CCTV and the super-recognisers

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1. Context: CCTV management and suspect identification in the 21st century

CCTV is "an utter fiasco" and "not fit for purpose," were 2008 headlines quoting the head of the London Metropolitan Police Service's (MPS) CCTV management unit (Bowcott, 2008). At least £4-5 billion of public and private funds (Norris, McCahill, & Wood, 2004) had been invested in 4.1-5.9 million cameras in the UK (British Security Industry Association, ND). With 90% public approval rates (Gill et al., 2003), CCTV was marketed as a crime deterrent (McCahill & Norris, 2003), although research revealed only minor crime reduction effects (e.g. see Gill et al., 2005 for a review), and simply displaced some to nearby locations (e.g. Ditton & Short, 1998). Criminals viewed systems as unmonitored and no threat to their activities (Gill & Loveday, 2003). This was partly rational, as although London is one of the most surveilled cities in the world, the MPS revealed only 3% of crimes were solved by CCTV, one per 1,000 cameras per annum (BBC News, 2009).

The massive investment had been directed at bespoke CCTV equipment employing technologically diverse standards. Far less was spent on staff, and the police struggled with footage collection, forensic processing, 'best' image selection, and distribution for officer, public, and court viewing (Bowcott, 2008). Indeed, the MPS shooting of the innocent Brazilian Jean Charles de Menezes in 2005, mistaken for a terrorist, was partly due to distribution of poor-quality CCTV images to surveillance teams (Davis & Valentine, 2015; H.M. Coroner, 2009). Between the negative headlines, the MPS announced plans to professionalise CCTV management. This included the creation of a *Caught on Camera* website to display London's wanted suspect images.

Empirical experiments reveal robust familiar face recognition of even poor-quality photos (e.g. Bruce, Henderson, Newman, & Burton, 2001; Burton, Wilson, Cowan, & Bruce, 1999), suggesting that making images available to those most likely to recognise them should

enhance suspect identification rates (hereafter 'idents'). However, most suspects are unknown to most police, and even in optimum conditions, unfamiliar face identification is often unreliable (e.g. Bruce, Henderson, Greenwood, Hancock, Burton, & Miller, 1999, Burton et al., 1999, Davis & Valentine, 2009; for a review see Davis & Valentine, 2015). In terms of individual differences in face recognition, prior to 2009, research had focussed on those at the low end who struggle to recognise photos of family members, due to brain damage (acquired prosopagnosia) (e.g. Rossion, Caldara, Seghier, et al., 2003), genetics (Wilmer, Germine, Chabris, et al. 2010), or from birth and with no known trauma (developmental prosopagnosia) (Duchaine, Germine, & Nakayama, 2007). Overall, the generally negative appraisals of unfamiliar face identification from visual images suggested that even if police CCTV management systems were improved, increased ident rates might not be guaranteed.

At the same time as the MPS planned these changes, US research by Russell, Duchaine, and Nakayama (2009) was gaining traction. This described four participants self-reporting exceptional face recognition ability, and who provided anecdotes such as: -

> *"It doesn't matter how many years pass, if I've seen your face before I will be able to recall it. It happens only with faces,"*
>
> or
>
> *"I've learned to stop surprising people with bizarre comments like, 'Hey, weren't you at that so-and-so concert last fall. . . . I recognize you.' Before that, I'd occasionally make people uncomfortable"*
>
> (p. 253).

After scoring near maximum on empirical tests of face recognition ability, the authors labelled them 'super-recognisers'. Once *Caught on Camera* was established, the MPS also realised that despite a workforce of 48,000, a substantial proportion of idents were being made by a very small cohort of about 25 police (Davis, Lander, & Jansari, 2013), some of

whom completed empirical face recognition tests administered by my team in April 2011. These tests found that some police performed at the level of Russell et al.'s (2009) super-recognisers (Davis, Lander, Evans, & Jansari, 2016). Supported by additional case evidence, many of their idents, even of briefly encountered suspects not seen for years, led to convictions. Descriptions were also redolent of Russell et al.'s (2009) super-recognisers' anecdotes: -

> *"One spotted and arrested a robber walking along a busy high street, 18 months after last viewing him in a poor-quality video of an armed robbery. Another arrested a suspect eight months after viewing an E-FIT facial composite. A third recognised a distinctive scar, last seen 10 years previously"*
>
> (Davis et al., 2013, p. 727).

Our unfunded research programme that started in April 2011 (Davis et al., 2013; 2016) was however interrupted by the August 2011 London Riots, which resulted in five deaths and £300 million damage. Police ($n \approx 100$) we most wanted to test identified multiple often disguised rioters from over 200,000 hours of mainly poor-quality, night-time captured, above-head height CCTV footage (Guardian, 2011). Twenty of the police empirically tested during our April 2011 sessions described above identified 600 rioters. One identified 190 (Manzoor, 2016). In total, approximately 4,000 rioters were identified from visual images by humans, a stark contrast to the single rioter identified by a computer face recognition system.

As the riots investigation closed in 2013, the MPS announced plans to create a suspect image database to exploit future technological advances, and a system for distributing new suspect images to those most likely to identify them. By now, also labelled super-recognisers by the MPS, police in each London borough would be given time to view some of the MPS's approximately 500 new suspect images per week, particularly those matching their specialist

local or crime-type knowledge. For this, a hunt for more super-recognisers was announced. As will be described, this led to a substantial increase in ident rates, positive media scrutiny, and public engagement in research following the establishment of a full-time specialist MPS Super-Recogniser Unit. Other worldwide police forces and businesses followed.

2. Underpinning Research: Identification from CCTV and other visual images

For decades, research has demonstrated the malleability of human memory (i.e. from delay, interference, stress) while eyewitness identification errors may be the leading cause of wrongful convictions (e.g., Garrett, 2011; Munsterberg, 1908). Indeed, misidentifications contributed to almost three-quarters of the first 360 US DNA exoneration cases (Innocence Project, ND). Despite positive reforms to procedures, about 25% of witnesses identify innocent foils from UK and US police line-ups, a clear demonstration of memory fallibility (Behrman & Richards, 2005; Horry, Memon, Wright, & Milne, 2012; for a review see Clark, Moreland, & Rush, 2015). Empirical research reflects concerns (for an edited volume see Valentine & Davis, 2015). Valentine, Davis, Memon, and Roberts (2012: Experiment 3) demonstrated that 35.9% of participants misidentified an 'innocent suspect' present in person in a showup procedure as someone seen arguing with a lecturer 15 minutes previously. Most (85%) repeated their identification when viewing the same person in video line-ups between a day and a month later. Errors were also high (54.4%) when the correct target was presented in a showup.

The investment in CCTV was seen as a panacea. With no time pressures or stress, police could directly compare footage with suspect photos. Policy-makers reasoned that in London with blanket coverage, a trawl of CCTV from crime scene localities should generate good-quality identifiable images. Nevertheless, most of the extant research showed that

whereas familiar face recognition from poor-quality images is normally reliable; identification of unfamiliar faces is error prone (e.g. Davis & Valentine, 2015). With high-quality close-up images, and no memory demands, simultaneous face matching designs reveal high rates of false positive (mistakenly believing two images of two different people are of the same person), and false negative errors (believing two images of the same person are of different people) (e.g., Burton, White, & McNeil, 2010; Henderson, Bruce, & Burton, 2001). Even with targets present in person errors are high (Kemp, Towell, & Pike, 2007). In an experiment at London's Science Museum, Davis and Valentine (2009: Experiment 2) found 44% of visitors failed to correctly match a good-quality CCTV video with the same actor standing by the monitor screen. Error rates (33%) were almost as high when a different actor was depicted in the video. Subsequent research has revealed that as a group, highly experienced passport officers who make multiple daily face matching decisions, perform no better than those with no experience (e.g. White, Kemp, Jenkins, Matheson, & Burton, 2014), although there is substantial within-group variability.

Forensic facial comparison techniques used by expert witnesses to attribute identity in crime scene images and undisputed images of defendants were also subjected to negative scrutiny (Davis, Valentine, & Davis, 2010, Moreton & Morley, 2011; for reviews see Davis, Valentine, & Wilkinson, 2012; Edmond, Davis, & Valentine, 2015), perhaps not surprisingly as different experts using virtually identical techniques have offered opposing opinions of identity in court (e.g. *R v Clarke*, 1995). The research literature was therefore justifiably negative in its assessment of the reliability of unfamiliar face identification from CCTV, as such errors in police investigations might lead to innocent individuals being suspected of crimes. However, almost all relevant research had ignored within-group variability (Young & Burton, 2019), perhaps treating high-scoring outliers as anomalies.

As described above, in the first super-recogniser research, Russell et al. (2009) tested four participants self-reporting exceptional abilities. They employed the *Cambridge Face Memory Test*: *Extended*, a standardised short-term six-person face learning and recognition test, since employed in most subsequent super-recogniser research; a *Before They Were Famous Test*, in which participants identify photos of celebrities when young; and the *Cambridge Face Perception Test*, a test with no memory demands. The authors described the super-recognisers' performances as "about as good at face recognition and perception as developmental prosopagnosics are bad" (p. 252). Later research (Bobak et al., 2018; Russell, Chatterjee, & Nakayama; 2012; Tardif et al., 2018) suggested that rather than possessing qualitatively different cognitive or neurological mechanisms, super-recognisers and developmental prosopagnosics inhabit opposite ends of a quantitative population-wide spectrum of face recognition ability (although see Belanova, Davis, & Thompson, 2018; Bobak, Bennetts, Parris, Jansari, & Bate, 2016; Bobak, Parris, Gregory, Bennetts, & Bate, 2017; Russell et al., 2009, for evidence of super-recogniser use of qualitatively different face processing strategies). Based on statistical conventions, in which scores more than 2 standard deviations outside the mean are designated outliers, this suggests prevalence of super-recognisers and developmental prosopagnosics at about 2% in the population (see Kennerknecht, Ho, & Wong, 2008). This standard has been a somewhat arbitrary minimum threshold in most subsequent research. Intriguingly, when my research team started testing police in 2011, this suggested prevalence of 480-960 super-recognisers in the MPS alone (1-2% of 30,000 officers and 18,000 civilian staff).

To be eligible for the first MPS super-recogniser research in 2011, police had made at least 15 idents within 12-months. For this, my team employed tests designed to match possible drivers of success (Davis et al., 2016). First, to replicate poor-quality CCTV idents of suspects not seen for years, a *Famous Face Recognition Test* (Lander, Bruce, & Hill,

2001) required recognition of 30 12-year-old degraded celebrity images whose subsequent media profile had varied. Ten further trials depicted non-celebrities. Second, in an *Unfamiliar Face Recognition Array Test* (adapted from Bruce et al., 1999), participants viewed 40 male faces, each immediately followed by a ten-person target-present or target-absent array. Participants selected a face or rejected the array. Third, in an *Unfamiliar Face Recognition Test (old/new)*, participants sequentially viewed 10 male and 10 female photos, their clothing and background information. In a 40-face test phase, with no warnings, only internal facial features were displayed. Participants responded 'old' (20 faces) or 'new' (20 faces). Fourth, in the *Glasgow Face Matching Test* (Burton et al., 2010), participants viewed 40 pairs of unfamiliar faces and decided whether each was 'matched' (20) or 'mismatched' (20).

Most police (n = 36) and participants, who at a London Science Museum event had attained Russell et al.'s (2009) super-recognition criteria on the *Cambridge Face Memory Test: Extended* (n = 10), individually outperformed age-, gender-, and ethnicity-matched controls (n = 143), some significantly. Effects were found with correct identifications (hits), and correct rejections (CRs) of non-targets. There were no between super-recogniser and police group differences. There was, however, large within-police and -super-recogniser group score variability, although some low performances were easily explained (i.e. brief face learning times, unexpected context changes, unfamiliarity with celebrities, police fatigue after night shifts). Importantly, many of the lowest performing police claimed that their 15 idents had been of highly familiar suspects, with often the same suspect identified more than once, a task not requiring exceptional ability. If these police had been excluded from analyses, effect sizes would have been larger.

Supporting models suggesting face processing is driven by face-specific neural pathways (Gobbini & Haxby, 2007; Haxby, Hoffman, & Gobbini, 2000), no reliable between-group differences were found in an additional object (flowers) recognition test (see

also Bobak, Bennetts et al., 2016). Importantly, a few super-recognisers and police producing outstanding face memory scores were relatively poor at simultaneous face matching (see also Davis, Bretfelean, Belanova & Thompson, under review; Bobak, Bennetts, et al., 2016; Bobak, Dowsett, & Bate, 2016). Assuming experimenter error, we asked one super-recogniser (based on face memory tests) from the Science Museum sample to retake the *Glasgow Face Matching Test*. His second score, below the control mean, was worse. These findings, since replicated, suggest albeit on a continuum, possible super-recogniser 'sub-types'. Those exceptional at face memory *and* matching, indeed many police and super-recognisers scored 100% on the *Glasgow Face Matching Test*. Others possess superior face memory only. Later research has also found evidence for 'super-matchers,' working in specialist forensic facial comparison roles whose skills may not transfer to memory tasks (e.g. White, Dunn, Schmid, Kemp, 2015). These findings are analogous to research with prosopagnosics who sometimes display perceptual and memorial task dissociations, suggesting heterogeneous neurological and cognitive mechanisms (Bate, Haslam, Jansari, & Hodgson, 2009; De Haan, Young, & Newcombe, 1987, 1991). For policing deployment, it was clear that super-recognisers should possess superior unfamiliar face memory *and* matching ability.

Parts of the MPS data described above were presented at a wind-down conference at New Scotland Yard for *Operation Withern* – the London Riots investigation (Security News Desk, 2013). As the data provided evidence that many (but not all) police who were making large numbers of idents possessed exceptional abilities, henceforth they were described by the MPS as super-recognisers. At the same event, the MPS announced methods to capitalise on their skills, and a search for others so far not identified. Critically in terms of research impact and legacy, in December 2013, a battery of pilot multi-ethnic face recognition and matching tests was uploaded to the MPS intranet. This was for an unpublished undergraduate

project supervised by me (Maigut, 2014). The aim had primarily been to examine whether the MPS and other IT systems would offer a suitable platform for the tests, rather than to provide an accurate measure of ability. We were pleasantly surprised when nearly 1,500 police voluntarily started the test battery, with many leaving contact details to be invited to contribute to future research. This was fortuitous. In August 2014, we were asked by senior MPS management for a list of the highest test scorers (after gaining participant consent) as they wished to deploy these officers in operations that might draw on their skills. A few were eventually seconded to the MET's *New Scotland Yard Proactive Super-Recognition Unit* (see below).

My BSc student's pilot tests had been uploaded to the MPS system once a successful bid for approximately €8,500,000 European Commission research funds had been announced (LArge Scale Information Exploitation of Forensic Data (LASIE), 2014). The LASIE project started in May 2014, when the MPS and the University of Greenwich joined an 18-partner consortium from 10 countries. LASIE aimed to improve police digital evidence use, with a focus on CCTV footage search. My team's role was to develop super-recognition tests, and to promote the concept. For this, we assembled a database of photos and videos of over 500 volunteers from multiple ethnicities. Details of a *Spotting the Face in a Crowd Test* (Davis, Treml, Forrest, & Jansari, 2018; Durova, Dimou, Litos, Daras, & Davis, 2017), and a *Long-Term Face Memory Test* (Bretfelean & Davis, 2017; Davis, Bretfelean et al., under review) have been disseminated (for a brief description of testing procedures see Davis, 2019).

The *Spotting the Face in a Crowd Test* (Davis et al., 2018) was designed to match CCTV review operations involving vigilance, concentration and attention to detail, skills unlikely to be possessed by all super-recognisers given this skills' face-specific characteristics. Video clips depicted actors walking through busy London tourist attractions. Participants had to spot the actors, identify clips empty of targets, but avoid identifying

bystanders. Participants were police from the MPS super-recogniser unit (*n* = 7), controls (*n* = 152), and members of (*n* = 46), or applicants to (*n* = 46) the MPS super-recogniser pool of front-line officers regularly viewing unidentified suspect images. In the previous 30 months, unit (*n* = 7) and established pool members (*n* = 46) had made a total of 3,740 idents; one had made 481. Overall, effect sizes were small, partly a consequence of low target-actor numbers and associated statistical power. However, the test was primarily designed to exclude police unsuitable for CCTV review roles. As expected, some police achieving *Cambridge Face Memory Test: Extended* super-recogniser range scores (Russell et al., 2009) performed relatively poorly. Others were exceptional on both tests. The MPS Super-Recogniser Unit team outperformed other groups, by making more correct target identifications, mainly with higher confidence; and fewer false alarms of bystanders, mainly with lower confidence, demonstrating good confidence-accuracy calibration - useful in real operations. Controls engaging in pre-test actor-photo familiarisation exercises made fewer false alarms than untrained controls, a method my team have used in subsequent training courses for superior face recognisers. The test was adapted for online remote testing by Greek collaborators, the Centre of Research and Technology, Hellas (CERTH) (Durova et al., 2017), and revised for subsequent consultancy projects.

The *Long-Term Face Memory Test* (Bretfelean & Davis, 2017; Davis et al., under review) was piloted in different experiments. With between-phase delays varying from 1- to 56 days, we demonstrated that whereas many super-recognisers (as assessed by two short-term memory tests) achieved good long-term performances, a substantial minority scored poorly (see also Davis & Tamonytė, 2017 for similar results with disguised faces).

The main LASIE project conclusions was that a four-component test battery was required to identify super-recognisers with a range of skills for policing etc. (Davis, 2019).

a. Short-term face memory;

b. Simultaneous face matching;

c. Long-term face memory;

d. Spotting faces in a crowd.

Faces of different ethnicities offset cross-ethnicity-effect influence (e.g. Meissner & Brigham, 2001). To reduce deductions or guessing, proportions of matched/old and mismatched/new trials are also varied. To optimise performances, testing is protracted to reduce fatigue, and because anyone can 'have a bad day at the office,' anomalously poor single-test performances are excluded, if the remaining profile suggests exceptionally good ability. Some organisations have deployed existing staff to new super-recogniser roles. Other research has generated new jobs in the UK and internationally, with more planned. As such, the programme has generated social impact in terms of crime detection, but also economic impact in the UK and internationally – a major assessment driver for the UK Government's Research Excellence Framework (2021).

Our super-recognition research is ongoing. Employing electroencephalography (EEG), Belanova, Davis, and Thompson (2018) revealed between super-recogniser and control group brain activity differences; super-recognisers' superiority at adult *and* infant face recognition; and that super-recognisers' cross-age effect (the difference between scores on adult and infant face recognition tests) is slightly larger. One super-recogniser who worked with infants displayed higher infant than adult face recognition scores, an opposite pattern to all other participants. This finding might have applications for child victim identification, as a super-recogniser with extensive child contact might be best placed to make decisions about child identity. This proposal has not been fully explored. However, as part of the MPS project, 48 police seconded to the National Crime Agency's *Child Exploitation and Online Protection Command* completed the tests described above in 2016/2017, although all test images were of adults.

Further academic research with colleagues on the analogous cross-ethnicity effect (Robertson, Black, Gilmour, Chamberlain, Megreya, & Davis, under review), and the ability of super-recognisers to recognise personality traits in 'selfies' (Satchell, Davis, Julle-Danière, Tupper, & Marshman, 2019); is under review or recently published. Research is also examining the relationship between parent and child recognition ability (Forrest, Monks, Vargo, van Zalk & Davis, in preparation); memorial, attentional, and physiological factors involved in spotting faces in a crowd (Petrov, Donald, Donald, & Davis, in preparation), and one of my PhD students, Ryan Jenkins is investigating the relationship between face and voice recognition ability (e.g. Jenkins & Davis, 2018).

3. The Transition from Research to Application

Unlike most research, in which attempts to transition to application may struggle to influence organisations that might most benefit, our super-recogniser research was driven by *prior* MPS high ident rates. Our first research mainly aimed to explain successes (Davis et al., 2013; 2016). Subsequent research was designed to assist police develop and promote new procedures to replicate successes – firstly within the MPS, and later the wider UK and international community. This required the usual dissemination activities (publications, conference presentations), as well as many worldwide media appearances, exhibits in museums (n = 3), and even providing advice to fiction writers, including one short-listed for a Waterstones Children's Book Prize (2019), Tracy Darnton's (2018), *The Truth about Lies*, which contained a URL link to take one of our super-recogniser tests.

Table 1: List of dissemination activities and academic impact involving Dr Josh P Davis, his collaborators or supervised students (see www.superrecognisers.com for more details).

	Presentations and Meetings [1]		TV/Radio Interviews		Other Media (newspapers, online)		Authored Articles	Citations [2]
	UK	International	UK	International	UK	International		
2019 [3]	1	5	-	-	-	-	7	-
2018	18	3	5	14	5	25	3	86

2017	14	13	4	1	3	4	3	60
2016	15	8	4	5	13	9	2	66
2015	7	8	8	2	7	6	8	80
2014	11	3	1	0	4	2	1	33
2013	7	0	2	2	2	5	2	27
2012	8	2	2	1	1	0	3	32
2011	2	1	0	0	1	0	0	15
2010	4	0	0	0	0	0	3	NA

[1] Peer-reviewed and keynote conference presentations, seminars, workshops, research consultancy dissemination meetings
[2] Google Scholar: https://scholar.google.co.uk/citations?user=Yev5EfIAAAAJ&hl=en
[3] First six months to 30 June 2019

Table 1 depicts a summary of my dissemination activities. Super-recognition was not always the primary focus. Some related more to policing or eyewitness identification. Most of all, however, because of substantial media interest, my research team answer a constant stream of e-mails, often followed by phone calls, video conferences or meetings, from members of the public, worldwide police or other organisations wishing to understand the super-recogniser phenomenon and to determine whether it might help their operations. I have rarely actively marketed services. However, most organisations have not followed quotes up. Resources not only need to be put aside for the identification of super-recognisers; career development planning is required, meaning human resources departments take an interest. Often, systematic operational changes are necessary to ensure super-recognisers' skills are effectively engaged. Many organisations simply do not have the resources.

With the MPS, I initially attended internal briefings and strategy meetings with senior management (up to Deputy Commissioner level), to advice on restructuring visual image management systems. Indeed, our testing of the first police super-recognisers just before the 2011 London Riots occurred at the same time as the MPS was centralising structures anyway. This was not a coincidence. Improvements in the distribution of suspect images, particularly on *Caught on Camera* led to idents. Initially, only the inner London boroughs with greater surveillance camera cover contributed. Additional super-recogniser testing ran parallel with outer borough realignments. County forces were encouraged to engage, and I gave presentations initially to national, and then later international forces at New Scotland Yard.

Nevertheless, the MPS is one of the largest police employers in the western world. It possesses resources shared by few others, and smaller forces require different structures.

Organisational change inevitably faces resistance. Most research consultants reading this chapter will have encountered communication difficulties within the institutions in which they engage, and the super-recogniser programme was no different. To start with there was very little published empirical evidence, and none funded until 2014. Nonetheless, the work was first picked up by the media after the London Riots (Grimston, 2011), probably because of the title 'super-recogniser' and the implied 'super-powers'. This was a blessing and a curse. For the criminal justice system, there are troubling, potentially prejudicial issues associated with the label, particularly if a police super-recogniser announced their status in cross-examination in court – something I always advice against. No police super-recogniser has ever scored 100% on all face recognition tests meaning there is always 'reasonable doubt' (e.g. Bate et al., 2019; Davis et al., 2016; 2018; Durova et al., 2017; Robertson, Noyes, Dowsett, Jenkins, & Burton, 2016), and although this applies to any witness, no ident should ever be accepted without question (see Davis et al., 2016; 2018). Encouragingly, the MPS shared data of known super-recogniser ident errors with the media (e.g. O'Keefe, 2016), demonstrating their acknowledgment of the risks associated with uncritically accepting ident evidence. Compared to the proportion of idents leading to criminal charges (73%), errors were far less common (13%), and they were mostly addressed during initial case review or investigation. The lack of a criminal charge in the remaining 14% of cases does not imply errors. Cases may be discontinued for many reasons, and idents may be of witnesses not involved in a crime.

Forensic and legal connotations: Later, the MPS embedded visual image management under the auspices of its forensic science department. This instituted a more cautious approach. This is not a surprise. Worldwide, forensic science has come under

scrutiny from policy-makers because of miscarriages of justice (e.g. see Innocence Project, ND), as well as scientific advances discrediting techniques once thought reliable (e.g. hair matching; Houck & Budowle, 2002). Experienced fingerprint experts were shown to be susceptible to cognitive biases, in that their decision-making could be altered from claiming a fingerprint match to a mismatch and vice-versa to the same set of fingerprints, by task-irrelevant information (e.g. Dror, Charlton, & Peron, 2006). Similar effects have been found in many forensic visual matching tasks (Kassin, Dror, & Kukucka, 2013). As forensic facial comparison methods used by expert witnesses in court were already being criticised (e.g. Moreton & Morley, 2011), it is not surprising that scepticism about super-recognisers remains high. Social and contextual information available in facial images might heighten cognitive bias risks (Edmund, Davis, & Valentine, 2015). Regardless of face processing ability and movement which can assist unfamiliar and familiar face identification (Davis et al., 2016), a single video frame only provides limited individuating information, and I have consistently noted that risks of super-recogniser error should be acknowledged (Davis, 2019).

Legal researchers have discussed best practice police deployment of super-recognisers (e.g. Evison, 2014; Edmond & Wortley, 2016). Inter-disciplinary workshops for legal experts, police, forensic scientists, criminologists and psychologists have debated how super-recognisers' evidence should be defined in law [1]. For instance, if an ident is based on prior familiarity with a suspect, a witness may be called to provide identification evidence in court in the manner of one present at the scene of the crime (Attorney General's Reference, No.2 of 2002, 2003). Cross-examination can test the nature of the familiarity and/or whether image quality supports recognition. However, MPS super-recognisers made idents of unknown suspects, matched across images of different crimes. Some argued that these idents might best be classified as a form of expert opinion evidence, and in which case, different legal procedures and standards apply. However, an expert presenting evidence in court can be

cross-examined on their professional credentials, training, and experience; and why these are relevant to each case. MPS super-recognisers had mainly been selected after achieving high face recognition test scores and received no specialist training. This created a legal anomaly, as effectively their idents were based on claims that because of their heightened skills they could see (in)consistencies in two facial images that others might not see.

In the same vein, the UK Forensic Science Regulator (Tully, 2018) argued that although super-recognisers may assist investigations, their workplace practices could not be considered forensic science as: -

> "a) The work is generally carried out within an operational policing unit, with no separation to ensure independence and impartiality;
>
> b) Photographs of known suspects or offenders are studied *prior to* watching the footage containing unknown individuals, without implementing safeguards against cognitive bias; and
>
> c) Although there is scientific literature to support the fact that some people have a greater propensity to match faces, the 'super recogniser' process of attempting to match faces from photographs against CCTV footage is not based on scientifically validated methodology, nor are error rates known."
>
> Tully (2018, p.20)

Societal and technological challenges: My team's super-recogniser research programme was developing at the same time as austerity-driven cuts to policing and crime prevention in the UK, as well as increasing computerised face recognition system use worldwide (Big Brother Watch, 2018; BBC, 2017; Department of Home Security, 2018). Some local authorities reduced CCTV budgets or proposed discontinuation, while police numbers were cut by 20,000 between 2010 and 2018 (Full Fact, 2018). Plans by other UK forces to create super-recogniser teams were cancelled. Some super-recognisers had already

been identified using our test procedures. The requirement to restructure systems and super-recognisers' ambiguous legal status perhaps made these programmes an easy target for policymakers to abandon. Therefore, all my recent public sector research consultancy projects have been with organisations outside the UK, where funding appears less of an issue.

Computerised systems: Mass installation of CCTV cameras was perceived to be the panacea to the problems associated with the reliability of eyewitness identifications, and algorithms are now perceived to be the panacea for the problems associated with human camera monitoring and suspect identification. Algorithms work best at places like passport control, or for one-to-one identity verification with full-face still images taken in perfect lighting with compliant targets (see www.Yoti.com). The annual worldwide market for computerised systems is expected to be over $2 billion in 2019 (Biometric Technology Today, 2015), partly driven by mass CCTV surveillance culture in countries more intrusive than even the UK. China has an estimated 170 million CCTV cameras, many fitted with artificial intelligence (BBC News, 2017). Media articles covering algorithms have almost all been negative and often evoke the spirit of George Orwell's 1984 (Big Brother Watch, 2018; Dodd, 2018). Freedom of information requests have revealed high false alarm rates of 95% in UK police pilots, when systems have been used to monitor large sporting or music events. The faces of many innocent people are stored on police databases. These criticism might be slightly unfair as these were pilot tests, mainly designed to evaluate the upper and lower limits of performance. Nevertheless, super-recognisers are often contrasted in the media as epitomising old-fashioned 'Dixon of Dock Green' policing values, when officers were expected to know all the local characters.

Unlike humans, algorithms never sleep, and commercial system accuracy at matching faces against very large databases is improving (National Institute of Science and Technology (NIST), ND). However, humans may still outperform algorithms with unconstrained images

(O'Toole & Phillips, 2015). Algorithms can also provide a rapid, effective search engine for identifying individuals depicted in multiple CCTV feeds. This is accomplished by pattern recognition from clothing or paraphernalia and estimates of movement between cameras covering different geographical locations with gaps in the field of view (e.g. LASIE, 2014).

The fundamental issue will always remain, in the west at least, that legally, a human being is always likely to be required to make final identity decisions. And this is a possible avenue for future policing and homeland security super-recogniser employment. Algorithms work by generating an array of potential matches from databases. A human must decide which is most likely to be the target. Recent NIST (Phillips et al., 2018) assessments comparing the most accurate commercial algorithms with super-recognisers revealed no differences. However, the fusion of decisions from both sources provided the most accurate results. This joint approach may offset the high false alarm rates described above.

In summary, despite the generally negative tone of some of this section, I do believe that super-recognisers can be highly beneficial to policing and security. They may enhance operations such as surveillance, and crowd monitoring, but most of all, in conjunction with effective CCTV image distribution systems, they may provide the first vital clue towards solving a crime. A super-recogniser ident can then be followed up by the investigating team to secure additional incriminating evidence.

4. The impact and legacy of the Greenwich super-recogniser research programme

The impact and legacy of the super-recogniser research programme which started in 2011, had its origins in my research on human recognition (i.e. voices: Wilding, Scott, & Davis, 2000), eyewitness identification (e.g. Valentine et al., 2012), facial composites (e.g. Davis, Gibson, & Solomon, 2014), and police investigative procedures (e.g. Davis, Valentine,

Memon, & Roberts, 2015). My PhD, "*the Forensic Identification of Unfamiliar Faces in CCTV Images*" at Goldsmiths, University of London (2007) supervised by Tim Valentine, was partly inspired by psychologists Vicki Bruce (e.g. Bruce et al. 1999), Mike Burton (e.g. Burton et al., 2001), Graham Davies (Davies & Thasen, 2000), and Richard Kemp (Kemp, Towell, & Pike, 1997) who had first demonstrated the unreliability of unfamiliar face matching decisions. Most of my data (n = 3,000+) was collected at London's Science Museum (e.g. Davis & Valentine, 2009).

MPS impact: Police and security have for decades deployed 'spotters' at events such as football matches to surveil crowds and to identify trouble-makers (College of Policing, ND). Some were probably super-recognisers. These factors are hard to capture in formal assessments of research impact such as my Research Excellence Framework (REF) Case Impact Study (e.g. Davis, 2014; see also Johnson & Fletcher, 2015). Therefore, although we could describe the relationship between our research results, and the high London 2011 rioter ident rates by super-recognisers, this cannot be claimed as cause and effect. The first *planned* legacy occurred with the uploading of the pilot tests to the MPS's intranet system in 2013 by my student, with high scorer's subsequently deployed to high profile operations. These operations established a model to capitalise on super-recognisers' skills.

Alice Gross (August 2014): The MPS super-recogniser's first deployment was to assist with a west London murder investigation. This operation started after the teenager was reported missing by her family, and the MPS had collected up to 500,000 hours of CCTV footage. The super-recognisers constructed a timeline of events leading to her death and her murderer's suicide. This required excluding very large numbers of innocent bystanders. The case was solved by the team realising that the unknown murderer and victim appeared in geographically and temporally separated clips at roughly the same time. This match would probably not have been made by a non-super-recogniser.

Hillsborough Inquest (September 2014): Other super-recognisers assisted with the second Hillsborough Stadium Disaster Inquest that had already commenced in March 2014 into the deaths of 96 people at the 1989 FA Cup semi-final between Liverpool and Nottingham Forrest. A 1991 inquest had returned an accidental death majority verdict, generating political pressure to overturn this decision. The longest-running jury case in British legal history delivered a final verdict of unlawful death on 26 April 2016 (Conn, 2017). Assisting Greater Manchester Police, the lead force on *Operation Resolve*, the super-recogniser team searched TV and CCTV footage to build individual victim timelines. Again, this required matching targets across gaps in the field of view, while discounting thousands of other football fans.

1970 River Thames Drowning (January 2015): The current author (Davis, Maigut, & Forrest, under review) assisted in an MPS River Police investigation. For this, a photo of a drowned man recovered from the River Thames in 1970 was displayed alongside a photo line-up. One line-up photo was of a man who went missing at about the same time. The others were foils selected from a larger short-list of 1970's images. Police (n = 164) provided confidence ratings to each line-up member as to whether they matched the deceased man's photo. Using the *Wisdom of the Crowd* procedure (e.g., Surowiecki, 2004; White, Burton, Kemp, & Jenkins, 2013), the amalgamated confidence ratings of police with superior face matching ability were highest to the missing man's image in comparison to the foils. This added support to proposals that the deceased man and missing man were one and the same person, evidence accepted by the coroner for issuing a death certificate.

MPS Super-recognisers were also deployed to pop concerts to identify pick-pockets, reducing mobile phone theft rates (Davenport, 2015); and to the Notting Hill Carnival where they familiarised themselves to suspect photos in advance, to later spot them in crowds of up

to one million (Venkataramanan, 2015). At a January 2015 super-recogniser event at New Scotland Yard, 72 police made 150 idents from 3,000 images (Davenport, 2015).

These successes led the MPS to create the world's first *Proactive Super-Recognition Unit* at New Scotland Yard, mainly made up of my undergraduate student's project highest test scorers (Maigut, 2014). Very high ident rates were soon recorded. The unit 'snapped' (as in the card game) unknown suspects depicted in new and previously unconnected cold case images stored on a very large database. This sometimes created a 'domino effect', whereby criminal associates were identified. Some suspects had never been arrested before. Before the unit's establishment most cases would probably never have been linked or investigated, particularly when crimes occurred in different London boroughs.

Austin Caballero (January, 2016): This thief was snapped in 40 different cold case crime scene images captured between 30 April 2013 and 22 December 2015 (Rice, 2016). Admitting guilt, he received a two-and-a-half-year prison sentence for theft of goods worth over £100,000 (A. Robertson, 2016).

Ilhan Karatepe (June, 2016): This man was filmed on three bus cameras committing serial child sexual assaults. He was coincidently spotted across a rush-hour crowd by an MPS super-recogniser (O'Keefe, 2016). Prior to taking our tests and joining the Unit, this officer had never made an ident, or possessed any insight into her superior skills.

Many other lower profile cases were solved within months by the Unit (e.g. Michael Prabucki: 39 crimes, ITV Report, 2016; gang murder: Manzoor, 2016). These earliest cases were possibly the most brazen, and probably because of this, the easiest to solve. The first *published* empirical research on the Super-Recognition Unit independently confirmed the superior simultaneous face matching abilities of four members (Robertson, Noyes, Dowsett, Jenkins, & Burton, 2016), and 18 months after its establishment, the Unit had made 2,250 idents, one quarter of the MPS total (Manzoor, 2016). Although not the most reliable measure

of 'ground truth of guilt,' most suspects (≈ 70%) confessed in police interview when confronted by CCTV images.

These outcomes generated substantial publicity with super-recognisers winning 'Cop of the Year' awards (e.g. Hickey, 2016); and not only in London (i.e. West Midlands Police: BBC, 2018). They were praised by the Mayor of London, Sadiq Khan when announcing a new anti-knife crime initiative (Mayor's Office for Policing and Crime, 2017). In 2018, they identified two alleged Russian Novichok-poisoning spies from 5,000 hours of CCTV images from Salisbury and London Gatwick Airport (Brunt, 2018). All took many of our tests.

Public impact: The impact and legacy in terms of the public awareness of my team's research has also been publicised in most countries worldwide. This started when a BBC Future online article describing the MPS Super-Recogniser Unit, together with our research was linked to a fun online test (*Could you be a Super-Recogniser?*) (Venkataramanan, 2015). Within a month over one million participants had taken this test, later made available in different languages. The flow of participants continues, with spikes whenever a media article on super-recognition is published. Participants from 99% of countries have contributed (including $n > 26$ on Antarctic bases). In December 2018, numbers hit six million (Davis, 2019). Many contributed to follow-up projects ($n > 100{,}000$), or left contact details ($n > 40{,}000$) to be invited to future research. This will hopefully result in a substantial legacy of high-impact journal articles.

Wider policing impact: Between 2015 and 2017, my team also generated research consultancy contracts with three UK police forces, and one UK security agency. Updated four-component tests replicating those used with the MPS were employed in a two-phase process (Davis, 2019). For the first online phase, the entire workforce of an organisation was encouraged to complete eight face matching and recognition tests taking about 90 minutes. The highest scorers completed the second longer phase in examination conditions.

Since 2017, additional consultancy projects have been conducted for security and police forces in two European countries, one Asian country, and Australia. Most requested no publicity. In contrast, the Polizeipräsidium München (Munich Police Department) super-recogniser programme was launched by the police president and me at a press conference. This was attended by at least five TV companies and over 20 other media organisations. More than 5,000 out of the 7,100 workforce had started the testing process, and over 35 were identified as scoring above the super-recogniser threshold (Crossland, 2018). Within a month, more than 100,000 members of the public had contributed to the German language version of the *Could you be a Super-Recogniser Test*, a direct link from news items to public interest in psychology. Four months after initial training at Oktoberfest, Munich Police announced that their MPS-modelled Super-Recogniser Unit had solved its first 200 crimes, a success given the sparse CCTV cover compared to London (Sueddeutsche Zeitung, 24 January 2019; see also Abendzeitung, 18 March 2019). Media reports can only be considered anecdotal, and not empirical evidence, although they provide a pointer to test battery validity.

Economic impact: My research team have also worked with one retail organisation to identify loss prevention officers with superior face recognition abilities. In terms of economic legacy however, research consultancy contracts have been arranged with two businesses including Yoti (www.yoti.com), an identity verification company. Over 50 full-time jobs in the UK and India have been created. This was partly because of the high media impact. Research participants who score in the super-recogniser range are provided with otherwise withheld information about potential jobs. Those interested take further recruitment tests, of the type described above for police.

Academic impact: Finally, it would be imprudent of any academic to suggest that their own research might have inspired empirical investigations by others. However, it is likely that the impact on police policy and practice has generated the growing body of inspirational

research into the super-recognition phenomenon. Some of the most influential case study research was conducted by Anna Bobak and Sarah Bate (e.g. Bobak, Bennetts et al., 2016; Bobak, Dowsett et al., 2016; Bobak et al., 2017), providing an insight into the cognitive mechanisms driving super-recognisers' superiority. This research would have been the focus of an alternative type of chapter, and indeed, it has inspired our police test battery design.

Other research has been more critical, suggesting that the claims of super-recognisers' superiority may have been overstated (Ramon, Bobak, & White, 2018). Others have criticised the use of specific tests, and published details of alternatives (e.g. Bate et al., 2018). As was highlighted in a recent edition of the *British Journal of Psychology* (e.g. Ramon, Bobak, & White, 2019), one of the problems is that there is no widely agreed super-recogniser definition or minimum inclusion criteria. Indeed, it is not clear whether task-specific recruitment tests should be employed (see Noyes, Hill, & O'Toole, 2018), rather than the more generalised approach we currently use (Davis, 2019). Some authors propose a moratorium on super-recogniser testing for legally critical roles until a consensus is agreed (Ramon et al., 2019). However, academic research progresses at a pedestrian pace, and predictably generates conflicting findings. I share some, but not all concerns, but have a pragmatic attitude. Criminals will not wait, and organisations need super-recognisers today.

To counter this anticipated 'backlash', my team have always set an exceptionally high standard before describing someone as a super-recogniser for any job (Davis, 2019). Well under 1% of the population would achieve the standard. This is far higher than in any published super-recogniser research paper, and because of the inexactness of any cognitive test, inevitably means some genuine super-recognisers will have been excluded. On the other hand, some organisations have been so satisfied with the calibre of their super-recogniser staff, they have extended consultancy contracts (several times) in order to recruit more.

5. Lessons Learnt

The impact and legacy of any research programme will continue to unfold for years or even decades. Traditionally for academics, impact has been valued in terms of publications in high quality journals, citations, grants, awards, and titles. However, with the Government embedding case impact studies in the Research Excellence Framework (REF) (2014), and weighting this factor higher in 2021, the perceived worth of an academic has changed. Status is increasingly linked to entrepreneurship and delivering benefit to wider society. This includes economic benefits, as well as to the benefits to the direct consumers – university students. I had a pre-university business background. This shift was relatively comfortable, even if not expected when starting a PhD in 2002. Not all colleagues are equally sanguine.

Writing this chapter has provided a perfect outlet for reflection. Perhaps the strongest lesson I can impart, was that when my super-recogniser research started in 2011, there was no sense that it could provide a fruitful research career. For a few years, precious time was spent on applying for grants in parallel or different fields which I now partly regret. An immediate emphasis on super-recognition might have been more worthwhile. Indeed, my 2014 REF Impact statement (Davis, 2014), "*Enhancing Suspect Identification Rates from Facial Composites and CCTV*", mainly focussed on facial composite research. This is an ongoing research avenue, as with commercial partners, VisionMetric Ltd who market the system EFIT, we were awarded a grant of £370,000 by Innovate UK in 2019 (Solomon, Gibson, & Davis, 2019). In the meantime, other researchers delivered high-quality super-recogniser publications (e.g. Bobak et al., 2016).

Therefore, the first recommendation to researchers working in a new niche area, that might generate impact, is to direct full focus immediately, and collaborate with other academics. The weakest part of my CV is the relatively small number of internationally rated

peer-reviewed publications (www.super-recognisers.com). Suitable research is done. However, I have had no time to write it up, despite, like many academics, often working 70-hour plus weeks and sometimes sustaining this through vacations. I have also applied for very large- and small-scale super-recognition research grants to link the recruitment tests we use to workplace practices. Despite good reviews, none were successful, although cross-European applications with multiple police force partners were perhaps not helped by the political climate of Brexit. Funding bodies also tend to argue that organisations benefiting from research should fund it themselves. Unfortunately, austerity in UK policing put paid to this. Even our very first MPS research in 2011 was unfunded.

As such, attempting collaborative projects with UK police forces meant that energies were directed for a long time at what appears to be a dead end. International police often possess more resources. If they are to thrive in the 21st century, pooling of UK police force resources is vital. Governments have previously attempted to merge forces, and if these steps fail, it is inevitable that private enterprises employing super-recognisers will fill the gap by being attached to UK police forces as and when their skills are required.

The second lesson learned from funding application failures in times of austerity, was the necessity to apply business experiences into developing a sustainable model of research consultancy despite the competing requirements of an academic (lectures, supervision, ever-growing administration, pastoral care etc.). Most of my projects have been short-term and hiring research fellows with PhDs who would need training each time would have been cost-prohibitive and time consuming. I do not personally financially benefit from any consultancy work in order to avoid conflicts of interest. And indeed, I have never bought out any teaching time, the usual solution for academics with research budgets. Instead, funds have mainly paid part-time undergraduate research assistants, on regularly updated contracts. Most of the day-to-day consultancy work, such as communications with clients; collaborations with other

universities; updating and piloting new tests; managing of volunteers who conduct face-to-face participant testing; and training of replacement staff; all provide very rare opportunities for my exceptionally high-calibre student staff to develop their research skills. This is probably the biggest *hidden* impact of my research, as many progressed to careers/further academic programmes at high status universities/businesses unavailable to most graduates. There are far too many to mention by name, but I must acknowledge their contribution.

A further lesson to other researchers developing their own careers in super-recognition would be to employ a full battery of diverse tests. This is important for practical and theoretical perspectives. No test will perfectly predict how anyone will transfer their skills to real work in different environments. Indeed, it should also be acknowledged that the use of 'face' in this chapter may sometimes refer to identity in general. Although the face is the most important identification cue (Burton, Wilson, Cowan, & Bruce, 1999), body shape and size (Noyes, Hill, & O'Toole, 2018), gait (Yovel & O'Toole**,** 2016), and idiosyncratic facial movement (Davis et al., 2016) facilitate recognition. These may be more important with poor-quality images. Face recognition tests are often designed to standardise conditions, and to reduce floor and ceiling effects. They allow only brief learning times for familiarisation to facial stimuli; and in test phases they often require a series of rapid identification decisions without opportunity to review and reflect on choices. In contrast, a series of careful checks and balances are included within police identification protocols, that bear little relationship with standardised tests (see for instance, Police and Criminal Evidence Act (1984), Codes of Practice (Code D) for proscribed police identification procedures in England and Wales).

Although many people working within the criminal justice system have a natural aversion to the term 'super-recogniser', these individuals do possess skills that are not shared with most of the population. For the police, the most uncontroversial use of their abilities is in

the early stages of an investigation, as they might generate that first clue that can be followed up by others. However, outside policing and security, there are many opportunities for super-recognisers in which the recognition of infrequently encountered people might enhance job efficiency (e.g. casino operations, marketing, hospitality, identity verification, public relations, media, and even politics). I have provided keynote addresses at many professional conferences for these groups, and I hope these avenues will generate future opportunities.

Finally, this edited volume is partly concerned with how universities support staff who will likely produce research impact case studies for REF2021, as well as the REF to follow. Currently, my own institution, the University of Greenwich supports research, teaching, and enterprise research career pathways. However, to maintain league table position and to retain high calibre staff, specific funds might be needed to be directed towards impact. Of course, this would be politically sensitive in institutions with strong equal opportunities philosophies. I have been fortunate, and I am grateful that my employer has supported my activities. However, I sometimes feel I have had far more hidden failures (research funding bids rejected, consultancy project quotes rejected, limited peer-reviewed publications) than the publicised successes (see Table 1). On the other hand, I have been lucky to make XXX research visits to xx countries in xx continents since REF2014. A lot of work goes on behind the scenes.

To round up, I must thank the many hundreds of genuine super-recognisers and millions of controls who have contributed to my research. Some may have inherited their skills (e.g. Shakeshaft & Plomin, 2015), which appear to eb driven by an underlying face-specific processing mechanism (McCaffery, Robertson, Young, & Burton, 2018; Verhallen, Bosten, Goodbourn, Lawrance-Owen, Bargary, & Mollon, 2017). However, they are still affected by the cross-age (Belanova et al., 2018) and cross-ethnicity effects (Robertson et al., under review) suggesting experiential influence. It is unlikely to be a trainable skill. Ramon et

al. (2016) demonstrated that world record holder memory competition winners, so called 'super-memorisers' with expertise in mnemonic techniques performed within the average range on standardised face recognition tests. As such, super-recognisers may be the Usain Bolts of the cognitive world. It may be innate, but it may need to be fine-tuned throughout their lives. How they do this is still a mystery.

[1] Interdisciplinary workshops debating super-recognisers' legal status and evidence reliability

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