THE LEGAL AND SCIENTIFIC CHALLENGE OF BLACK BOX EXPERTISE

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Legal commentators widely agree that forensic examiners should articulate the reasons for their opinions. However, findings from cognitive science strongly suggest that people have little insight into the information they rely on to make decisions. And as individuals gain expertise, they rely more on cognitive shortcuts that are not directly accessible through introspection. That is to say, the expert's mind is a black box — both to the expert and to the trier of fact. This article focuses on black box expertise in the context of forensic examiners who interpret visual pattern evidence (eg fingerprints). The authors review black box expertise through the lens of cognitive scientific research. They then suggest that the black box nature of this expertise strains common law admissibility rules and trial safeguards.

I INTRODUCTION

> The child who tries to open a door has to manipulate the handle (the input) so as to produce the desired movement at the latch (the output); and he has to learn how to control the one by the other without being able to see the internal mechanism that links them. In our daily lives we are confronted at every turn with systems whose internal mechanisms are not fully open to inspection ...[1]

When forensic scientists provide evidence in court, they bear the significant responsibility of clearly and accurately explaining their opinion to an audience that cannot be expected to share their level of knowledge. One of the most important matters for forensic scientists who interpret visual pattern evidence (eg handwriting, hair, shoeprints, fingerprints, voiceprints, bullets, toolmarks, bitemarks, blood, and imagery of various kinds) is their cognitive process or how they 'think'. In the lab, scientists are encouraged to report the basis of their claims by showing and sharing their methods, raw data and the analytic code that reproduces their results.[2] Forensic scientists who deal with visual pattern

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1 W Ross Ashby, *An Introduction to Cybernetics: The Black Box* (Chapman & Hall, 1956) 117.

2 For a review of open research practices in science, see BA Spellman, EA Gilbert and KS Corker, 'Open Science: What, Why, and How' in J Wixted & E-J Wagenmakers (eds), *Stevens' Handbook of Experimental Psychology and Cognitive Neuroscience* (John Wiley, 4th ed, 2018) vol 5, 729. For a review

evidence in the courtroom, however, cannot show their work in this way because the 'analysis' occurs in their mind. The cognitive processes underpinning their judgments and decisions hum along in the background just outside of awareness.[3] In other words, forensic experts, in many cases, are *black box* thinking machines whose internal workings are not fully open to introspection.

In this article, we draw on findings from cognitive science to explore the extent to which forensic experts can articulate their reasoning about visual pattern evidence (Parts II–III). Then, in Part IV, we go on to discuss the orthodox ways in which courts regulate expert evidence, and how those mechanisms strain in the light of the opaque nature of black box experts. Finally, we conclude in Part V with a suggestion that black box expert witnesses perhaps provide some information about the cognitive science that underpins their decisions. In other words, they should acknowledge what they know and what they do not know about their thinking.

II The Expert and the Evidence

Recent controversies and miscarriages of justice involving forensic science have resulted in scrutiny from peak scientific and legal bodies in a number of jurisdictions.[4] At the core of concerns about the value of forensic science lies the

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of these practices in the context of expertise research, see Rachel A Searston, Matthew B Thompson, Samuel G Robson, Brooklyn J Corbett, Gianni Ribeiro, Gary Edmond and Jason M Tangen, 'Truth and transparency in expertise research' (2019) 2(4) *Journal of Expertise* (forthcoming).

3 While examiners might be consciously aware of *some* elements of their thinking (eg how their gaze seems to gravitate towards a particular area in a sample, how they line up and compare particular features, how confident they feel at different time points), these elements are just the tip of the iceberg. As we will discuss in Part III, much of our mental life is hidden from introspection, even in the case of more challenging and protracted decisions that are further from our experience. As an amuse-bouche, what number do you get when you multiply 3 x 4 in your head? For most people who are familiar with the problem the number '12' springs to mind without much thought. But the mental steps that triggered this automatic response disappear without a trace as soon as you think about them or try and draw your attention towards them. If you were encountering this problem for the first time, as a novice, these mental steps might be closer to the surface and more accessible to you as you struggle to solve it, but your memory for similar problems and other subtle situated cues that you might automatically rely on remain out of view. For a review of the interpretive nature of forensic expert decisions, see Jason Tangen, 'Identification Personified' (2013) 45(3) *Australian Journal of Forensic Sciences* 315, 322.

4 National Research Council, *Strengthening Forensic Science in the United States: A Path Forward* (National Academies Press, 2009) ('NAS Report'); Expert Working Group on Human Factors in Latent Print Analysis, *Latent Print Examination and Human Factors: Improving the Practice through a Systems Approach* (US Department of Commerce, National Institute of Standards and Technology, 2012) ('NIST Report'); Anthony Campbell, *The Fingerprint Inquiry Report* (December 2011) ('SFI

problem that humans are fallible, and many forms of forensic evidence rely principally on human interpretation of visual pattern evidence. Progress has been made in estimating the accuracy of examiners' judgments about evidence of this kind. But understanding how and when such judgments can go right (or awry) is complicated by the fact that they result from difficult-to-observe cognitive processes.

A 2016 report prepared by the United States President's Council of Advisors on Science and Technology ('PCAST') offers one of the most comprehensive reviews of human performance in forensic science to date.[5] A working group of leading scientists and legal scholars were assembled to review empirical evidence for the accuracy of several commonly used forms of visual pattern evidence, including bitemarks, fingerprints, firearms, footwear and hair. The authors of the report recognised the opacity of an examiner's thinking by referring to it as the 'black box in the examiner's head'. In response, they suggest that the 'foundational' scientific validity of forensic practices can only be established by measuring human performance across many examiners and many independent cases.[6] Further, they suggest that foundationally valid methods must then be validly applied to the instant case. This can be demonstrated by examiners showing they are '*capable* of reliably applying the method' and have '*actually* reliably applied the method'.[7] We understand 'the method' to include the examiner's thinking at the time of the examination in addition to any external workflows and frameworks they may have used.[8]

In the context of fingerprint evidence, these criteria require the examiner to report their individual proficiency test results, the features they marked on the prints, a written explanation of how they selected and compared those features in the prints, their awareness of other facts in the case that might influence the results, and a judgment about the sufficient 'quality' of the prints.[9] The trouble is

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Report'); President's Council of Advisors on Science and Technology, *Forensic Science in Criminal Proceedings: Ensuring Scientific Validity of Feature-Comparison Methods* (Executive Office of the President of the United States, 2016) ('PCAST Report'); William Thompson et al, *Forensic Science Assessments: A Quality and Gap Analysis — Latent Fingerprint Examination* (AAAS, Washington DC, 2017) 89–90 ('AAAS Report'). For a discussion on how these reports apply in an Australian context, see Gary Edmond and Kristy Matire, 'Antipodean Forensics: A Comment on ANZFSS's Response to PCAST' (2017) 50(2) *Australian Journal of Forensic Sciences* 140, 151.

5 PCAST Report (n 4).

6 Ibid 49. 'Foundational' scientific validity, as defined by the authors of the PCAST Report (n 4), is demonstrated by empirical evidence of repeatable, reproducible and accurate results.

7 Ibid 6.

8 As an external decision-making framework, the ACE-V procedure may take place as follows: by Analysing the questioned sample, Comparing it to a known sample, Evaluating them together, and repeating the procedure with one or more examiners to Verify the conclusion.

9 PCAST Report (n 4) 87–103.

that the 'features' marked on the crime-scene print during analysis may have limited bearing on the features *actually* used when comparing it to the candidate or suspect print (see Part III below). And the examiner's explanation of how they selected and compared the different visual features may bear little resemblance to how they *actually* arrived at a decision. Moreover, different experts can apply different cognitive strategies to the same cases at different times and still consistently arrive at a correct response. That is, experts' conclusions can be reliable, even when the 'method' is idiosyncratic.

By way of example, fingerprint examiners visually compare latent prints found at a crime scene with highly similar known prints found through a search of a national database.[10] This perceptual task is made more challenging by natural variation and distortion in how the same finger impresses on different surfaces at different times, with changing pressure, perspiration, positioning and movement. The expert examiner can resolve this superficial variation to detect prints from the same finger far more accurately than novices,[11] and with 89 per cent repeatability,[12] despite evidence of considerable variation in their judgments of value and marking of features in prints from one occasion to the next.[13] In any given case, at any given time, the expert may see the same set of features differently through the lens of their experience. But reliable feature marking does not appear to be necessary to achieve a high degree of accuracy in fingerprint comparison conclusions.

In reviewing validation efforts for several forms of visual pattern evidence, the PCAST Report emphasised their 'subjective' nature, where accuracy or (legal) reliability are bound by human judgment or the expert's interpretation of the evidence.[14] That is to say, the expert and the evidence in such cases are inextricably linked.[15] But the Report also defines expert opinion as the subjective application of a 'method' of examining the evidence. Confusingly, this definition implies an intermediary between the expert and the evidence that can be reliably

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10 Itiel Dror and Jennifer Mnookin, 'The Use of Technology in Human Expert Domains: Challenges and Risks arising from the Use of Automated Fingerprint Identification Systems in Forensic Science' (2010) 9(1) *Law, Probability and Risk* 47, 67.

11 Jason M Tangen, Matthew B Thompson and Duncan McCarthy, 'Identifying Fingerprint Expertise' (2011) 22 *Psychological Science* 995. For a brief overview of studies on this topic, see Alice Towler et al, 'Are Forensic Scientists Experts?' (2018) 7(2) *Journal of Applied Research in Memory & Cognition* 199, 208.

12 Bradford Ulery et al, 'Repeatability and Reproducibility of Decisions by Latent Fingerprint Examiners' (2012) 7(3) *PLoS ONE* 1, 12. The term 'repeatability' refers to the extent to which the same examiner consistently arrives at the same decision with the same case materials.

13 Itiel Dror et al, 'Cognitive Issues in Fingerprint Analysis: Inter- and Intra-expert Consistency and the Effect of a 'Target' Comparison' (2011) 208 *Forensic Science International* 10, 17.

14 PCAST Report (n 4) 46.

15 For an in-depth discussion on this point, see Tangen (n 3).

independent of the expert. On the contrary, the expert and the intermediating method are one and the same, as Simon Cole vividly captures with this analogy:

> There is no methodology without a practitioner, any more than there is an automobile without a driver and claiming to have an error rate without the practitioner is akin to calculating the crash rate of an automobile, provided it is not driven.[16]

We would add that the driver need not know how the engine runs to successfully navigate in traffic, any more than the forensic practitioner need know how their mind works to successfully interpret samples of evidence. And as we discuss in Part III, the most expert of examiners may not have special insight into how they interpret evidence because their cognitive processes (ie their method) proceed automatically in a black box.

There are other approaches to expert testimony thought to make an examiner's opinion evidence more transparent and thus easier to evaluate in the instant case. These include probabilistic approaches, for instance, where a statistical model estimates the likelihood of specific feature similarities in the case at hand.[17] This quantitative approach is routinely used to communicate the strength of DNA evidence, where the features are well-defined and predictable. Visual pattern evidence, by comparison, has proven more difficult to capture quantitatively.[18] As a result, it is currently left to the examiner adopting this approach to evaluate the probability of particular feature similarities in their minds. Proponents argue that expressing the human reasoning process as a likelihood ratio or verbal equivalent (eg correspondence between the writing on the wall at the crime scene and the writing of the accused is '64 times more likely' (numerical), or 'offers strong support' for the proposition they originated by the same author compared with different authors (verbal)) is more transparent.[19] Such an argument assumes that the examiner is intimately aware of how they weigh particular features to compute and express their probability. That is, this approach assumes experts have an accurate read out of their own thinking — an almost unbelievable feat of self-awareness, as we will now discuss.

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16 Simon Cole, 'More than Zero: Accounting for Error in Latent Fingerprint Identification' (2004–05) 95 *Journal of Criminal Law & Criminology* 985, 1039.

17 C Neumann, I W Evett and J Skerrett, 'Quantifying the Weight of Evidence from a Forensic Fingerprint Comparison: A New Paradigm' (2012) 175 *Journal of the Royal Statistical Society: Series A (Statistics in Society)* 371, 415.

18 AAAS Report (n 4) 23: 'Because the characteristics of fingerprints are unlikely to be statistically independent, it will be difficult to determine the frequency of any particular combinations of features. While research of this type is important, it is unlikely to yield quick answers.'

19 For an analysis of how different expressions of forensic opinion evidence are interpreted, see Kristy Martire et al, 'The Expression and Interpretation of Uncertain Forensic Science Evidence: Verbal Equivalence, Evidence Strength, and the Weak Evidence Effect' (2013) 37(3) *Law and Human Behavior* 197. For an introduction to probabilistic approaches to forensic expert testimony and a discussion of their use in promoting transparency, see William C Thompson et al, 'After Uniqueness: The Evolution of Forensic-Science Opinions' (2018) 102(1) *Judicature* 18, 27.

III Black Box Evidence

Computer scientists and engineers use the analogy of a black box to describe a machine whose input and output behaviour are known, but whose inner workings are otherwise opaque. As machines become more efficient at dealing with complex tasks, their operations are not only harder to see, they are also more difficult to interrogate or explain. A simple locking mechanism is a black box to the everyday user, but the mystery of its operation is relatively easy to unveil by inspecting its moving parts. On the other extreme, deep learning algorithms that are trained to guide self-driving cars, recognise faces, or detect disease in medical images comprise many hidden components or 'layers' that distribute visual information in a way that is exceedingly difficult to explain. [20] There are no visible moving parts to a silicon chip. And just as the inner workings of such algorithms are obscured by their own complexity and efficiency, so too are the mechanisms of the mind. [21]

The black box problem is particularly acute in the legal domain where one seeks an explanation for expert opinion (see Part IV below). Transparency as to how the expert produced a conclusion in a given case is important because it reveals how it could rationally be reproduced at another time, by another expert. In other words, transparency is necessary to properly evaluate the reliability of expert evidence. But an expert's thinking is analogous to a black box whose crucial inner cognitive processes are not immediately accessible through introspection. A consideration in communicating expert evidence, therefore, is the extent to which the expert's recollection of their examination assists the court beyond that of their bare opinion. Can they explain their thinking to help reveal its reliability to the fact-finder?

Cognitive scientists use a range of experimental and computational techniques to understand how the mind works from a third-person point of view without direct observation of mental states.[22] Indeed, advances in cognitive science are revealing striking differences between the richly detailed conscious experience one has of the world and the sparsely detailed unconscious mental models that give rise to it.[23] Our application of the black box analogy to expert evidence refers to one's limited insight into the cognitive basis of their judgments

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20 For a review of these models, see Yann LeCun, Yoshua Bengio and Geoffry Hinton, 'Deep learning' (2015) 512 *Nature* 436, 444.

21 Scientists have puzzled for centuries over the nature of conscious experience. See, eg, David Chalmers, 'Facing up to the Problem of Consciousness' (1995) 2 *Journal of Consciousness Studies* 200, 219.

22 George Miller, 'The Cognitive Revolution: A Historical Perspective' (2003) 7(3) *Trends in Cognitive Sciences* 141, 144.

23 Michael Cohen, Daniel Dennett and Nancy Kanwisher, 'What is the Bandwidth of Perceptual Experience?' (2016) 20(5) *Trends in Cognitive Sciences* 324, 325.

and decisions from a first-person point of view. A schematic example of black box expert evidence is illustrated in Figure 1, with a pair of fingerprints from the same finger as 'input'. The expert relies on complex visual cognitive processes (inside the box) to interpret the prints and arrive at an opinion as 'output'.

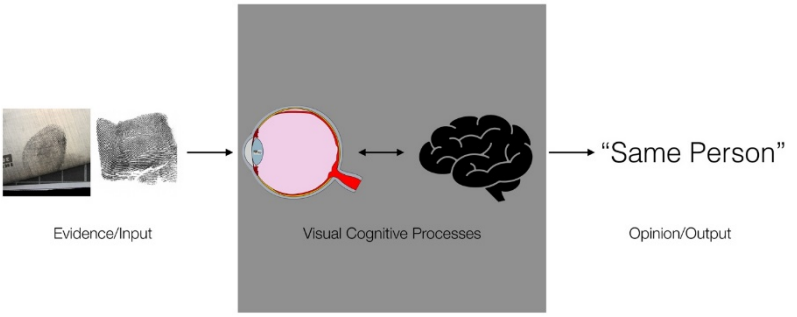

Figure 1 — A schematic example of black box evidence with a crime scene or 'latent' print (left) and rolled print (right) from the same finger as example 'input'. Many of the visual cognitive processes relied on by the expert to interpret the prints and arrive at a correct judgement proceed inside the shaded black box or outside of the expert's direct awareness.

Peering more deeply into the box, the expert might glean the gist or overall 'look' of the prints very quickly,[24] with this first impression guiding his or her more deliberate search for particular features.[25] The expert's opinion (eg 'same', 'different', 'not enough information to confidently say') comes into focus as a threshold amount of detail is picked up from the prints.[26] Their final opinion may also be tuned by their experience with similar cases and other aspects of the context that are not 'on the page'.[27] Several idiosyncratic facets of the black box

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[24] Aude Oliva and Antontio Torralba, 'Building the Gist of a Scene: The Role of Global Image Features in Recognition' (2006) 155 *Progress in Brain Research* 23, 36. For evidence from fingerprint research, see Matthew B Thompson and Jason M Tangen, 'The Nature of Expertise in Fingerprint Matching: Experts Can Do a Lot with a Little' (2014) 9(12) *PLoS ONE* e114759.

[25] David Navon, 'Forest before Trees: The Precedence of Global Features in Visual Perception' (1977) 9(3) *Cognitive Psychology* 353, 383. For examples of experts detecting 'global' features in fingerprints, see Rachel A Searston and Jason M Tangen, 'The Style of a Stranger: Identification Expertise generalizes to Coarser Level Categories' (2017) 24(4) *Psychonomic Bulletin & Review* 1324.

[26] Hector Palada et al, 'An Evidence Accumulation model of Perceptual Discrimination with Naturalistic Stimuli' (Working Paper, 2018) 48 <https://doi.org/10.31234/osf.io/zr8wd>.

[27] Lee Brooks, Geoff Norman and Scott Allen, 'Role of Specific Similarity in a Medical Diagnostic Task' (1991) 120(3) *Journal of Experimental Psychology: General* 278, 287. For an example of how people rely on similarity with prior cases in fingerprints, see Rachel A Searston, Jason M Tangen and Kevin W Eva, 'Putting Bias into Context: The role of Familiarity in Identification' (2016) 40(1) *Law and Human Behavior* 50, 64.

are operating outside of the expert's direct awareness: his or her response threshold (eg the amount of visual information required to make a response),[28] response bias (eg tendency to preference one decision over the other),[29] and the amount of sleep he or she had the night before or the last case he or she worked on.

Next, we consider some basic findings from cognitive science demonstrating the tremendous difficulty of (accurately) explaining how a judgment unfolds in the mind of an expert. In particular, we will discuss: how people depend on pattern recognition or their memories for similar situations to resolve ambiguity; how visual pattern evidence, in particular, is not so easily boiled down to a set of defined features; and how the automaticity and efficiency with which an expert's thinking proceeds masks the basis of his or her judgment from introspection.

A *Seeing Patterns*

To start, we urge the reader to critically examine the intuition that his or her conscious experience is a direct reflection of reality.[30] Consider, for instance, how easy it is to find structure in the world, even where there is none. This chronic tendency to see patterns even in randomness is called *apophenia*, and it is illustrated by several well-known illusions and fallacies of thinking. For instance, people see illusory faces in strange places, like tree trunks and toasted cheese sandwiches (a quick internet search for the phrase 'pareidolia' will bring up many such examples). People also hear illusory backward messages in rock music when told to listen for specific phrases, such as 'it's fun to smoke marijuana' in Queen's *Another One Bites the Dust* played in reverse.[31] And people even falsely remember events that never happened or misremember particular details, like recalling a yield or give way sign in place of a stop sign.[32] Collectively, these are all examples

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28 For a look at how 'response threshold' can be measured with fingerprint judgments, see Palada et al (n 26).

29 For a look at how 'response bias' can be measured with fingerprint judgments, see Searston, Tangen and Eva (n 27).

30 See generally Marshal Segall, Donald Campbell and Leville Herskovits, *The Influence Culture on Visual Perception* (Bobbs-Merrill Inc, 1966).

31 John Vokey and John Read, 'Subliminal Messages: Between the Devil and the Media' (1985) 40(11) *American Psychologist* 1231, 1239.

32 Elizabeth Loftus, David Miller and Helen Burns, 'Semantic Integration of Verbal Information into a Visual Memory' (1978) 4(1) *Journal of Experimental Psychology: Human Learning and Memory* 19, 31.

of *expectancy effects*[33] or *confirmation bias*,[34] where one tends to see, hear and remember details in line with their pre-existing mental model of the world.

This reliance on expectations and similarity to prior experience as a guide to the world is fundamental to our everyday functioning; without it we would not be able to act or make decisions under conditions of uncertainty.[35] Similarly, forensic experts are trained to detect patterns in complex samples of handwriting, blood, fingerprints, shoeprints and images of various kinds. And just like everyone else, their opinions are based on more than what is on the page. That includes their prior experiences and expectations, and contextual details surrounding the case at hand.[36] Without these cognitive shortcuts or 'heuristics',[37] experts would not be able to do what they do.[38] But it is the automaticity and efficiency with which this kind of pattern recognition operates that obscures it from the user, creating the naïve realist impression that one experiences the world unfiltered by the mind.[39]

B *Blind Reasoning*

Pattern recognition is difficult to articulate in legal cases because it eludes the mind's eye. Indeed, people demonstrate a blindness to their own thinking in a variety of contexts.[40] For example, students cram for exams because it feels more effective for remembering content than spreading the same amount of study over

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33 This term first appeared when scientists discovered they could inadvertently influence the outcome of a study by changing their behavior in accordance with their predictions: Robert Rosenthal and Kermit Fode, 'The Effect of Experimenter Bias on the Performance of the Albino Rat' (1963) 8 *Systems Research and Behavioral Science* 183. The procedure known as 'blinding' is now commonly used to inoculate against such effects in research.

34 For a review of confirmation bias in forensic decision-making, see Saul Kassin, Itiel Dror and Jeff Kukucka, 'The Forensic Confirmation Bias: Problems, Perspectives, and Proposed Solutions' (2013) 2 *Journal of Applied Research in Memory and Cognition* 42.

35 Douglas Hofstadter and Emmanuel Sander, *Surfaces and Essences: Analogy as the Fuel and Fire of Thinking* (Basic Books, 2013) 512.

36 For a discussion on context effects in forensic decision-making, see Gary Edmond et al, 'Contextual Bias and Cross-Contamination in the Forensic Sciences: The Corrosive Implications for Investigations, Plea bargains, Trials and Appeals' (2015) 14 *Law Probability and Risk* 1.

37 Amos Tversky and Daniel Kahneman, 'Judgment under Uncertainty: Heuristics and Biases' (1974) 185 *Science* 1131.

38 For an example of fingerprint experts performing more accurately than novices, see Tangen, Thompson and McCarthy (n 11).

39 For a description of naïve realism and the role of interpretation in the context of forensic decision-making, see Searston, Tangen and Eva (n 27).

40 Emily Pronin, Daniel Lin and Lee Ross, 'The Bias Blind Spot: Perceptions of Bias in Self versus Others' (2002) 28 *Personality and Social Psychology* Bulletin 369.

time, even though cognitive scientific research says differently.[41] Similarly, forensic experts' confidence does not always predict their accuracy in ways one might expect.[42] Another example of this blind reasoning is that people lack insight into the reasons for their decisions, as illustrated by a phenomenon known as *choice blindness*.[43] In one study of choice blindness, people were presented with two photos of faces. They were then asked which one they found more attractive. After making that choice, they were given a closer look at that 'chosen' photograph and asked to explain why they picked it. The twist was that the experimenter used sleight of hand to swap out the chosen picture with the discarded one. Most people failed to notice the switch, and many provided elaborate explanations of a choice *they never made*. Simply put, people tell a good story to resolve ambiguity, but they are not the best narrator of their unconscious cognitive processes. Similarly, forensic experts may not have direct access to the reasons for their decisions, even if they feel they do.

C *Summing Features*

The problem with articulating decisions that are born out of unconscious cognitive processes is compounded by the fact that many forensic practices involve analysing images that are themselves difficult to describe. By way of analogy, consider explaining Claude Monet's artistic style to someone who shares your language but who has never seen a painting before. A description of the contents of Monet's famous *Water Lilies*, for instance, would fail to capture his fondness for painting flower gardens, poppy fields, sailboats and sunsets. Likewise, any description of his use of colour or the thickness of his brushstrokes would be insufficient to distinguish one Impressionist artist from the next. One can only appreciate Monet's style by looking across his different paintings and seeing for oneself how they tend to vary from other artistic styles. In fact, even when the contents of Impressionist paintings are completely obscured by reducing them down to a few pixels, people can still distinguish them from other types of paintings.[44] One need not be able to describe something in order to *distinguish* it.

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41 Sarah Tauber et al, 'Self-Regulated Learning of a Natural Category: Do People Interleave or Block Exemplars during Study?' (2012) 20(2) *Psychonomic Bulletin & Review* 356.

42 Indeed, confidence does not predict accuracy reliably at all in some tasks. For an example in the fingerprint context, see Searston and Tangen (n 25).

43 Petter Johansson et al, 'Failure to Detect Mismatches between Intention and Outcome in a Simple Decision Task' (2005) 310 *Science* 5745.

44 Rachel Searston et al, 'How Low Can You Go? Detecting Style in Extremely Low Resolution Images' (2019) 45(5) *Journal of Experimental Psychology: Human Perception and Performance* 573, 584.

Explaining the gist or the look of a person's fingerprints to the fact-finder who has never seen a print before is similarly challenging; the contents or 'features' of one print do not reveal much about the variation across prints of the same person. Indeed, fingerprint experts can tell if two prints belong to the same person even when they are deposited by different fingers (eg Smith's left thumb and index prints).[45] In this example, the features may change but examiners can still detect the overall look or *style* of the person's prints without being able to describe it. They can also pick the 'odd' pattern out of a grid of 40 different prints more efficiently than novices,[46] and they can distinguish prints from the same finger with very little time to pick out the details.[47] In other words, visual pattern evidence is more than a sum of features that one can easily explain to the fact-finder. It is precisely this amorphous quality to visual pattern evidence that is so difficult to pry from the mind of an expert witness, and that continues to challenge modern computer algorithms attempting to quantify it.[48]

D *Articulating Automaticity*

Finally, and perhaps paradoxically, it is the years of experience that forensic examiners gain that increases the challenge involved in articulating their thinking. As one builds experience with images (ie as we become experts with them), we develop a mental model of their 'look' that enables us to recognise new images of the same kind.[49] Experts are thought to rely more on similarity to prior cases as a shortcut to the correct response (compared with novices who do not have the experience to draw on).[50] Chess masters, for example, are highly accurate at reconstructing chess piece positions from memory.[51] More experienced chess players can remember pieces in more positions than less experienced players, but only when the configuration of pieces is left intact resembling their prior experience.[52] Likewise, medical residents' and doctors' diagnostic acumen with skin diseases is improved when the lesion is similar to

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45 Searston and Tangen (n 25).

46 Rachel Searston and Jason Tangen, 'Expertise with Unfamiliar Objects is Flexible to Changes in Task But Not Changes in Class' (2017) 12(6) *PloS ONE* e0178403.

47 Thompson and Tangen (n 24).

48 AAAS Report (n 4) 23.

49 Trainee fingerprint examiners show improvements across a range of fingerprint tasks that require them to generalise to new impression within the first three months of their training. See Rachel Searston and Jason Tangen, 'The Emergence of Perceptual Expertise with Fingerprints Over Time' (2017) 6(4) *Journal of Applied Research in Memory and Cognition* 442, 451.

50 Brooks, Norman and Allen (n 27).

51 Adriaan de Groot, '*Thought and Choice in Chess*' (Mouton Publishers, 1946/1978).

52 William Chase and Herbert Simon, 'Perception in Chess' (1973) 4(1) *Cognitive Psychology* 55, 81.

specific cases they have seen before.[53] This increasing reliance on memory with expertise, while efficient, also makes it more difficult to pinpoint the source of expert decisions.

Indeed, fingerprint examiners appear to be no different to experts in these other perceptual domains. Cognitive scientific research shows that their superior performance to novices is specific to prints, both facilitated and constrained by their particular set of experiences.[54] Research with novice examiners also shows that fingerprint discrimination decisions can be influenced by exposure to similar cases.[55] Applying this research to forensic experts' interpretations of visual pattern evidence more broadly, it is apparent that examiners do not have special access to their unconscious cognitive processes. That is, experts (especially) are not witnesses to the inner workings of their own minds. And the opaque nature of their thinking poses a problem for the fact-finder seeking to understand *how* they have formulated their opinion in the case at hand.

IV The Legal (Non-)Regulation of Black Box Evidence at Common Law

Now, in the light of the above research, we will assess the orthodox legal response to contested expert evidence. The orthodox approach relies on admissibility rules and adversarial trial safeguards (eg cross-examination, rebuttal witnesses) to ensure that expert evidence is susceptible to rational evaluation.[56] We will suggest that these mechanisms could, in theory (and especially at common law) be used to regulate black box expertise in a safe and scientifically informed manner. Unfortunately, they have not been used that way. To illustrate this, we will describe the orthodox approach's application to two cases, both in common-law evidence jurisdictions, in which the Crown heavily relied upon the expertise of a fingerprint examiner (a black box field): a 2005 South Australian case, *R v Bennett* ('*Bennett*'), and a 2018 Queensland case, *R v Nguyen* ('*Nguyen*').[57]

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53 Brooks, Norman and Allen (n 27).

54 Searston and Tangen (n 46).

55 Searston, Tangen and Eva (n 27).

56 Gary Edmond, 'Forensic Science Evidence and the Conditions for Rational (Jury) Evaluation' (2015) 39(1) *Melbourne University Law Review* 77.

57 *Bennett v Police* [2005] SASC 167 ('*Bennett* (Appeal)'); *Bennett v Police* [2005] SASC 415 ('*Bennett* (Full Court Appeal)'); Transcript of Voir Dire Proceedings, *R v Nguyen* (Queensland District Court, Rafter DCJ, 2018) ('*Nguyen*').

A *Admissibility Rules*

In *Bennett*, a fingerprint examiner initially provided a very bare opinion. He said that he compared the two relevant fingerprints and found them to be identical: 'When I say that something is identical, what I mean is that the impressions were made by one person excluding all others.'[58] Later, during cross-examination, he said that he found over 20 similarities between the latent print and the accused's, but did not take notes as to what they were specifically.[59] The *Bennett* examiner's evidence was — if examined closely enough — telling. It implicitly acknowledged the black box nature of the examiner's expertise in that all he could really say about his process was that he compared two prints, found some similarities, and determined them to be 'identical'.[60] And while there were over 20 similarities, he could not (and did not) say how many are sufficient to declare a match.

As we saw from the first half of this article, asking an examiner to count the similarities that he or she noticed is not a particularly useful way of revealing reasoning. This is because expert fingerprint examiners are able to glean information from a person's prints that cannot be reduced down to a number of describable details. Indeed, any description of particular similarities risks misleading the fact-finder into believing that the fingerprint examination process is a simple matter of counting up matching features.

A better approach would be for examiners to admit the subjective nature of the examination and provide scientific evidence on the nature of expertise in the domain (eg studies showing how well experts do in cases similar to the present one).[61] That is not to say that one could perhaps infer based on the *Bennett* examiner's testimony that his opinion was founded on subjective reasoning processes. But that was far from obvious to a lay person. It is now possible for experts in such cases to provide knowledge from a growing evidence-base exploring the nature of fingerprint expertise and how accurate the process tends to be.[62] As we will discuss in the remainder of this subsection, expert admissibility rules, properly applied, demand this more useful information from experts.[63]

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58 *Bennett* (Full Court Appeal) (n 57) [16]. See also Edmond, this volume, 332–4, for a review of *Bennett*.

59 *Bennett* (Full Court Appeal) (n 57) [19]

60 Ibid [16].

61 For an example of this approach, see Gary Edmond, Matthew Thompson and Jason Tangen, 'A Guide to Interpreting Forensic Testimony: Scientific Approaches to Fingerprint Evidence' (2013) 13(1) *Law, Probability & Risk* 1, 25.

62 Tangen, Thompson and McCarthy (n 11).

63 Edmond, this volume, 354, prefers regulating expert evidence at the admission stage instead of leaving it to untested trial safeguards: 'In principle, it seems better to regulate the admission of expert evidence rather than try to repair exaggerated claims during adversarial proceedings before

We will now review three common-law admissibility rules: (1) the requirement that experts identify the intellectual basis and factual underpinnings of their expertise (ie the basis rule); (2) the reliability rule; and (3) the exclusion of evidence when its prejudice exceeds its probative value. After reviewing these rules, we will suggest that they were not appropriately applied in *Bennett*, leading to an outcome in which the trier of fact simply did not have the knowledge needed to understand and evaluate the examiner's conclusions. *Bennett* also helps demonstrate that while the common law is sometimes formally more rigorous than the Uniform Evidence Law ('UEL') in its approach to expert evidence, those differences rarely have any real-world impact.[64] In other words, the same untested forensic testimony was admitted in both common-law and UEL jurisdictions.[65]

According to the basis rule, experts must present their evidence in a manner that allows the trier of fact to determine how their expertise applies to the assumed or observed facts to produce the opinion.[66] At common law, this includes experts identifying their assumptions, proving the facts they observed, and stating their reasoning.[67] The statement of reasoning rule is especially important in the context of black box evidence because experts' reasoning consists of unverbalisable unconscious cognitive processes that may not be apparent to the fact-finder.

The general purpose of the statement of reasoning requirement is transparency as to the 'expert's thinking'.[68] This will, in theory, assist the fact-finder in 'assessing the rational force of expert evidence'.[69] The rational force includes the reliability of the expert's process. In other words, the transparency required by the basis rule enables 'the conclusions to be tested and a judgment made about the reliability of them'.[70] When it comes to scientific and technical expertise, the fact-finder should be provided with the 'necessary scientific

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non-technical audiences.' See also Gary Edmond et al, '*Christie*, Section 137 and Forensic Science Evidence (After *Dupas v The Queen* and *R v XY*)' (2014) 40(2) *Monash University Law Review* 389.

64 We will discuss several other instances in which a formally more demanding common law operates, in fact, very similarly to the UEL.

65 At common law, see *R v Sica* [2013] QCA 247 ('*Sica*').

66 *Honeysett v R* (2014) 253 CLR 122, [27]; *Dasreef Pty Ltd v Hawchar* (2011) 243 CLR 588, [36]–[37] ('*Dasreef*'); *HG v The Queen* (1999) 197 CLR 414, [39].

67 JD Heydon, *Cross on Evidence* (LexisNexis, 10th ed, 2015) 1027–40. There appears to be considerable disagreement about the degree to which these components survived the UEL and whether any or all of the three requirements changed or softened. See generally *Makita (Australia) Pty Ltd v Sprowles* [2001] NSWCA 305, [50]–[147] (Heydon J) ('*Makita*'); Miiko Kumar, 'Admissibility of Expert Evidence: Proving the Basis for an Expert's Opinion' (2011) 33(1) *Sydney Law Review* 427.

68 *Dasreef* (n 66) [91].

69 Ibid [93].

70 *Pownall v Conlan Management Pty Ltd* (1995) 16 ACSR 227, 245

criteria' to evaluate this evidence.[71] As we have discussed, black box experts cannot state their reasoning in the traditional sense. Still, they can meet some necessary scientific criteria by providing: the results of scientific studies measuring the performance of similarly trained examiners; their own test scores on similar problems; and general research on how experts make decisions (such as in Parts II–III above).

The statement of reasoning rule assists in determining the evidence's admissibility at the next stage of the analysis. To be admissible at common law,[72] the expert must be qualified in a subject that is beyond common knowledge and is part of a *reliable body of knowledge*.[73]

As a demonstration of how the reliability rule *might* be applied in the face of black box evidence, consider its application in the recent *Liyanage v The State of Western Australia* ('*Liyanage*') decision.[74] In that case, the defence sought to adduce evidence from a social worker about the results of two risk assessment tools that she had administered to the accused, which purported to quantify the degree of danger faced by abused individuals.[75] Applying the reliability rule, the trial judge (with the appellate court agreeing) held that neither instrument had been sufficiently validated and thus should be excluded.[76] The trial judge further questioned whether the results of instruments could be trusted when they relied on the subjective responses of the accused (who may have been motivated to make her situation seem more dire): 'By ascribing numerical values and a score to the answers the Scale *gives the appearance of being an objective outcome independent of the person tested, but it is not that at all*.'[77]

Finally, the trial judge has a residual discretion to exclude evidence when its probative value is outweighed by its prejudicial effect.[78] At common law, probative

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71 Ibid; *Makita* (n 67) [87].

72 As we will see below, this rule is not rigorously applied. The reality, as we will discuss, is likely much similar to the role of reliability in UEL jurisdictions where courts have not read reliability into the expert evidence admissibility rule (s 79). See *Tuite v R* [2015] VSCA 148, [45]–[82] ('*Tuite*'); Gary Edmond, 'A Closer Look at *Honeysett*: Enhancing Our Forensic Science and Medicine Jurisprudence' (2015) 17(2) *Flinders Law Journal* 287.

73 *The Queen v Bonython* [1984] 38 SASR 45, 46–7. This formulation has been followed in Queensland and Western Australia; see: *R v Jones* [2015] QCA 161, [16]; *Cairns Regional Council v Sharp* [2013] QCA 297, [18]; *Liyanage v The State of Western Australia* WASCA 112 [110], [122] ('*Liyanage* (Appeal)'); *State of Western Australia v Liyanage* [2016] WASC 12, [54] ('*Liyanage* (Trial)'). However, as we will see in *Bennett*, courts in common law evidence jurisdictions rarely actually demand reliability. See also *Sica* (n 65).

74 *Liyanage* (Trial) (n 73); *Liyanage* (Appeal) (n 73).

75 *Liyanage* (Trial) (n 73) [22]–[28].

76 Ibid [76]–[80]. *Liyanage* (Appeal) (n 73) [149]–[154].

77 *Liyanage* (Trial) (n 73) [77] (emphasis added); *Liyanage* (Appeal) (n 73) [111].

78 *R v Christie* [1914] AC 545; *IMM v The Queen* [2016] HCA 14, [144]–[148] ('*IMM*'); *Dupas v R* [2012] VSCA 328, [69]–[78].

value includes the evidence's reliability (in UEL jurisdictions, reliability's role is much murkier).[79] The evidence's prejudice includes the difficulty the fact-finder would have in comprehending the evidence and the possibility that the fact-finder would accord the evidence undue weight.[80] This prejudice is often cast as being mitigated by trial safeguards, such as judicial warnings and cross-examination (of which more below).[81]

Applying these rules to *Bennett*, which predates the NAS, SFI and PCAST reports,[82] it is apparent there was no reference to measures of accuracy or expertise beyond the examiner's bare identification judgment. And on appeal, Bennett challenged the fingerprint evidence for violating the basis rule. He argued that the examiner did not provide the factual basis of the opinions (ie descriptions and diagrams of the matching features) or fully reveal his reasoning process.[83] On appeal, Doyle CJ appeared to accept a capacious interpretation of the basis rule,[84] but still found that the examiner's evidence did not violate it. Most of Doyle CJ's reasons focused on the expert's failure to provide a photograph of Bennett's fingerprint as a way to explain the similarities that were found.[85] Ultimately, Doyle CJ held that there was no requirement to tender the photograph and that the Magistrate was 'fully informed' of the examiner's 'reasoning process'.[86] The result was, according to the Court, that the accused was not cross-examining 'in the dark'.[87] In other words, the defence was not forced to go fishing for an understanding of how the examiner came to his opinion — the basis was clear.

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79 *IMM* (n 78); *Dupas* (n 78). The formal position, as with the basis rule and the expert evidence exception, is likely different in UEL jurisdictions. With regard to the probative value of evidence, UEL trial judges appear to be under the obligation to take reliability at its highest. See Gary Edmond, 'Icarus and the Evidence Act: Section 137, Probative Value and Taking Forensic Science Evidence "At its Highest"' (2017) 41(1) *Melbourne University Law Review* 106.

80 *Tuite* (n 72) [125]; *Pfennig v R* (1995) 127 ALR 99, 118.

81 *R v Shamouil* [2006] 66 NSWCCA 112, [77]; *Tuite* (n 72) [125]; *Collins Thomson Pty Ltd (in liq) v Clayton* [2002] NSWSC 366, [26]; *Fagenblat v Feingold Partners Pty Ltd* [2001] VSC 454, [8]; *Chen v R* [2018] NSWCCA 106, [75].

82 See the reports listed above n 4.

83 *Bennett* (Appeal) (n 57) [18], [23].

84 Doyle CJ appeared to adopt Heydon J's expanded view of the basis rule: *Bennett* (Appeal) (n 57) [53]. And in *JP v DPP* [2015] NSWSC 1669, [33] ('*JP*'), a case we discuss below, a New South Wales court noted that the UEL had relaxed the basis rule. For that and other reasons, the Court found that a fingerprint examiner, who gave similar evidence to the *Bennett* examiner, should be admitted. It appears that despite some formal differences in the basis rule across the UEL and common law, both jurisdictions do not apply it in a way that is sensitive to the black box nature of some forms of expertise.

85 *Bennett* (Appeal) (n 57) [27]–[54].

86 Ibid [54].

87 Ibid [55], quoting *Makita* (n 67) [62]. Doyle CJ's opinion was upheld on further appeal to the Full Court: *Bennett* (Full Court) (n 57) [5]. One judge of the Full Court suggested several ways in which a fact-finder might not have accepted evidence of the kind that the *Bennett* examiner provided:

The reasoning in *Bennett* (and the defence's specific basis challenge) demonstrates a mistaken understanding of the expertise in question and the futility of the basis rule in black box cases. By focusing on photographs and points of comparisons, all of the parties incorrectly assumed that such information would provide the Magistrate some insight into the expert's reasoning process. Rather, expressly pointing to comparisons would not have explained what it was like to see the prints through the lens of the expert's experience, nor would it have provided any notion of accuracy. The decision was, however, correct in one facet: the defence lawyer was not left to cross-examine in the dark; rather, he was forced to cross-examine in the black (box).

Reliability and probative value versus prejudicial effect were not raised in *Bennett*. However, without knowledge about the method's error and the examiner's own proficiency, it is difficult to understand how a court could find that the opinion was sufficiently reliable or more probative than it was prejudicial. By way of contrast, recall that the *Liyanage* Court demanded validation testing to support the reliability of a process whose outputs consisted of subjective judgements. It is unclear why jurisprudence on expert judgements about visual pattern evidence would be different.

B *Trial Safeguards*

As we saw above, courts sometimes admit expert witnesses under the theory that any prejudice associated with their testimony is mitigated by trial safeguards, like cross-examination, judicial warnings and rebuttal experts. Beginning with cross-examination and the example of 2018's *Nguyen* case, we now turn to these trial safeguards.

1 *Cross-Examination*

Nguyen represents an unusually robust challenge to a fingerprint examiner's report.[88] In particular, and unlike in *Bennett*, the defence counsel in *Nguyen* delved not just into the identification at hand, but also asked about 'the science of fingerprinting … generally' (and some of this was discussed in the examination-

simply not finding it 'convincing', doubts about qualifications and independence, not thinking there were enough points of similarity, and police tampering. This seems unlikely and, importantly, none of these reasons acknowledge the black box nature of the opinion.

[88] *Nguyen* (n 57); Edmond, (n 79) 140–2. Edmond, in this volume, finds that fingerprint examiners are not usually challenged on the epistemic basis of their opinion.

in-chief as well).[89] *Nguyen* therefore offers a case study into how well cross-examination — a very strong one — can work in the context of black box expertise. In this respect, the cross-examination in *Nguyen* demonstrates the limitations of cross-examination as a tool for revealing the basis of an expert's opinion and provides some lessons for how black box experts may wish to proceed in similar cases.[90]

As to the fundamental issue of whether fingerprint comparison is a method that the expert can verbally articulate, the *Nguyen* examiner, in chief, described it as follows: 'I believe that whilst there are small subjective elements to the process, the overall process is objective … I can look at it. I can see it. I can show it to you.'[91] This statement somewhat downplays the subjective, black box nature of the task.[92] To the examiner's credit, he went on to acknowledge that experts do make errors on more difficult comparisons, which he referred to as subjective:

> At that more subjective end where you have, say, pressure distortions or reversals in the pattern, you need to be able to explain those and you need to have seen them very many times, and experience is a very large part of that … In fact, there was a study here in Queensland — or Australia-wide … that showed that with similar but non-matching impressions, novices misidentified 55 percent of the images in terms of saying they were a match when they, in fact, were not. And experts have a .068 per cent error rate.[93]

We note, however, that there are no widely adopted guidelines or pre-set criteria on what comparisons represent those on the easy and 'objective' end of the spectrum, and those on the more difficult subjective end. The quality or clarity of a sample is in the eye of the examiner. In other words, it is hard to say in any given case whether it is one in which we can trust that an examiner can actually explain the process or whether, rather, it is a predominantly black box judgement.[94]

Regarding cognitive bias, the *Nguyen* examiner acknowledged, on cross-examination, the shortcomings in the fingerprint comparison that led to a prominent misidentification in Scotland.[95] He explained some of the findings of the SFI Report, including the dangers of confirmation bias with a point-based

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89 *Nguyen* (n 57) 1-17.

90 See also Gary Edmond et al, 'Forensic Science and the Limits of Cross-examination' (2019) 42(3) *Melbourne University Law Review* (advance).

91 *Nguyen* (n 57) 1-14.

92 NAS Report (n 4) 142–3.

93 *Nguyen* (n 57) 1-14. The quoted error rates are the false positive (ie false identification) rates of novice and expert participants in Tangen, Thompson and McCarthy (n 11). These are errors in which the participant incorrectly concludes the prints come from the same person when they come from different people.

94 The examiner went on to describe several other studies measuring the error rate of fingerprint comparisons: *Nguyen* (n 57) 1-15–1-16.

95 Ibid 1-17–1-18.

system of counting up some number of feature similarities (eg stopping an examination once a set number of similarities confirm a 'match' conclusion without an exhaustive search for potentially disconfirming differences).[96] He was also knowledgeable about the mistaken fingerprint identification of Brandon Mayfield (by two examiners, who identified him with 100 per cent certainty) as the Madrid train bomber, which is widely considered to have been driven by cognitive bias.[97] He said that he would have not made the same identification, but prefaced this with an acknowledgement that he was biased by hindsight, stating: 'I have the benefit of hindsight, but I could not objectively … do that with sufficient detail and clarity to form my opinion that it would be the same.'[98]

The examiner further acknowledged that blind verifications were the 'gold standard' but explained that this would involve a lengthy process of repeating all searches and comparisons in the case that is simply 'not practical to have someone do … Particularly in this instance where it's a very clear impression. For a highly-distorted impression, often other experts are asked to conduct another examination.'[99] Indeed, scientific evidence suggests that when different examiners make independent judgements about the same pair of prints, those judgements are more likely to be unanimous when the prints are clear or 'pristine', and less so for the more ambiguous in between cases.[100]

Finally, the *Nguyen* examiner did mention the PCAST Report, citing its conclusion that fingerprint analysis is a foundationally valid method.[101] This was indeed one of the Report's key conclusions.[102] Directly followed by that conclusion, however, were cautions about the application of fingerprint comparison method by examiners: (1) whether they have undergone proficiency testing; (2) whether they have documented the features in the latent print in writing before it was compared to the known print; (3) whether they were aware of any other facts that may influence the conclusion; and (4) whether the prints are of a similar quality to those considered in foundational studies.[103]

While he did not directly acknowledge the expressed limitations in the PCAST Report, the *Nguyen* examiner more or less disclosed those points throughout the examination. In his examination-in-chief, he offered details about proficiency

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96 Ibid 1-5; SFI Report (n 4).
97 PCAST Report (n 4) 90.
98 *Nguyen* (n 57) 1-19.
99 Ibid 1-24.
100 Bradford Ulery et al, 'Accuracy and Reliability of Forensic Latent Fingerprint Decisions' (2011) 108(19) *Proceedings of the National Academy of Sciences USA* 7733, 7738.
101 *Nguyen* (n 57) 1-20.
102 PCAST Report (n 4) 101–2.
103 Ibid.

testing, and even some limitations of fingerprint evidence.[104] These included the variability in the quality of the impressions and in the 'experience' or 'talent' of the examiner and 'how they were feeling on the day'.[105] He also provided an explanation of black box studies and reported error rates that he later expanded on during cross-examination.[106] As to point (3), the examiner's knowledge that the accused had previously been identified by two or three other examiners was provided, but later on cross-examination.[107] Still, these points should be offered in a straightforward way in the examiner's initial report because systemic imbalances in the criminal justice system make it difficult for many accused parties to retain lawyers who will draw out such information.

Overall, *Nguyen* demonstrates that experts can provide insight into the science behind their expertise as a part of their evidence. However, there is still room for improvement in the way examiners explain their thinking and resulting conclusions. As we noted above, the examiner emphasised (possible) objective components of his task and thus downplayed the role of his experience and expertise. He also tended to highlight the parts of scientific reports that were favourable to his practice. These aspects of his testimony posed challenges to the cross-examining lawyer who did not appear sufficiently well-versed in the research to pose further probing questions.[108] Still, *Nguyen* may be favourably contrasted with *JP v Director of Public Prosecutions* ('*JP*'), a case recently detailed by Edmond and colleagues.[109] In that case, a well-prepared defence counsel similarly pressed a fingerprint examiner on reports like that from PCAST.[110] The examiner in *JP* was not aware of such reports, making it — in some ways — more difficult to convey the relevant scientific knowledge to the trier of fact.[111]

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104 *Nguyen* (n 57) 1-12–1-13. See lines 10–45 on proficiency testing.

105 Ibid 1-15–1-16. See lines 5–40 on limitations, including the expert's in-depth explanation and evaluation of the quality of the impressions in the case.

106 Ibid.

107 Ibid 1-22.

108 The examiner further focused much of his early evidence in chief on the biological reasons why fingerprints may be unique and permanent: see ibid 1-13–1-14. As the PCAST Report (n 4) 64 noted, however, uniqueness and permanence distracts from the more important point of whether examiners are proficient at what they do: 'Yet, uniqueness studies miss the fundamental point. The issue is not whether objects or features differ; they surely do if one looks at a fine enough level. The issue is how well and under what circumstances examiners applying a given metrological method can reliably detect relevant differences in features to reliably identify whether they share a common source.'

109 Edmond (n 90) 17.

110 *JP* (n 84). For another account of *JP*, see Gary Edmond, Kristy Martire and Mehera San Roque, 'Expert Reports and the Forensic Sciences' (2017) 40(2) *University of New South Wales Law Journal* 590.

111 See Edmond, this volume, 347: 'Notwithstanding detailed cross-examination on the NRC and NIST reports, these are not cited in the written decisions by the trial and appellate courts. The

Returning to the basis rule, after the above cross-examination (which occurred during a voir dire), the defence in *Nguyen* argued that the evidence should not be admitted: 'As I said … he has not provided reasons for his decision to say it's a match.' Despite this challenge to the basis of the examiner's opinion, the Court held:

> [The examiner's] qualifications were not challenged. Mr Hands, who appears for the accused, cited no authorities for his argument that the evidence should be excluded. Fingerprint evidence is routinely led in trials in Queensland. [The examiner] is clearly qualified to express an expert opinion on the subject matter. The application by the accused to exclude the evidence … is dismissed.[112]

Cases like *Nguyen* and *Bennett* demonstrate the distinct challenges that black box experts pose to the cross-examining lawyer. They will not be able to testify about the way in which their memory for similar cases may unconsciously inform their opinion, nor how they are able to see through distortion and superficial differences in visual pattern evidence, nor how their reasoning might have led them astray in the presence of biasing or unexpected information without their awareness.[113]

There are also practical limits on the ability of a lawyer to cross-examine experts in the criminal-law context. These are driven by the fact that the defence is often underfunded as compared to the prosecution.[114] The opaque nature of expertise may heighten this disparity by exaggerating the need for the cross-examining lawyer to have an understanding of the science, which takes time and resources. And there are practical constraints on the ability of experts to articulate a burgeoning body of scientific evidence on their expertise, too. Keeping apprised of the latest research findings takes time and training *on top of* casework demands.

2 *Judicial Directions and Warnings*

Judicial directions suffer from many of the same limitations as cross-examination. Topics like unconscious thinking and expertise are not common knowledge, nor are they sufficiently incontrovertible to be judicially noted under

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examiner's inability to accept them as authoritative — because he was not familiar with them — meant that they were not available to impugn his credibility or inform the evaluation of his conclusion. They were effectively marginalised in the evaluation of the opinion and the determination of guilt. They were not, in effect, (in) evidence.'

112 *Nguyen* (n 57) 1–21.

113 See above Parts II–III; Edmond (n 79) 147: 'how, for example, do you effectively cross-examine a confident and experienced witness about unconscious influences?'

114 See Keith A Findley, 'Innocents at Risk: Adversary Imbalance, Forensic Science, and the Search for Truth' (2008) 38(3) *Seton Hall Law Review* 893.

common law or statute.[115] A judge might therefore generally warn the jury about the dangers of uncritically accepting expert evidence (eg pursuant to recommendations in a bench book).[116] However, these warnings would do nothing to introduce the type of scientific knowledge required for the jury to assign any reasonable weight to black box expert opinion.[117]

3 *Rebuttal Experts*

Rebuttal experts offer another way to introduce knowledge about black box experts into the courtroom. The most obvious limitation with respect to this adversarial mechanism, however, is resources. It is asking a lot of a criminal defendant to both find a rebuttal expert and pay for that expert's services.[118] Indeed, within forensic science, most practitioners will be affiliated with the police in some fashion. Even if an expert is found and the accused can afford that expert's services, such an individual may seem like a hired gun compared to the state's witness.[119] Further, if the expert's retainer is limited to providing evidence about the nature of expert decisions in the field (eg the reliability of fingerprint examination, as opposed to offering his or her own identification), that expert risks being excluded because his or her evidence is not sufficiently probative of case facts.[120]

V Conclusion: Embrace the Dark?

In the absence of meaningful regulation during the admissibility inquiry, and given the limits of adversarial safeguards, a great deal of responsibility rests with the experts themselves to provide the fact-finder with the knowledge required to evaluate their opinion. In *Bennett* and *Nguyen*, we saw experts challenged to articulate their thinking about visual pattern evidence in different ways. And, accordingly, we saw how difficult it was to interrogate the unconscious cognitive basis of their opinions. A description of points of comparison in a pair of

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115 See *Munro v Tooheys Ltd* (1991) 29 FCR 79; *Evidence Act 1977* (Qld) ss 65–66. See also *Aytugrul v The Queen* (2012) 247 CLR 17; Edmond et al (n 63) 407–8.

116 Queensland Courts, 'Supreme and District Courts Criminal Directions Benchbook' <https://www.courts.qld.gov.au/___data/assets/pdf_file/0009/86058/sd-bb-58-expert-witnesses.pdf>.

117 Edmond et al (n 63) 410.

118 Findley (n 113).

119 Edmond (n 79) 141.

120 See *R v Madigan* [2005] NSWCCA 170, [23].

fingerprints, for instance, falls short of revealing how they contribute to the expert's opinion.

But this non-interrogable quality of black box evidence is more a feature of expertise than a bug. A large body of research in cognitive science indicates people are not privy to the cognitive processes they depend on to make sense of complex situations. They are, in fact, so in the dark that they often fail to notice they have even made an interpretation at all.[121] These findings extend to judgements about visual pattern evidence, where it is even harder to appreciate the role of experience and context in one's judgements because the initial interpretative process is so immediate and 'non-analytic'.[122] Moreover, the job of interrogating one's own black box may be even harder for experts, who rely more on automatic thinking with experience.[123]

Nevertheless, expert witnesses are expected to explain their reasoning process. They are also expected to provide some estimate of the reliability of their evidence. And they are expected to provide an opinion that is susceptible to meaningful cross-examination. Here, the forensic expert is confronted with a paradox: he or she is called as an expert witness to explain a certain kind of visual pattern evidence because he or she possessed perceptual expertise in interpreting it. But this same proficiency that qualifies the witness to testify as an *expert* obfuscates the cognitive steps that he or she has taken during his or her examination of the evidence.

So what can experts in such cases do to assist the court? While they may not be able to recount what happened in the black box of their mind when they formed their opinion, they can educate the court about external aspects of their examination process (eg chain of custody from crime scene to court, databases and search algorithms, comparison tools and software, contextual details, time spent on the examination, and peer review).[124] Importantly, they can also provide the scientific evidence for their expertise. What are the hallmarks of expert decisions in the domain? How do experts differ from novices? Does demonstrable expertise emerge with training of the kind completed by the examiner in this case? When are experts more likely to make errors with the particular pattern evidence at hand? An explanation of the cognitive scientific evidence for the

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121 Tangen (n 3).

122 Matthew B Thompson, Jason M Tangen and Rachel A Searston, 'Understanding Expertise and Non-Analytic Cognition in Fingerprint Discriminations Made by Humans' (2014) 5 (July) *Frontiers in Psychology* 1.

123 Searston and Tangen (n 49).

124 For a more comprehensive review, see Gary Edmond et al, 'Model Forensic Science' (2016) 48(5) *Australian Journal of Forensic Sciences* 496.

nature of expertise in the field would furnish the court with a third-person glimpse into the black box.

The idea that expert testimony should encompass scientific evidence as a means of articulating the basis of an opinion is not new. Several others have suggested ways in which model forensic expert witnesses might go about articulating research on human performance in their domain.[125] Authoritative scientific bodies, including the PCAST, have also recommended that quantitative information about the accuracy of forensic experts' judgments be clearly and accurately stated in their testimony.[126] As a modest addition, we suggest that the inclusion of cognitive scientific findings about *how* experts tend to make decisions could help the trier of fact to further interrogate the black box, enabling better evaluation of the probative value of the evidence. Exogenous cognitive scientific knowledge may have the greatest impact appended to an expert's written report, given the shortcomings of trial safeguards in the context of black box evidence. In other words, cognitive scientific research exploring *how* forensic experts think may offer another way for the fact-finder to navigate in the dark.

125 Ibid.

126 PCAST Report (n 4) 46.