Forensic Genetics and the Prediction of Race: What is The Problem?

Abstract

A new wave of innovations in forensics seeks to support criminal investigations by making inferences about the racial or ethnic appearance of as yet unknown suspects using genetic markers of phenotype or ancestry. This paper argues that to grasp fully the potentials of these innovations they must be understood both in the context of established patterns of police-minority relations and as part of significant changes in the use of ‘race’ as an object of knowledge in science, policy, and politics. Socio-technical developments offer new means of identification through geneticization, datafication, and visualization and heighten the visibility and valorisation of racial difference. Elements of this are already evident in existing national police forensic DNA databases whose operation, outcomes, and accompanying ethical frames are racialized in varied ways. By openly mobilising race and ethnicity, however, predictive techniques raise new questions about the validity, interpretation, dissemination, and application of results. Examination of existing use by the police and public of suspect descriptions shows the enduring power of common sense visual and linguistic understandings of race and appearance. That very power makes it hard to transition effectively from moments of collective stigmatization to the identification of individual suspects.

Keywords

Ethnicity; Forensic Genetics; Phenotype Prediction; Race; Racism

Introduction

The application of genetic science to police forensics is sometimes understood in terms of three overlapping waves (Williams and Wienroth 2014). The first saw, from the 1980s onwards, the establishment of genetic testing as a credible identification tool and means of linking known suspects to crimes. The second involved, in the next two decades, the growth of national police DNA databases containing millions of records that are routinely, speculatively searched in an attempt to match as yet unknown people to offences. We are now entering a third wave where new techniques infer personal characteristics of as yet unknown suspects using crime scene samples. Experts seek to predict the likely appearance of suspects using genetic markers of phenotype or ancestry. The growing list of potentially detectable Externally Visible Characteristics (EVCs) includes age, eye colour, hair colour, and skin pigmentation. Moreover, ‘phenotyping’ is a promissory science which, its proponents argue, will eventually allow prediction of a wider set of traits and deliver finer grained descriptions of suspect appearance (Aldhous 2014; Claes et al 2014; Kayser 2015). Forensic scientists also utilize analysis of biogeographic Ancestry Informative Markers (AIMs), a technique used for some time by genealogy services, to generate statements about the likely continental origins of a suspect’s family. In the USA commercial forensic services already make (currently questionable) claims to be able to produce DNA ‘mugshots’ of suspects based on genetic information about ancestry, skin tone and face shape (see for example <https://snapshot.parabon-nanolabs.com/>). In 2017 assertions made by a company led by human genome pioneer Craig Venter that machine learning allowed the increasingly accurate prediction of appearance from DNA excited considerable media attention and public concern ( Lippert et al 2017; Reardon 2017; Regalado 2017).

The detail of implementation of forensic genetics across the first two waves of its development has varied between nation states (Hindmarsh and Prainsack 2010). One axis of variation relates to systems of governance and the extent to which these were developed prior to, alongside, or following the adoption DNA testing and databasing. Often these systems emerged post-hoc to ensure public trust in already stabilised techniques and practices. Legal frameworks for forensic genetics matured as policing and prosecution practices were challenged in court. Similarly forms of institutional transparency and ethical deliberation developed around DNA databases in the face of concerns about their growing size and reach (see for example Author XXXX and Author XXXX). Phenotype prediction is arguably different in the extent to which it has attracted concerted debate about its Ethical Social and Legal implications (ELSI) prior to widespread implementation. Some of its high profile champions might appear to dismiss ethical objections to phenotyping: notably Manfred Kayser, Professor of Forensic Molecular Biology at Erasmus University Rotterdam, who famously argued that the imperative to catch a hypothetical “murderer who otherwise cannot be caught and thus continues murdering” overrides other concerns (Toom et al 2016). Overall, however, in Europe at least, scientists (including Kayser), practitioners, and regulators have been willing to engage with ELSI challenges thrown up by new techniques. The European Forensic Genetics Network of Excellence (https://www.euroforgen.eu/) funded by the European Commission between 2012 and 2017, for example, sought to facilitate exchange between scientists, practitioners, the public, and ELSI academics. Underlying this and other initiatives is the promotion of what has been termed “anticipatory governance deliberations” for this third wave of forensics (Weinroth et al 2014). These anticipatory practices mobilise the promise of the new science whilst managing expectations about its capacities. They have operational (the development of scientific protocols), epistemic (what counts as sound evidence), and, in some jurisdictions, legal dimensions (Weinroth 2018).

The capacity of current or nascent techniques to divine race or ethnicity has proved the most controversial aspect of this new wave of genetics and is a focal point around which critics raise concerns about phenotype prediction in general. Supporters argue that new techniques that analyse genetic traits for skin tone (also soon face shape) and/or test for ancestry can now or will shortly allow the ‘prediction’ of the race or ethnicity of a crime suspect (see for example Phillips 2015). Even before recent developments, however, the ELSI literature on forensics had already deemed the possibility of such race prediction an indication of the dangerous potentials of phenotyping in policing and criminal justice (Koops and Schellkens 2008; Senker 2010).

‘Race’ and ‘ethnicity’ are notoriously tricky terms whose usage has varied over time and between different national contexts. Race has historically been used to make sense of biological heritability and invites focus on physical markers of people’s common origins. Ethnicity has been used to understand human groups in terms of shared cultures, traditions and identifications. This seemingly clear distinction has, however, proved hard to sustain even within the humanities and social sciences, not least because of both terms’ common grounding in highly politicised notions of descent and belonging (Meer 2014). In some jurisdictions all use of race has been superseded in public discourse and policy-making by talk of ethnicity but the two terms are often hard to disentangle; in the United Kingdom, for example, the term ‘ethnic minority’ is applied almost exclusively to groups previously deemed racially distinct. These kinds of elisions are all too evident in the language of phenotype prediction and its accompanying ethical and political frames. To make and communicate their analyses scientists use a variety of group classifications relating to ‘population’ or ‘ancestry’ from which they generate descriptions using range of terms relating to race, ethnicity, region, and nationality. Some of the resulting formulations can seem contradictory or even disingenuous, not least claims to determine someone’s ‘ethnicity’ from their DNA or indeed to equate ethnicity with appearance. Given the centrality to third wave forensics of the production (either directly or at once removed) of descriptions of how a suspect might look, this paper will default to the terms ‘race prediction’ and ‘racialization’ while remaining sensitive to the variety of terms in play in the production and consumption of the science of phenotyping.

A number of past controversies prefigure and act as referents in the current discussion about the genetic prediction of race. In the 1990s the London’s Metropolitan Police’s Operation Minstead made ill-judged use the results of ancestry and skin pigmentation tests to shape the investigation into a serial sex attacker, wrongly (as it later turned out) convinced that the attacker was from a particular part of the Caribbean. Detectives sought ‘voluntary’ DNA samples from a thousand men and intimidated those who refused to cooperate (McCartney 2006). In the Netherlands in 1999 the murder of Marianne Vaatstra whose body was found close to a centre for asylum-seekers prompted heated discussion of the potential value of ancestry testing and, despite this ultimately having no bearing on the resolution of the case, lead to a framework for race testing to be enshrined in Dutch law in 2003 (M’charek 2008). In 2012 the Minister of the Interior for the German federal state of Baden-Württemberg apologised to the Sinh and Roma community for the bungled interpretation by police of DNA evidence in the investigation of a series of murders in Heilbronn in 2007 (Lipphardt et al 2016). With hindsight, in each of these cases genetic testing proved an irrelevance or impediment; they show the potential for over-investment in or misunderstanding of test results in the context of existing stigmatization of minority groups. Unsurprisingly therefore, experiments (2009-2011) by the UK Border Agency utilizing ancestry testing to verify refugees’ narratives and biographies excited considerable opposition from scientists and antiracism campaigners (Tutton et al 2014).

These miss-steps and controversies show that discussion about race phenotyping is hard to separate from public debates about migration, minorities and crime, and police racism. At the time of writing Germany is debating a change in the law which will allow analysis of ‘coding’ as well as ‘non-coding’ parts of crime scene DNA and facilitate prediction of phenotype and biogeographic ancestry (Nature Editorial 2017). This proposal emerged and gained political traction in the aftermath of the murder of a local, white, female medical student in Freiburg widely suspected to have been committed by a refugee from Afghanistan (Lipphardt et al 2016). As Veronica Lipphardt et al’s analysis of public debate about the legal change suggests, there are interesting switches between supposedly emotive and dispassionate positions in the ensuing public debate. Some politicians and sections of the media erroneously portray race prediction as a powerful technical fix that is hampered by political correctness (Lipphardt 2017). The response of many forensic scientists, however, to criticism of the use of predictive techniques is typically more measured, arguing that phenotyping is a useful tool that is as likely to exonerate as to incriminate. Race and ethnicity are portrayed as just two of many possible descriptive categories that could pragmatically be helpful to an investigation. Supporters, who adopt the rhetoric of DNA as ‘biological witness’, also point to the ways in which racialized descriptions and photofits derived from notoriously unreliable human witness’s statements are already routinely used in policing and criminal justice (Kayser and Schneider 2009; Fox 2010; Weinroth 2018).

Critics of developments in Germany have called for the adoption, alongside legal regulation, of infrastructures of ethical and professional governance of forensics of the kind that are already established in many other European countries. Whether such infrastructures are, their existing configuration, up to the job of evaluating and containing race prediction is, however, a moot point. The current state of the art commentary on phenotyping is well summarised in a letter to *Forensic Science International: Genetics* authored by ten leading figures from the small community of scholars of the social and legal aspects of forensic genetics (Toom et al 2016, from now on referred to as the FSIG Letter). The FSIG Letter is a response to an earlier contribution to the same journal by Kayser. It adopts what Williams and Wienroth (2014: 34) have termed the “prevailing repertoire” of bioethics; this asserts the importance of maintaining public trust in science and prioritises dignity and respect for person, bodily integrity, informed consent, personal privacy, proportionality and democratic discussion. The FSIG Letter highlights a series of issues of concern, referring in part backwards to examples of previous hard cases in biomedicine and in part forwards, speculating about future dilemmas thrown up by the development and dissemination of phenotype prediction. The letter reaches out to forensic researchers and practitioners; its primary message being the importance of integrating ELSI into the socio-technologies of phenotyping.

“Ethical issues are not a burden but an opportunity for engagement, for technology enhancement and for negotiating (social) legitimacy.” (p6)

For all its engagement and insight, the FSIG Letter seeks to improve implementation of phenotyping and, for the best of intentions, risks incorporation into the wider tendency across genomics for ethical deliberation and its associated practices of public consultation and institutional transparency to be broadly enabling and preclude fundamental existential questions about innovation (see for example Hedgecoe 2010; Hoeyer and Tutton 2005; Pickersgill 2012).

Central to the FSIG Letter is a call to move beyond “a merely principle-driven ethics” to a “thick ethics” that appreciates the breadth and complexity of the issues thrown up by the implementation of phenotyping. As the authors assert, this requires an appreciation of “the messiness of how technologies are understood and used in the real world.” They argue that promotors of phenotyping underplay the ways in which the use of descriptions of race or ethnicity in policing or media coverage of crime open the way for the victimization of people deemed to fit racialized notions of similarity to a suspect (Toom et al 2016). The implication is that a complementary “thick” appreciation of real world identities and inequalities is also required: a colour-blind ethical discourse which focuses on individual rights and group discrimination in generic, hypothetical terms misses the specifics of racism as a social challenge.

There is, therefore, widespread acceptance that the adoption of phenotyping in forensics presents novel ethical and political challenges; arguably, however, there is less clarity as to why race prediction is particularly problematic. The remainder of this article focuses on these specifics. It argues that to understand the problem with racialized forensics we must appreciate both the pre-existing social structural realities of racial and ethnic divisions and also the ways in phenotyping is part of a reinvention of race as an object of expert knowledge and policy-making. It is divided into four sections. The first locates phenotyping in wider changes to both science and identity politics. Having established these contexts, the second section examines the ways in which race and forensics are already conjoined in national police DNA databases. As the section that follows explains, by openly mobilising race and ethnicity, predictive techniques raise new questions about the validity, interpretation, dissemination, and application of results. Moreover, phenotyping is one of an array of new policing technologies that potentially increase the visibility and significance of racial or ethnic difference - the theme of the fourth section. As the discussion concludes, phenotype prediction and associated developments involve a continual back and forth between moments of individualization and moments of collectivization. In this there is a wicked paradox: race has an enduring power as a means of describing and stigmatizing collectivities but that very power makes it hard to transition effectively from moments of collectivisation to the just and effective identification of individual suspects. This suggests problems associated with race phenotyping that cannot be contained within the realms of scientific ethics.

The Changing Politics of Race Knowledge and Race Identity

It is important to place discussion of the racialization and forensic genetics in a wider account of changing knowledge and expertise about ‘race’ that considers how it is understood, used, disputed across contemporary life science, social science, data science, and policy making. In recent years it has become common place to highlight the ways in which, not only in forensics but also in biomedicine, population genetics, and ancestry testing, race, ethnicity and biology are once again discussed together. This process has been referred to as “the molecularisation of race” or the “genetic reinscription of race” but is something more than the return of a repressed biological race determinism (Author XXXX; El-Haj, 2007; Fullwiley 2007). The putative *genetization* of race is a reconfiguration of knowledge and technologies that also encompasses new forms of *datafication* and *visualization*.

The generation, mobilization, and analysis of data has become fundamental to social, political, economic, technical, and cultural organisation. As Adrian Mackenzie and Theo Vurdubakis suggest, in this setting:

“Code, whether in the guise of information technology, genomics or some other form, commonly appears as a means through which any problem can be solved.” (Mackenzie and Vurdubakis, 2011:8)

This faith is underpinned by new techniques for mining, repurposing, bringing together, and representing large quantities of data drawn from a variety of sources. In this the goal is primarily inference and prediction (in the anticipatory sense) rather than the determination of causes: the emphasis is on the pragmatic exploration and combination of data in the expectation of finding significant patterns and issues. In his ground-breaking work on biomedicine, Peter Chow-White has proposed the term “informationalization” to capture what he deems a “new regime of racial signification” (2008).

“ … information becomes the material by which racial meaning is worked on. As cultural code meets computer code, analogue systems enter the digital world producing new modalities as well as reproducing old ones.” (Chow-White 2009: 221)

But the term *race datafication* better highlights the breadth and novelty of the processes Chow-White highlights. Data does not speak for itself: we should appreciate the processes by which it is brought to light, organized, and interpreted - that is, turned into racialized information.

The connection between race as data and race as genetics is evident in the science of phenotype prediction which depends on the conversion of DNA samples into numerical profiles that can be stored, categorized and searched by computer. The divination of ancestry and/or the link between genotype and phenotype is made by comparison of computerized profiles to population databases. Just as importantly, a key feature of data science and digital culture is a growing preoccupation with visual representation and, in particular, the collection, re-purposing, storage, searching and circulation of a multiplicity of images of people. As a number of commentators have suggested this has the potential to increase the visibility and value of race through a process Simone Browne terms “digital epidermalization” (Browne 2010; Nakamura 2008). This tendency and the convergence of genetics, data and images is also evident in phenotyping, for example, in recent crude attempts to produce DNA-derived suspect ‘mugshots’.

In this coming together of corporeal and digital elements we can see the significance and novelty of race as an object of contemporary knowledge and politics. This object is a material-informational hybrid which may be discussed as an ‘obvious’ reflection of bodily characteristics but always relies on an array of cultural referents (M’charek 2013). This hybrid is manifestly unstable and contested: experts mobilise racial or ethnic categories while acknowledging that they are provisional placeholders, what Jonathan Kahn (2013) in his discussion of the development of supposedly ‘ethnic’ pharmaceuticals terms “race in the meantime”. It is a recurring complaint of social studies of new genetics that scientists use ‘race’ and ‘ethnicity’ in sloppy or inconsistent ways; for example slipping between objective and subjective and between social and biological accounts of difference (Author, XXXX). This complaint may, however, miss the point: the multi-valence of racial and ethnic designations allows them to be useful and usable across different settings. In criminal justice, for example, their plasticity allows them to be mobilized in witness derived suspect descriptions, in laboratory analysis of forensic evidence, and the compilation of crime statistics.

The production and consumption of racialized data are key moments when, for all its ambiguity race categories are made solid and, for all their complexities, the connections between people and those categories are, temporarily at least, simplified. Rather than, at the heart of this, ‘race’ being fixed or essentialized as either biology or via a shared understanding of cultural similarity, technologies and data sets provide key points of convergence and stabilization that enable the intellectual, political and commercial exploitation of group differences. Race making (in both senses of classification and discrimination) thus increasingly takes place through systems of data collection, storage, and management. Thus in genetic databases complex biographies and genealogies must be made into usable information: the simplification and reification of difference takes place through the transformation of human samples and human stories into sequences of data and the use computers to combine, organise, and represent this data (Chow-White and Green, 2013).

These changing dynamics of race knowledge-making are inseparable from the wider political context. Scientific research on human difference now requires engagement with multiculturalist social policy, adherence to protocols of inclusive research, and the active enlistment of supporters, subjects, and the public. Pivotal here is the value attached to accounts of ‘identity’ as a freely chosen description of group membership. Scientists often utilize official governmental categories of population difference and adhere to the convention of allowing people to assign themselves to those categories. Although there are considerable variations between nation states, some generate large amounts of social policy statistical data broken down along racial and/or ethnic lines. In the UK the collection and debate of racialized official statistics in the criminal justice system stretches back more than thirty years. Data is recorded and published using race and ethnic categories relating to police stop and search, hate crimes, arrests, use of tazers, court process, prisons, victims, suspects, witnesses and the staffing of the criminal justice system. This sustained commitment to data collection has not on its own delivered improvements in police minority relations and, by some measures, has coincided with worsening in criminal justice outcomes for minorities. Consequently the intention and consequences of the continued collection of data on disadvantage in this form is increasingly open to question (Rowe, 2012).

UK practices of ‘ethnic monitoring’ of criminal justice outcomes highlight an important feature of contemporary politics and policy: a complex relationship between explicit talk of races and ethnicities (racialization) and patterns of discrimination and structures of disadvantage (racism). Despite frequent assertions that race does not or should not matter anymore we are evidently not living in ‘post-racial’ societies.

“Race today is supposedly a thing of the past. And yet all we do, seemingly, is talk about it. We talk (about) race when not talking (about) it; and we don’t talk about it when (we should be) talking (about) it.” (Goldberg 2015:1)

In some situations open naming and discussion of differences is deemed a helpful starting points for discussion of inequalities and mobilization against those inequalities. This is in part because, in many other situations, race and ethnicity are an absence-presence, nominally missing but all too evident in unequal practices and outcomes (M’charek et al 2014). Public debate frequently hinges on a definition of racism which understands it as a personal pathology and tends to focus on the motivations behind and meanings of particular utterances or actions. As Miri Song argues, these debates, lack context and by attaching the term to “almost any utterance of racial terms and attributes” (Song 2014: 125) obscure how racism is rooted in longstanding structures of power and inequality.

Learning from the Racialization of National Police Forensic DNA Databases

National police forensic DNA databases are amongst the largest contemporary collections of genetic information. Their growth marks a significant shift in policing practice as they place sizeable populations under continual (if usually non-invasive) surveillance (Toom 2010). The commitment required to build and maintain national databases by police and government has been driven by what Robin Williams (2010) terms the ‘forensic imaginary’, faith in science to produce a step-change in the efficiency and accuracy of crime detection and deterrence. Delivery of this promise is not easy. Underlying the production, maintenance and use of these forensic systems are a complex set of spatially dispersed processes: the collection of bodily material; its translation into digital records; the storage, searching and matching of those records; the interpretation of results in a variety of scientific and legal settings; and the on-going professional and political governance of all of the above.

The expansion of forensic DNA databases has provoked public debate about their cost, effectiveness and implications for civil liberties. Debates have often focused on *proportionality*: put crudely, the appropriate criteria for inclusion in and optimal size of databases. This issue is typically considered in terms of a trade-off between individual rights and the collective good but this ignores the inefficiencies associated with overly inflated databases and, crucially for our purposes, the unequal distribution of their supposedly universal impositions and benefits. As national databases grew critics began to raise questions specifically about racism and forensic genetics. In the USA there was some acknowledgement of potential of DNA analysis to exonerate black and Hispanic men falsely accused or convicted by a biased justice system (Washington 2010). Overall, however, the primary concern is that second wave forensics would exaggerate that bias. There were two distinct dimensions to this. The first can be seen as a negative mirror image of the forensic imaginary: a fear that developments could validate and enable new forms of deterministic genetics focused on black criminality (Duster 2004). The second was a more immediate concern about proportionality: that the database would further exaggerate already entrenched patterns of over-policing, discrimination and disadvantage by collecting the DNA of large sections of minority communities (Chow White and Duster 2011; Roberts 2011). These two sets of concerns differed in the ways in which they problematized the racialization of the DNA. The first focused on overt discussion of race in genetic terms while the second suggested that collective surveillance and disadvantage would be intensified in the operation and outcomes of databases despite their apparent colour-blind neutrality.

While warnings that databases heralded a “new phenology” may have been misplaced, explicit talk of race and genetics does take place in varied and complex ways in wave two forensics. In the USA court room discussion of match probabilities between DNA samples and individuals have conventionally been discussed in terms of differences between race populations (Kahn 2008). In some countries in Europe any link between race and forensic DNA has been taboo whilst in others (for example in the Netherlands and France) this has been the focus of significant parochial legal discussion (M’charek 2008; Vailly 2017) In the UK, whilst until recently, there has been relatively minor interest in marshalling the racial characteristics of DNA for legal purposes, the national database has been racialized in significant ways that give pause for thought about the consequences of future developments in phenotyping. The UK example is salutary as it reminds us that the racialization of forensic genetics does not begin with recent developments in phenotyping.

The origins of the UK Police National DNA Database (the NDNAD) go back to 1995. In 2013-2014, in response to a judgement from the European Court of Human Rights, over 1.3 million profiles were erased from it (Author XXXX). Even after this mass deletion almost six million people have searchable records on the database. The NDNAD is racialized in a number of distinct ways. There are disproportionate numbers of people from minorities with records on the database; in particular, young black and Asian men are represented in large numbers. Consequent discussions of disproportionality and racism have taken a particular tone because records have routinely been classified by police officers according to, to use the convoluted official terminology, ‘ethnic appearance’ at time of entry. Overt racialization enables the monitoring of the composition of the database, facilitating the production of audit data broken down by race/ethnicity categories. Alongside monitoring, the use of these categories also facilitated early experiments to ‘ethnically profile’ unknown suspects using crime scene DNA as they provided a ready-labelled set of reference populations (Lowe et al 2001).

The NDNAD case is, therefore, worth examination for what it tells us about the affordances and complexities of explicit racialization. In this case it is arguable as to whether the categorization of DNA by race is a protection from or a manifestation of racism. We should also note that monitoring and profiling has taken places using two apparently incommensurate approaches to race classification. Database records have been classified using Police National Computer witness identification codes which are already the established ways in which British police officers share racialized descriptions. Meanwhile Census data and monitoring data from the criminal justice system used to discuss the disproportionality of the racial composition of the NDNAD depends on a different set of categories (the 16+1 Census classification). This is not just a variation in categories but also in processes and philosophies of classification. Genetic profiles on the database have until recently been classified on the judgement of an arresting police officer whilst comparisons to Census data (used, for example, to make judgements about proportionality) are based on people’s self-identifications (Author XXXX).

As the NDNAD grew formal systems of governance and professional standards were developed to ensure public trust (Williams 2010). The issue of ‘race’ presented a significant challenge to this developing ethico-political infrastructure. To understand the potential seriousness of this challenge we need to place it in the context of wider discussions of racism and policing in the UK. The Macpherson Inquiry and resulting influential Report (1999) argued that the police were “institutionally racist” and that minorities suffered because of the normal operating assumptions and procedures of criminal justice. The Report has been criticised for producing an ambiguous definition of institutional racism because of its emphasis on “discrimination through unwitting prejudice, ignorance, thoughtlessness and racist stereotyping”. Never-the-less it contributed to a changed approach to racism, focused on systems and their consequences that had a major influence on the UK public sector in the first decade of the twenty-first century. This influence can be seen in the formulation of the Race Relations (Amendment) Act (2000) and subsequent attempts to reform policing (Foster et al 2005), focused on systems and their consequences. It challenged anyone seeking to justify the disproportionate outcomes of the NDNAD as it shifted focus away from direct discrimination by individuals to consider racism as an organisational issue and placed the onus onto public bodies to demonstrate that their procedures did not, intentionally or unintentionally, disadvantage minorities.

Discussion of race and racism can be tracked in the minutes and reports of Parliamentary Committees, the database Ethics Committee, and Strategy Board. Analysis of these discussions show how concerns about disadvantage and discrimination have been neutralized through two related processes: firstly, borrowing from approaches established in biomedicine, by framing ‘race’ as an ethical question to be managed by ethical experts; and secondly by subjecting the database to ‘ethnic monitoring’ procedures that are commonplace across UK policing and other public services (Author XXXX). The collection, discussion and dispute of racialized data have played a significant part in this through a performance of institutional transparency and reflexivity and compliance with equalities legislation. For all the consideration of ‘race’, engagement with racism as a systemic problem has, however, generally been displaced by examination of the detail of racialization. Discussions have focused on the inadequacies of the regime of categorization, the validity and reliability of the resulting monitoring data, and the need to move to self-identification as a means of classifying DNA. When racism has been considered comparison with different race data sets on arrest and incarceration are used to suggest that, since the pattern of disproportionality of the NDNAD is comparable to that in other aspects of criminal justice, the database itself is neutral. In this, the database is understood as operating in a distinct realm of professional standards and scientific ethics that can be clearly demarcated from the messiness and inequalities of the wider context of policing and race relations.

The disproportionate composition of the NDNAD, the ways in which this has been problematized and legitimated, and the processes whereby groups are demarcated for monitoring all reflect racially inflected notions of individual and collective identities and rights. Talk of ‘ethnic appearance’, ‘ethnic profiling’ and ‘ethnic monitoring’ can seem contradictory given their focus on ‘visible’ minorities. Race emerges in varied forms as material, data, and discourse: an elusive object that is at certain points made solid through strategic essentialism and at other points tactically deconstructed to problematize evidence of racism. Underlying the politics of the NDNAD are fundamental tensions in discussions of the proportionality and fairness that at heart rest on different accounts of racism as either discrimination by or against individuals or as the manifestation of group disadvantage. The open discussion of race and collection of racialized data have enabled discussion of inequalities but this has often been in ways that had the effect of both legitimating the socio-technology and collectively stigmatizing its subjects: the underlying message of monitoring and ethical discussion is that, despite the best efforts to ensure even-handedness, the criminality of minorities ensures that they are over-represented on the database.

Guess Who? Phenotype Prediction and the Visibility of Race

For some of its supporters, phenotype prediction does not generate ethical or legal dilemmas comparable to other forms of genetic forensics because it is mobilised primarily as an aid to criminal investigation rather than as evidence in court. The argument that phenotype prediction is ‘just’ an intelligence tool was encapsulated for me by a UK detective who, at an event that I also spoke at, portrayed the use of the technique and the racialized predictions it generated as being like the children’s game *Guess Who?* In this game players ask a series of yes/no elimination questions (is it a man? does he wear glasses? does he have red hair?) to determine a mystery individual selected by their opponent from an initially large pool of candidates. It is correct that because of its focus on generating policing intelligence rather than court room evidence the third wave of forensics will “create bio-legal (or bio-investigatory) resources that have different epistemic and criminal justice standings than those generated in the first and second waves” (Williams and Wienroth 2014:21). The *Guess Who?* analogy is, however, flawed in a number of important respects.

One way in which third wave forensics is novel is in the explicit use of race and ethnicity as investigatory resources. As my anecdote suggests, supporters of phenotype prediction may suggest that skin colour and ancestry are just two of a multiplicity of markers of difference potentially highlighted by forensic scientists but it is disingenuous to suggest that all descriptions have the same traction in police operations or, indeed, the same political resonance. These assertions also assume that markers of race and ethnicity are obvious and unproblematic and in the process gloss over questions of categorization: why pick particular race categories, how should people be placed in or out of those categories, and what operational and social implications attach to these choices? In addition, unlike *Guess Who?*, phenotype prediction does not, on its own, result in a single felon but creates a group of suspects.

Operationalizing genetic ancestry or phenotype data into usable racialized descriptions of a suspect is a multi-phase, multi-site process in which the collection and laboratory analysis of DNA is only one element. To make predictions about suspects’ race and/or ethnicity involves series on translations between genetics, data and visual description and requires a chain of related but distinct steps:

1. The construction and use of racialized reference populations;
2. The ascription of racial appearance and/or ancestry to as yet unidentified suspects through comparison to those reference populations;
3. The communication of these scientific results beyond the laboratory;
4. Their translation into terms that make sense in policing practice;
5. Via (1) (2) (3) and (4) the delineation of racialized suspect descriptions that might reasonably generate suspect populations and which could be a precursor to identifying individual suspects;
6. The communication of suspect descriptions to those on whom investigators may want to draw for further data or assistance, notably various publics or media.

Even at steps (1), (2) and (3) there are significant questions about the reliability of race prediction. The basic genetic science of skin pigmentation and face shape is far from resolved (see for example Crawford et al 2017). Statements about race appearance or ancestry rely on comparison to reference databases whose coverage, composition and organisation is limited and uneven. Similarly the interpretation of results of biogeographical testing is complicated, not least by their tendency to reveal mixed heritage. In genealogy where these forms of testing are well established, the results of tests are imaginatively and selectively interpreted in ways that do sit well with forensic science (Nelson 2016; Tyler 2017). Step (3) adds another level of ambiguity as techniques generate probabilities rather than certainties: police, prosecutors and forensic scientists need new statistical skills to assess test results properly. The potential here for confirmation bias is considerable, reinforced by misunderstandings of the implications of results which may be presented as 95% accurate but (because of differences in prevalence of minority groups within a wider population) may deliver little more than a 50/50 guess about a suspect’s race or ethnicity (Staubach et al 2017).

As the discussion of potential errors of statistical interpretation suggests, the epistemic stabilization of phenotyping is far from complete (Wienroth 2018). Moreover if we reflect on Steps (4), (5) and (6), we can see how hard it is to separate issues about the reliability of predictions from their validity. To create and act upon racialized suspect populations requires translations between different contexts – the laboratory, the police station, the media report, and the local community – and between below the surface and above the surface notions of similarities and differences. The value of results in an investigation also depends

on the dubious assumption that ancestry or phenotype will always be unambiguously evident in a racially distinct face (M’charek 2016). The local variability and complexity of folk understanding of appearance (which are both embodied and cultural) potentially undermine the utility of ‘objective’ phenotype predictions. In any case appearance can never be understood as a simple manifestation of genetics but also reflects biography and environment and is subject to continual modification.

The practical task of operationalising race and ethnicity in relation to phenotyping might, therefore, seem insurmountable. Yet, in the light of previous experiences in policing, in genomics, and in the NDNAD example discussed in the previous section, we might reasonably assume that racial appearance will be made to function as a boundary object between scientific, criminal justice and public domains. For all its contradictions, phenotype retains its pre-eminence as a common sense marker of racial and ethnic differences (Saldanha 2006). The likely tendency will be to resort, in both forensics and day to day policing, to a small array of classifications rooted in shared notions of supposedly obvious differences and problematic minorities (M’charek 2013).

Given the centrality of how people appear and how people see to these new forensic and investigatory techniques it is important to reflect on how this visual field of racial difference is ordered (Browne 2015). In this there is what Les Back terms an “oracular grammar” inscribed onto bodies (Back 2007). Looking different is associated with often unspoken but powerful assumptions about being different: “somatic norms” mean that some people’s faces do not fit and their bodies seem out of place (Puwar 2004). As ground breaking discussions of the ethics of phenotyping rightly argued, given the significance already attached to face and skin tone as a marker of difference, new techniques may potentially reinforce existing patterns of race disadvantage in policing anther elements of the criminal justice system (see for example M’charek et al 2012). These patterns are firmly entrenched; for example, a recent independent review for the UK government has highlighted the treatment of, and outcomes for Black, Asian and Minority Ethnic (BAME) people in the criminal justice system.

Those who are charged, tried and punished are still disproportionately likely to come from minority communities. Despite making up just 14% of the population, BAME men and women make up 25% of prisoners, while over 40% of young people in custody are from BAME backgrounds. (Lammy 2017:3)

This review is the latest of a long series of reports and studies highlighting the persistence of disadvantage and disproportionality despite considerable attempts at reform. The accumulation of evidence (much of it generated from government sponsored ethnic monitoring) prompts recurring debate: to what extent are inequalities a reflection of minority criminality or of police racism?

To progress beyond this unhelpful polarisation and to appreciate better the impact of phenotyping it is important to reflect in more detail on how judgements based on appearance may contribute to racial disadvantage. Because it involves levels of discretionary judgements (that may or may not be based on appearance), a useful reference point is research about race, racism and the use of stop and search powers by the police. In the UK official monitoring data suggests that BAME people are four to five times as likely to be stopped and searched by the police as white people (ECHR 2016). Evidence of this disproportionality was one of the key indicators used to justify the conclusion of the Macpherson Report that the UK police were institutionally racist. Since the publication of the report in 1999 the figures on stop and search have, despite intense scrutiny of police practice, sustained the same pattern (Shiner and Dersol 2015). To understand the complexity, intractability of this issue and the controversies it generates, reviewing the extensive research literature, Robert Reiner argues for importance of disaggregating the various interconnected processes often bundled together under the headline term ‘racial discrimination’ (2010). He suggests a six point typology to understand this: alongside direct differential **categorical discrimination**, there is also group stereotyping based on previous professional experience (what Reiner terms **statistical discrimination**), **transmitted discrimination** whereby police act on the prejudices of the public, **interactional discrimination** that emerges from uneasy encounters between police and members of minorities, **situational discrimination** that means that because of socio-economic or lifestyle factors minorities are more likely to come to the attention of the police, and the **institutional discrimination** of biased policies and practices.

Reiner’s typology is useful firstly because it invites us to think more clearly about how, when and why the established visual common sense of race is significant in policing. Interactional, situational and institutional processes may reflect a wider history and structure of disadvantage but have little to do with day to day police judgements about who looks suspicious. Categorical, statistical and transmitted discrimination all, on the other hand, depend on racialized notions of appearance but only the first type confirms the caricature of the bigoted cop. These distinctions thus also allow analysis of another feature of this debate, the unwillingness of many police officers to accept, despite robust evidence to the contrary, that there is any racial bias in stop and search (Shiner 2010). They also suggest that racialization and its associated injustices cannot be reduced to pathological prejudice. This is once again confirmed by existing empirical work research on police use of their powers. Paul Quinton’s (2015) detailed English ethnography of decision-making around stop and search post-Macpherson found relatively little evidence of direct discrimination. The officers Quinton interviewed were concerned that he found them professional, thoughtful and fair in their dealings with minorities. Quinton argues that much disproportionality arose out of an over-reliance on suspect descriptions and an assumption that colour was likely to be a particularly reliable element of those descriptions.

By relying on race more than other aspects of a suspect description, officers were liable to stop and search people unnecessarily and exacerbate disparities. (Quinton 2015: 70)

Phenotyping and the Convergence of New Policing Technologies

As qualitative research on stop and search decision-making suggests, the use of race as a means of accessing and communicating suspect appearance is compelling but politically charged. The credibility attached to race and ethnicity as a means of anchoring and ordering descriptions encourages the over-policing of ‘visible’ minorities and makes it difficult to move effectively from ascription of group membership to the isolation of an individual suspect. This is a manifestation of the resilience of historic patterns of race thinking and race inequality. We should also appreciate, however, the ways in which other innovations in policing, that similarly relate to both datafication and visualization, converge with forensic genetics and, in combination, are likely to alter the meaning of and increase the value of racialized descriptions.

Returning to the example of English police officers studied by Paul Quinton, one contributing factor to their reliance on racialized descriptors is the convention of routinely recording ‘ethnic appearance’ using a standard set of codes (the Police National Computer Codes also used in the NDNAD) when taking, making and reporting witness statements. The role of technology and associated systems of codification is significant here; they help to establish race, along with age and gender, as a key factor of qualification or elimination as to whether a person “answers” a suspect description. This points to trends that are likely to become exaggerated as policing becomes more computing-dependent: race becomes a conventional and convenient means of labelling and organizing data which consequentially allows subjects to be attached to each other in ways that routinely reinforce existing social divisions.

Considerable attention is currently being devoted to the adoption and debate of new policing technologies which use data mining and algorithmic decision making to predict crime and target resources at people and places (Sanders and Shreptycki 2017). Beyond their lauded efficiency, these systems are attractive to police services precisely because their apparent rationality and neutrality allows services to side-step accusations of victimization of minorities and their communities (Ferguson 2017). Beneath their dispassionate veneer, however, critics suggest that systems and their hidden algorithms operationalise racial profiling (Ajana 2013; Amoore 2013; Jones 2014). Important though these innovations may prove to be, they should not distract from another associated (and currently more advanced) trend: the ways in which policing is increasingly reliant on the computer-mediated collection, searching, and verification of digitized images of people and their faces.

In recent years there has been a rapid expansion of the quantity and variety of digital images and the capacities of technologies that capture and manage those images. This is driven by both the development of surveillance technologies including public and private use CCTV, the availability of local recording devices such as body cameras and smart phones, and the wider emphasis on visual images in digital culture. The UK Police National Database contains over 19 million facial images and in the USA the FBI database contains over 30 million facial images. Local police forces also manage large numbers of facial records (UK Biometrics Commissioner 2017). Facial recognition technology and data management software (such as FILM - the Forensic Image Linking and Management system used by London’s Metropolitan Police) seek to improve and speed visual identifications. Although these innovations are often portrayed as means of automating decision-making, they rather rely on or facilitate identification by human observers by, for example, producing a pool of suspects or offering new ways of accessing and ordering large numbers of images. The continuing significance of this non-machine dimension is reflected in attempts to regularize the human component. In the UK a new science of visual identification seeks the development of systematic methods to conduct, justify and teach the techniques of matching images to identities and promotes the concept of Super Recognizers, experts who possess extraordinary abilities to spot, remember and name faces (Evison 2015).

Given the centrality of the description of human appearance and its digital capture and analysis not just in phenotype prediction but in this array of new policing technologies and techniques, the conditions are right for the visual epistemology of race to be reinvigorated. A common feature of these socio-technologies is that they function alongside, depend on, and generate discretionary activity (Matzer 2016). Operators who must evaluate risks, persons, activities highlighted by systems have an emotional, ambivalent, and, sometimes, fearful response to supposedly rational information (Smith 2015; Leese 2016). In their search for who looks suspicious or out of place they are likely to rely on what Les Back describes as a racist affective structure, “a kind of rigged collective nervous system which is the result of a particular kind of education of the senses” (Back 2011: 314). Similar dynamics are at play in new data gathering systems that seek to gauge neighbourhood ‘sentiment’ and encourage the crowd sourcing of the concerns of members of the public: these facilitate new expressions of what Reiner terms transmitted discrimination in policing (Lowe et al 2017). As this suggests, cultural assumptions, unspoken feelings and deep-seated prejudices meet in these supposedly objective, scientific ways of dealing with digitized bodies and faces (Browne 2015).

In the future phenotyping may be directly integrated into this wider array of digital and visual policing technologies: one possibility is the eventual linkage of genetically derived mugshots with facial image databases for example (Ferguson 2017). For the moment it would be better to understand phenotyping as part of an emerging regime in which the emphasis on the body and in particular the face as an investigatory resource encourages “racialized ways of seeing” (Beutin 2017). In this regime lies a paradox, shared between phenotyping and other new policing technologies: the preoccupation with making racialized descriptions goes hand in hand with concerns about their effectiveness. There is a substantial literature in Cognitive Psychology and in Socio-Legal Studies on the lower reliability of ‘cross-race’ or ‘other-race’ witness identifications and descriptions. This has been replicated in attempts to scientize and automate identification; many facial capture technologies and facial recognition algorithms appear to engage better with white subjects than with members of other groups (Phillips et al 2011; Magnet 2011). Thus once again race is both obviously accessible in the face and, at the same time, hard to capture.

Conclusion

As the opening pages suggested, phenotyping is an emerging innovation whose mass implementation will have been prefaced by considerable anticipatory governance. The legal, epistemic and operational discussions involved display an awareness that race prediction is a particularly thorny issue. Given the magnitude of the issues discussed in this paper, however, it is hard to see how they will be adequately addressed using the standard repertoire of bioethics. Phenotyping may, for example, be tempered by measures to ensure that race descriptions are used in ways that are culturally sensitive and respect people’s right to self-identify their ethnicity. The extent to which such niceties and restrictions challenge the underlying logic or consequences of systems is open to question. As the NDNAD case shows, this kind of ethical and diversity work often legitimates systems rather than questioning their fundamentals. Moreover, given structural inequalities, supposedly generic issues and practices around consent, privacy, and monitoring are likely to be understood quite differently by people depending on their backgrounds and prior experiences of racism and policing.

The potentials of race prediction cannot be fully grasped if science is ring-fenced as a separate domain whose ethics and professional standards are considered separately from the social and political contexts into which forensics is applied. In phenotyping ‘race’ is useful precisely because it travels between different expert, governmental, legal, and everyday domains. The capacity of race - either openly expressed or coded at once removed in a terminology of ethnicity, region or nationality - to act as means of translation between technical processes and pragmatic, common sense descriptions means it is likely to be foregrounded as a finding of EVC or ancestry analysis. Attempts to critique racialization in phenotyping on ontological grounds, as bad science or biological determinism, miss the ways in which the contemporary race object can encompass corporeal, digital and discursive elements. This object is stabilized and exploited through varied genetic, informational and visual technologies: differences ascribed to bodies are made readable and classifiable in specific socio-political settings, through technical and governmental practices.

The promise of phenotype prediction rests on its capacity to move back and forth between the individual (personal identity) and the collective (population or group membership). The ethical and political debates that have accompanied its development have similar variability of scale, expressed in terms, for example, of personal privacy on the one hand and the obligations of citizenship on the other. This transitioning from moments of collectivization to moments of individualization cannot, however, be understood in universal, generic terms. Racialized description has a particular solidity and significance as a means of matching people to groups but, in both the failings of technologies and the realities of policing, the journey from group classification to the identification of individuals is particularly hard. Creating racialized suspect populations thus potentially generates a double disadvantage by directing suspicion towards members of minorities and by inviting further group stigmatization by association. As such it conforms to a historical pattern whereby criminality is seen as collective failure of minority communities but an individual failing of white people (Muhammad 2011). The troubling characteristic of phenotype prediction is that it likely once again to heighten the visibility of race in ways that mask the individual humanity of the people who are its subjects.

References

Aldhous, P. (2014) You dunnit: reconstructing faces from DNA evidence.

Ajana, B. (2013) *Governing Through Biometrics: The Biopolitics of Identity*, London: Palgrave Macmillan.

Back, L. (2007) *The Art of Listening*, Oxford: Berg.

Back, L. (2011) Trust your senses? War, memory, and the racist nervous system. *The Senses and Society* 6 (3). pp.306-324.

Beutin, L.P. (2017) Racialization as a way of seeing: the limits of counter-surveillance and Police reform, *Surveillance and Society*, 15(1), pp.5-20.

Browne, S. (2009) Digital epidermalization: Race, identity and biometrics, *Critical Sociology*, 36(1), pp.131-150.

Browne, S. (2015) *Dark Matters: On the Surveillance of Blackness*, Duke: Duke University Press.

Chow-White, P. A. (2008) The informationalization of race: communication technologies and the human genome in the digital age. *International Journal of Communication* 2: 1168-1194.

Chow-White, P.A. and Duster, T. (2011) Do health and forensic DNA databases increase racial disparities? *PLoS Medicine*, 8(10).

Chow-White, P. A and Green, S.E. (2013) Data mining in the age of Big Data: Communication and the social shaping of genome technologies from 1998 to 2007." *International Journal of Communication* 7: 556-583.

Chun, W.H.K (2009) Introduction: race and/as technology; or, how to do things to race, *Camera Obscura* 24 (1): 7-35.

Claes, P., Liberton, D. K., Daniels, K., Rosana, K. M., Quillen, E. E., Pearson, L. N., ... & Tang, H. (2014). Modeling 3D facial shape from DNA. *PLoS genetics*, 10(3), e1004224.

Duster, T. (2004) Selective arrests, an ever-expanding DNA forensic database, and the specter of an early-twenty-first-century equivalent of phrenology in *DNA and the Criminal Justice System*, edited by D. Lazer, 315-335. London: The MIT Press.

ECHR (2016), *Healing a Divided Britain: the Need for a Comprehensive Race Equality Strategy* Equality and Human Rights Commission Report

Evison, M.P. (2015) The Third Forensics – images and allusions, *Policing and Society*, 25(5), pp.521-539.

Ferguson, A.G. (2017) *The Rise of Big Data Policing: Surveillance, Race, and the Future of Law Enforcement*, New York: New York University Press.

Foster, J. Newburn, T. and Souhami, A. (2005) *Assessing the impact of the Stephen Lawrence Inquiry* Home Office Research, Development and Statistics Directorate.

Fox, D. (2010) The second generation of racial profiling. *Am. J. Crim. L*., 38, 49

Goldberg, D.T. (2015) *Are We Post-Racial Yet?* Polity.

Hedgecoe, A. (2009) Bioethics and the reinforcement of socio-technical expectations *Social Studies of Science* 40(2), pp.163–186.

Hoeyer, K.L. and Tutton, R. (2005) “Ethics was here”: Studying the language-games of ethics in the case of UK Biobank *Critical Public Health*, 15(4), pp.385–397.

Jones, C. (2014). Predictive Policing: Mapping the future of policing, *Open Democracy*.

Kahn, J. (2008) Race, genes, and justice: a call to reform the presentation of forensic DNA evidence in criminal trials. Brooklyn Law Review, 74(2), 325.

Kahn, J. (2013) *Race in a Bottle: The Story of BiDil and Racialized Medicine in a Post-Genomic Age* New York: Columbia University Press

Kayser, M. (2015) Forensic DNA Phenotyping: predicting human appearance from crime scene material for investigative purposes. *Forensic Science International: Genetics*, 18, pp.33-48.

Kayser, M., & Schneider, P. M. (2009). DNA-based prediction of human externally visible characteristics in forensics: motivations, scientific challenges, and ethical considerations. *Forensic Science International: Genetics*, 3(3), 154-161

Koops, B.-J. and Schellekens, M.(2008) Forensic DNA Phenotyping: regulatory issues. *Science and Technology Law Review*, 9, pp.158-202.

Lippert, C. et al (2017) Identification of individuals by trait prediction using whole-genome sequencing data. *Proceedings of the National Academy of Sciences*, 114 (38) 10166-10171.

Lammy, D. (2017) *Lammy Review: Final Report* https://www.gov.uk/government/publications/lammy-review-final-report

Leese, M (2016) ‘Seeing Futures’: Politics of visuality and afffect, in: Amoore, L., Piotukh, V. (eds.), Algorithmic Life: Calculative Devices in the Age of Big Data. Routledge, Milton Park/New York, pp. 148–164.

Lipphardt, V., Lipphardt A., Buchanan, N., Surdu, M., Toom, V., Wienroth, M., Mupepele, A.C., Cedric Bradbury, C., Lemke, T. (2016) Open Letter on critical approaches to Forensic DNA Phenotyping (FDP) and Bio-Geographical Ancestry (BGA), published online 08 Dec 2016

Lowe, A L., Urquhart, A., Foreman, L.A., and Evett, I.W. (2001) ‘Inferring Ethnic Origin by Means of an STR Profile’, *Forensic Science International* 119 pp.17-22.

Lowe, M.R., Stroud, A. and Nguyen, A. (2017) Who Looks Suspicious? Racialized Surveillance in a Predominantly White Neighborhood. *Social Currents*, 4(1), pp.34-50.

Mʼcharek, A. (2008) Silent witness, articulate collective: DNA evidence and the inference of visible traits. *Bioethics*, 22(9), pp.519-528.

M'charek, A., Toom, V., and Prainsack, B. (2012) Bracketing off populations does not advance ethical reflection on EVCs: a reply to Kayser and Schneider. *Forensic Science International: Genetics*, 6(1), e16-e17.

Mʼcharek, A. (2013) Beyond fact or fiction: On the materiality of race in practice. *Cultural Anthropology*, 28(3), pp.420-442.

M’charek, A., Schramm, K. and Skinner, D. (2014) Topologies of race: Doing territory, population and identity in Europe, *Science, Technology & Human Values*, *39*(4), pp.468-487.

Mackenzie, A. and Vurdabrakis, T. (2011) Codes and coding in crisis: Signification, performativity and excess, *Theory, Culture & Society*, 28(6), pp.3-23.

McCartney, C. (2006) The DNA expansion programme and criminal investigation. *British Journal of Criminology* 46 (2): 175-92.

Magnet, S. A. (2011) *When Biometrics Fail: Gender, Race, and the Technology of Identity,* Durham: Duke University Press.

Matzner, T. (2016) The model gap: cognitive systems in security applications and their ethical implications. *AI & Society* 31, pp.95–102.

Meer, N. (2014) *Key Concepts in Race and Ethnicity*, London: Sage.

Muhammad, K. G. (2011). *The Condemnation of Blackness*, Harvard University Press.

Nakamura, L. (2008) *Digitizing Race: Visual Cultures of the Internet*, Minneapolis: University of Minnesota Press.

Nelson, A. (2016). *The social life of DNA: Race, reparations, and reconciliation after the genome*. Beacon Press.

Phillips, C. (2015) Forensic genetic analysis of bio-geographical ancestry, *Forensic Science International: Genetics*, 18, pp.49–65.

Phillips, P. J., Jiang, F., Narvekar, A., Ayyad, J., and O’Toole, A. J. (2011) An other-race effect for face recognition algorithms. *ACM Trans. Appl. Percept.* 8, 2, Article 14

Pickersgill, M. (2012) The co-production of science, ethics, and emotion. *Science, Technology, & Human Values*, 37(6), pp.579-603.

Puwar, N. (2004) *Space Invaders: Race, Gender and Bodies out of Place*. Berg.

Quinton, P. (2015) ‘Race Disproportionality and Officer Decision-Making’ in R. Delsol and M. Shiner (Eds.), *Stop and Search: The Anatomy of a Police Power*, Palgrave, pp.57-78.

Reardon, S. (2017) Geneticists pan paper that claims to predict a person's face from their DNA, *Nature* 12th September

Regalado, A. (2017) Does your genome predict your face? Not quite yet, *MIT Technology Review* 7th September

Reiner, R. (2010) *The Politics of the Police* Oxford: Oxford University Press.

Roberts, D. (2011) Collateral consequences, genetic surveillance, and the new biopolitics of race, *Howard Law Journal*, 54, pp.567-586.

Rowe, M. (2012) *Race & Crime* London: Sage.

Saldanha, A. (2006) Reontologising race: The machinic geography of phenotype. *Environment and Planning D: Society and Space*, 24(1), pp.9-24.

Sanders C.B. and Sheptycki J. (2017) Policing, crime and ‘big data’; towards a critique of the moral economy of stochastic governance, Crime Law Soc Change 68: pp.1–15.

Senker, P. (2010) ‘Forensic DNA Phenotyping: Reinforcing Race in Law Enforcement’, in I. Whitmarsh and ‎ D.S. Jones (eds) *What's the Use of Race?* MIT Press, pp.49-62.

Shiner, M. (2010) Post-Lawrence policing in England and Wales: Guilt, innocence and the defence of organizational ego. The British Journal of Criminology, 50(5), pp.935-953.

Shiner, M. and Delsol, R. (2015) ‘The Politics of the Powers’ in R. Delsol and M. Shiner (Eds.), *Stop and Search: The Anatomy of a Police Power*, Palgrave, pp.31-56.

Smith, G. (2015) Opening the Black Box: the Work of Watching Abingdon, Oxon, Routledge.

Song, M. (2014) Challenging a culture of racial equivalence. *British Journal of Sociology*, 65(1), pp.107-129.

Staubach et at al (2017) letter *Nature* 545, 30 4th May

Toom, V., Wienroth, M., M’charek, A., Prainsack, B., Williams, R., Duster, T., Heinemann, T., Kruse, C., Machado, H., Murphy, E., (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, pp.e1–e4.

Tutton, R., Hauskeller, C. and Sturdy, S. (2014) Suspect technologies: Forensic testing of asylum seekers at the UK border, *Ethnic and Racial Studies* 37(5), pp.738-752.

Vailly, J. (2017) The politics of suspects' geo-genetic origin in France: The conditions, expression, and effects of problematisation, *BioSocieties*, 12(1), pp.66-88.

Washington, H.A. (2010) ‘Base assumptions? Racial aspects of US DNA forensics’ in Hindmarsh R and Prainsack B (eds) *Genetic Suspects: Global governance of Forensic DNA Profiling and Databasing*. Cambridge: Cambridge University Press. pp. 131-152.

Wienroth, M. (2018) Governing anticipatory technology practices. Forensic DNA phenotyping and the forensic genetics community in Europe, New Genetics and Society, 37(2) pp.137-152.

Wienroth, M., Morling, N., & Williams, R. (2014). Technological innovations in forensic genetics: social, legal and ethical aspects, *Recent Advances in DNA & Gene Sequences*, 8(2), pp.98-103.

Williams R (2010) ‘DNA Databases and the Forensic Imaginary’ in Hindmarsh R and Prainsack B (eds) Genetic Suspects: Global governance of Forensic DNA Profiling and Databasing. Cambridge: Cambridge University Press. pp. 131-152.

Williams, R. and Wienroth, M. (2014) *Ethical, Social and Policy Aspects of Forensic Genetics: A Systematic Review*