 2017.
6. A biological anthropologist during a workshop on facial shape analysis, 18 December 2018.
7. A professor in molecular genetics during a talk on forensic DNA phenotyping, 06 July 2018.
8. https://www.merriam-webster.com/dictionary/common accessed 01/04/2019
9. Freiburg, Germany, 18 December 2018.
10. Single Nucleotide Polymorphisms, particular kind of marker.
11. The HIrisPlex-S model for prediction of pigmentation traits I describe above is performed in another lab in the Netherlands.
12. Quote taken from fieldnotes, 21 March 2018.
13. Quote taken from fieldnotes, 5 April 2018.
14. Quote taken from fieldnotes, 24 April 2018.
15. Quote taken from interview, 6 December 2018.
16. Quote taken from interview, 6 December 2018.
17. Quote taken from interview, 5 October 2017.

References

Adams, V., M. Murphy, and A. E. Clarke. 2009. "Anticipation: Technoscience, Life, Affect, Temporality." *Subjectivity* 28: 246–265. doi:10.1057/sub.2009.18.

Amoore, L. 2006. "Biometric Borders: Governing Mobilities in the War on Terror." *Political Geography* 25: 336–351. doi:10.1016/j.polgeo.2006.02.001.

Amoore, L., and M. De Goede. 2012. "Introduction: Data and the War by Other Means." *Journal of Cultural Economy* 5 (1): 3–8. doi:10.1080/17530350.2012.640548.

Amorim, A. 2012. "Opening the DNA Black Box: Demythologizing Forensic Genetics." *New Genetics and Society* 31 (3): 259–270. doi:10.1080/14636778.2012.687083.

Chaitanya, L., K. Breslin, S. Zuñiga, L. Wirken, E. Pośpiech, M. Kukla-Bartoszek, T. Sijen, et al. 2018. "The HIrisPlex-S System for Eye, Hair and Skin Colour Prediction from DNA: Introduction and Forensic Developmental Validation." *Forensic Science International: Genetics* 35: 123–135. doi:10.1016/j.fsigen.2018.04.004.

Claes, P., D. K. Liberton, K. Daniels, K. M. Rosana, E. E. Quillen, L. M. Pearson, B. McEvoy, et al. 2014. "Modeling 3D Facial Shape from DNA." *PLoS Genetics* 10 (3): e1004224. doi:10.1371/journal.pgen.1004224.

Cole, S. A. 2013. "Forensic Culture as Epistemic Culture: The Sociology of Forensic Science." *Studies in History and Philosophy of Biological and Biomedical Sciences* 44: 36–46. doi:10.1016/j.shpsc.2012.09.003.

Cole, S. A., and M. Lynch. 2006. "The Social and Legal Construction of Suspects." *Annual Review of Law and Social Science* 2 (1): 39–60. doi:10.1146/annurev.lawsocsci.2.081805.110001.

Hallgrimsson, B., W. Mio, R. S. Marcucio, and R. Spritz. 2014. "Let's Face It – Complex Traits are Just Not That Simple." *PLoS Genetics* 10 (11): 1–3. doi:10.1371/journal.pgen.1004724.

Hopman, R., and A. M'charek. 2020. "Facing the Unknown Suspect: Forensic DNA Phenotyping and the Oscillation between the Individual and the Collective." *BioSocieties*. doi:10.1057/s41292-020-00190-9.

Innes, M. 2002. "The 'Process Structures' of Police Homicide Investigations." *British Journal of Criminology* 42: 669–688. doi:10.1093/bjc/42.4.669.

Innes, M. 2003. *Investigating Murder: Detective Work and the Police Response to Criminal Homicide*. Oxford: Oxford University Press.

Jong, L., and A. M'charek. 2018. "The High-Profile Case as 'Fire Object': Following the Marianne Vaatstra Murder Case Through the Media." *Crime Media Culture* 14 (3): 347–363. doi:10.1177%2F1741659017718036.

Jordan, K., and M. Lynch. 1998. "The Dissemination, Standardization and Routinization of a Molecular Biological Technique." *Social Studies of Science* 28 (5-6): 773–800. doi:10.1177%2F030631298028005005.

Karberg, S. 2017. "Phenotyping: The Hidden Mugshot in a Culprit's DNA." *European Biotechnology*. https://european-biotechnology.com/up-to-date/backgrounds-stories/story/phenotyping-the-hidden-mugshot-in-a-culprits-dna.html.

Kayser, M. 2015. "Forensic DNA Phenotyping: Predicting Human Appearance from Crime Scene Material for Investigative Purposes." *Forensic Science International: Genetics* 18: 33–48. doi:10.1016/j.fsigen.2015.02.003.

Knorr-Cetina, K. 1999. *Epistemic Cultures – How the Sciences Make Knowledge*. Cambridge: Harvard University Press.

Koops, B. J., and M. Schellekens. 2008. "Forensic DNA Phenotyping: Regulatory Issues." *The Columbia Science and Technology Law Review* 9: 158–202. doi:10.2139/ssrn.975032.

Kruse, C. 2016. *The Social Life of Forensic Evidence*. Oakland: University of California Press.

Kruse, C. 2019. "Swedish Crime Scene Technicians: Facilitations, Epistemic Frictions and Professionalization From the Outside." *Nordic Journal of Criminology*, doi:10.1080/2578983X.2019.1627808.

Lander, E. S. 1989. "DNA Fingerprinting on Trial." *Nature* 339: 501–505. doi:10.1038/339501a0.

Law, J. 2004. *After Method: Mess in Social Science Research*. London: Routledge.

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%2F0967010614544204.

Liu, F., K. Van Duijn K, J. R. Vingerling, A. Hofman, A. G. Uitterlinden, A. C. J. W. Janssens, and M. Kayser. 2009. "Eye Color and the Prediction of Complex Phenotypes from Genotypes." *Current Biology* 19 (5): R192–R193. doi:10.1016/j.cub.2009.01.027.

MacKenzie, D. [1990] 1993. *Inventing Accuracy. A Historical Sociology of Nuclear Missile Guidance*. Cambridge: MIT Press.

M'charek, A. 2000. "Technologies of Population: Forensic DNA Testing Practices and the Making of Differences and Similarities." Configurations 8: 121-158. doi:10.1353/con.2000.0005.

M'charek, A. 2008. "Silent Witness, Articulate Collective: DNA Evidence and the Inference of Visible Traits." *Bioethics* 22 (9): 519–528. doi:10.1111/j.1467-8519.2008.00699.x.

M'charek, A. 2016. "Data-Face and Ontologies of Race." Theorizing the Contemporary, *Fieldsights*, March 24. https://culanth.org/fieldsights/data-face-and-ontologies-of-race.

M'charek, A. Forthcoming. "Tentacular Faces: Race and the Return of the Phenotype in Forensic Identification." *American Anthropologist*.

Mol, A. 2008. *The Logic of Care. Health and the Problem of Patient Choice*. New York, NY: Routledge.

Mol, A. 2016. "Clafoutis as a Composite: On Hanging Together Felicitously." In *Modes of Knowing: Resources From the Baroque*, edited by John Law and Evelyn Ruppert, 242–265. Manchester: Mattering Press.

Olesko, K. M. 1996. "Precision, Tolerance, and Consensus: Local Cultures in German and British Resistance Standards." In *Scientific Credibility and Technical Standards in 19th and Twentieth Century Germany and Britain*, edited by Jed Z. Buchwald, 117–156. London: Kluwer Academic Publishers.

Ossorio, P. 2006. "About Face: Forensic Genetic Testing for Race and Visible Traits." *The Journal of Law, Medicine & Ethics* 34 (2): 277–292. doi:10.1111/j.1748-720X.2006.00033.x.

Rothman, B. K. 1998. *Genetic Maps and Human Imaginations. The Limits of Science in Understanding Who We Are*. New York, NY: W. W. Norton & Company.

Samuel, G., and B. Prainsack. 2019. "Forensic DNA Phenotyping in Europe: Views 'on the Ground' from Those Who Have a Professional Stake in the Technology." *New Genetics and Society*, 119–141. doi:10.1080/14636778.2018.1549984.

Skinner, D. 2018. "Forensic Genetics and the Prediction of Race: What is the Problem?" *BioSocieties*, 1–21. doi:10.1057/s41292-018-0141-0.

Timmermans, S., and M. Berg. 2003. "The Practice of Medical Technology." *Sociology of Health and Illness* 25 (3): 97–114. doi:10.1111/1467-9566.00342.

Toom, V. H. 2010. "Dragers van waarheid: normatieve aspecten van twintig jaar forensisch DNA-onderzoek in Nederland." PhD diss., University of Amsterdam.

Toom, V., and A. M'charek. 2011. "Van individuele verdachte naar verdachte families en populaties: het wegen van nieuwe forensische DNA-technieken." *Nederlands Juristenblad* 86 (3): 142–148.

Toom, V., M. Wienroth, A. M'charek, B. Prainsack, R. Williams, T. Duster, T. Heinemann, C. Kruse, H. Machado, and E. Murphy. 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. doi:10.1016/j.fsigen.2016.01.010.

Vermaas, P. 2018. "Via DNA naar een compositietekening." *Opportuun*, March 20.

Walsh, S., F. Liu, K. N. Ballantyne, M. Van Oven, O. Lao, and M. Kayser. 2011. "IrisPlex: A Sensitive DNA Tool for Accurate Prediction of Blue and Brown Eye Colour in the Absence of Ancestry Information." *Forensic Science International: Genetics* 5: 170–180. doi:10.1016/j.fsigen.2010.02.004.

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. doi:0.1080/14636778.2018.1469975.

Wienroth, M., N. Morling, and R. Williams. 2014. "Technological Innovations in Forensic Genetics: Social, Legal and Ethical Aspects." *Recent Advances in DNA and Gene Sequences* 8: 98–103. doi:10.2174/2352092209666150328010557.

Williams, R., and P. Johnson. 2008. *Genetic Policing. The Use of DNA in Criminal Investigations*. Uffculme: Willan Publishing.