PERSPECTIVE

Why eyewitnesses fail

Thomas D. Albright[a,1]

Edited by Charles D. Gilbert, The Rockefeller University, New York, NY, and approved June 13, 2017 (received for review April 25, 2017)

Eyewitness identifications play an important role in the investigation and prosecution of crimes, but it is well known that eyewitnesses make mistakes, often with serious consequences. In light of these concerns, the National Academy of Sciences recently convened a panel of experts to undertake a comprehensive study of current practice and use of eyewitness testimony, with an eye toward understanding why identification errors occur and what can be done to prevent them. The work of this committee led to key findings and recommendations for reform, detailed in a consensus report entitled *Identifying the Culprit: Assessing Eyewitness Identification*. In this review, I focus on the scientific issues that emerged from this study, along with brief discussions of how these issues led to specific recommendations for additional research, best practices for law enforcement, and use of eyewitness evidence by the courts.

forensic science | visual perception | memory | lineup | criminal justice

The identification of a criminal suspect by an eyewitness to the crime constitutes a form of direct testimonial evidence that may be used for forensic purposes: that is, for the establishment of facts in a criminal investigation or prosecution. Eyewitness identification has a long history of use in this capacity by law enforcement and the courts, in the United States and elsewhere, and has played a valuable role in both convictions and acquittals. Despite this value, our society has been confronted in recent years with many egregious failures of eyewitness testimony in the form of misidentifications that led to convictions of innocent people (1). Of particular note are findings from the era of postconviction DNA profiling made possible by the development of the polymerase chain reaction, which enables amplification of crime-scene DNA to quantities sufficient for forensic analysis. To date, nearly 350 people, many serving lengthy prison sentences, have been exonerated because their own DNA was discovered to be incompatible with evidence long ago collected from the crime scene. In ∼70% of these cases, misidentification by one or more eyewitnesses contributed significantly as evidence for conviction (2).

The consequences of erroneous convictions based on flawed eyewitness accounts are profound and multifaceted. Hundreds of innocent people have spent many years of their lives behind bars while the perpetrators remain at large, the latter often committing additional crimes (3). Moreover, these outcomes risk undermining public trust in the criminal justice system, which can lead to social unrest and enmity directed at law enforcement and the courts. In light of these concerns, the National Academy of Sciences (NAS) recently assembled a committee of experts from fields of cognitive and neural science, statistics, law enforcement, and the courts, to undertake a comprehensive study of the causal factors behind eyewitness misidentification. This study, which was funded by the Laura and John Arnold Foundation and which I chaired, together with Judge Jed Rakoff of the US District Court for the Southern District of New York, focused on three areas of interest: (*i*) scientific evidence for limits on visual perception and memory, which in turn place constraints on the veracity of eyewitness reports; (*ii*) eyewitness identification practices used by law enforcement for criminal investigation and prosecution; and (*iii*) legal standards and practices for use of eyewitness evidence in the courtroom.

The work of this committee led to key findings and recommendations for reform, which are detailed in a consensus report entitled *Identifying the Culprit: Assessing Eyewitness Identification* (4). In the sections that follow, I primarily focus on the scientific issues that emerged from this study, particularly as they pertain to the problem of eyewitness misidentification. (The scientific interpretations and opinions expressed herein are my own. They are meant to summarize the relevant science, but they do not necessarily reflect the positions

[a]The Salk Institute for Biological Studies, La Jolla, CA 92037

Author contributions: T.D.A. wrote the paper.
The author declares no conflict of interest.
This article is a PNAS Direct Submission.

[1]Email: tom@salk.edu.

of the NAS consensus report on eyewitness identification.) This is accompanied by brief discussions of how these issues led to specific recommendations for additional research, best practices for law enforcement, and use of eyewitness evidence by the courts.

I Saw It With My Own Two Eyes

Throughout recorded history, people have borne witness to their sensory experiences. We routinely share first-person accounts of what we've seen or heard and do so in nearly every form of discourse, from gossipy descriptions of an encounter in the elevator to an exact observation from a laboratory experiment. Indeed, the ability to report our experiences is an irrepressible and highly valued human trait. Many ancient texts, such as the Hindu Smriti (Sanskrit for "that which is remembered"), consist of experience-based allegory for the benefit of society. Similarly, books of the *New Testament Bible* are said to be first-person accounts, and present-day memoirs do the same for life in our modern world. Bearing witness to what we've seen, with objectivity and precision, has long been part of the scientific method—from Kepler's testimony in support of the laws of planetary motion based on his surveillance of Mars, to Darwin's testimony in support of the theory of evolution based on his observations of Galapagos finches—and as new sciences evolve they rely upon increasingly sophisticated tools for improving the quality of observations and, hence, the validity of the resulting testimony.

Given this rich cultural history and our human predilection for reporting what we've seen, it's not surprising that the testimony of observers—eyewitnesses—is frequently sought to resolve disputes about actions or circumstances or to identify suspect objects. Decisions about the state of a game of sport, for example, are made by professional eyewitnesses known as umpires and referees. Professional eyewitnesses in the form of quality inspectors are used to identify defective products by their similarity to specific visual patterns previously seen. Luggage and freight inspectors serve a similar function for transportation security. Accidental eyewitnesses to daily events, ranging from the mundane to the tragic, are made every moment and are frequently called upon to support one or another version of what purportedly happened: Did the driver run the light? When did he leave the party? Who threw the first punch? Was the boat adrift in the canal? Was she the one who pulled the trigger?

All human efforts to bear witness can be characterized as gathering, interpreting, storing, and recalling information and, as such, depend fundamentally upon brain systems that mediate sensation, perception, and memory. Research over the past few decades has revealed much about how these systems work, particularly in the case of information received through the visual sense. One of the primary tasks undertaken by the NAS committee on eyewitness identification was to consider this body of research with an eye toward understanding what factors influence the performance of an eyewitness: to understand, in particular, why identification errors occur and what can be done to prevent them.

Variables That Influence Eyewitness Performance

Traditionally, the problem of eyewitness identification has been approached through applied research aimed at understanding how relevant variables influence the ability of a witness to correctly identify the culprit: that is, the "performance" of the eyewitness. Because a crime is an unexpected event (at least to an eyewitness), one can draw a natural distinction between variables that reflect the witness' unplanned situational or cognitive state at the time of the crime and variables that reflect controllable conditions and internal states following the witnessed events. Researchers categorize these factors, respectively, as estimator and system variables (5).

Estimator variables include such things as the viewing conditions (e.g., lighting, distance, duration), the presence of distracting stimuli (e.g., weapons, bright lights, loud noises), and internal states of the observer (e.g., attention, motivation, skill, prejudice). The criminal justice system has no control over these variables but they must be taken into account. System variables, by contrast, are those that can be controlled by the criminal justice system and include such things as the manner in which a lineup is presented to an eyewitness, the instructions given, and whether the lineup administrator is blind to the status of the lineup participants.

Estimator and system variables are often manipulated in laboratory studies that take the form of a staged crime followed by interrogation of the experimental subjects (the "eyewitnesses"). Three decades of such studies have quantified the effects of many of these variables on identification accuracy (6–20). Simply put, data on estimator variables tell us something about the probative value of eyewitness testimony—and thus the degree to which law enforcement and the courts should be circumspect—given the conditions under which a crime was witnessed. Data on system variables point to procedures actionable by law enforcement and the courts that may help lead to correct identifications and reduced likelihood of error. Indeed, several of the specific recommendations made by the NAS committee on eyewitness identification are derived from this research. These recommendations include, for example: (*i*) the use of lineup administrators who have no knowledge of which participant is the suspect (i.e., they are "blinded"), which precludes the possibility that the administrator could inadvertently influence the outcome (this is, of course, a standard method used to ensure objectivity in science, but it has not been standard practice in many law enforcement jurisdictions); and (*ii*) the use of standardized witness instructions designed to yield a consistent and conservative response.

A dominant theme in recent eyewitness research has been the possibility that lineup type (a system variable) might be manipulated to improve eyewitness performance. This possibility was first raised in 1985 following a study that compared the traditional lineup—"simultaneous"—in which all of the faces (typically six photographs) are presented to the eyewitness at the same time, with a novel lineup type—"sequential"—in which faces are presented one at a time (20). This study concluded that the sequential lineup was superior to simultaneous because it led to a reduction in the frequency of incorrect identifications. These early findings satisfied public desire to reduce the frequency of erroneous convictions and have inspired a number of legal jurisdictions to switch procedures (21). Subsequent studies using a more sophisticated statistical approach based on receiver operating characteristics indicate, however, that the primary effect of the sequential procedure is the elicitation of more conservative responses on the part of the eyewitness: witnesses simply make fewer lineup picks (17). Furthermore, several reports now suggest that witnesses are better able to optimize sensitivity to their memories—that is, they manifest better discriminability—when simultaneous lineups are used (17, 22–24). Future research may identify how variations of these or other lineup procedures can further improve performance, but the NAS committee on eyewitness identification concluded that there was not sufficient evidence to warrant a change from the traditional simultaneous procedure.

This large and growing body of applied eyewitness research has thus led to important practical steps toward improving the performance of eyewitnesses—including a remarkable recent update

of US Department of Justice guidelines for lineup procedures (25), which is based on the NAS recommendations (4)—and understanding the utility of their testimony. The value of this research notwithstanding, the approach is palliative, in that it aims to mitigate the symptoms but does little to address the underlying cause of failure. Eyewitness testimony reflects a decision made by a human observer based on things seen and remembered. It naturally follows that a causal and predictive understanding of why eyewitnesses make errors depends upon an appreciation of how human vision and memory work.

Why Eyewitnesses Fail

Broadly speaking, eyewitness misidentifications can be characterized as failures of visual perception or memory, the former being seeing things inaccurately, the latter being loss of accuracy or precision in the storage, maintenance, and recall of what was seen.

Believing Is Seeing. The first step toward correctly identifying something you've seen before is seeing it accurately to begin with. Research over the past few decades has revealed much about how vision works. Visual sensation is the initial process of detecting light and extracting basic image features. Sensations themselves are evanescent; only a small fraction of what is sensed is actually perceived. Attention is the filtering process by which information sensed by the visual system is selected for further processing. Perception is the process by which attended visual information is integrated, linked to environmental cause, made coherent, and categorized through the assignment of meaning, utility, value, and emotional valence. It is the things perceived that populate visual experience and memory.

The fidelity and significance of reported visual experience is necessarily limited by three related factors: uncertainty, bias, and confidence. (This is not unique to vision. These factors influence reports of any sensory experience.) Uncertainty here refers to the probabilistic nature of sensory signal detection in the presence of noise. Vision is plagued by noise from many natural sources, some associated with the structure of the visual environment (e.g., occluding surfaces, glare, shadows), some inherent to the optical and neuronal processes involved (e.g., refractive error or scattering of light in the eye), some reflecting sensory content not relevant to the observer's goals (e.g., a distracting sign or a loud sound). The presence of such noise leads to uncertainty about what we're actually looking at, such that any decision we might make or information that we store in memory has a significant likelihood of being wrong.

If uncertainty can be likened to a breakdown of accurate sensory communication, bias is the patch. Bias fills in the blanks when visual information is uncertain, fills them in with what we believe is likely to be out there based on prior experience. Formally, this characterizes vision as a problem of statistical inference, in which the observer infers properties of the world from data in the form of retinal images. Bias refers here to prior probabilities ("priors")—knowledge or dispositions derived from experience—that enable the observer to make context-dependent inferences about the environmental cause of visual stimulation. For example, prior knowledge that bank robbers carry guns enhances the probability that the bank robber will be perceived with gun in hand, even when the sensory evidence is equivocal. Because these biases are rooted in statistical regularities of our sensory world, they are commonly on target and grant us the perceptual certainty needed for survival in a noisy visual environment.

But there is a catch: This same system that grants certainty of perceptual experience in the face of noise is also capable of filling in the blanks with the wrong information. In other words, misinformed biases cause us to perceive or make decisions about things that don't exist. The coat rack may be experienced as an intruder in the hall, the shrubbery is mistaken for a police car, or the woman at the rendezvous point is wrongly identified as a friend. Similarly, uncertainty and bias can yield a situation in which information sensed by an eyewitness is of poor quality but the witness nonetheless perceives what he or she expects to see.

To make matters worse, the perceptual naiveté born from uncertainty and bias is often associated with misplaced confidence, which is arguably the most pernicious feature of eyewitness reports. An eyewitness may be wrong for the reasons described above, but a witness who testifies in court with confidence is generally very compelling to triers of fact (26). Contrary to common intuition, however, courtroom statements of confidence are very poor predictors of accuracy (26–29). The cause of this confidence–accuracy disparity is well captured by Daniel Kahneman's cognitive "illusion of validity" (30):

> Subjective confidence in a judgment is not a reasoned evaluation of the probability that this judgment is correct. Confidence is a feeling, which reflects the coherence of the information and the cognitive ease of processing it. ... Declarations of high confidence mainly tell you that an individual has constructed a coherent story in his mind, not necessarily that the story is true.

Coherence is the key here; observers become confident when multiple pieces of sensory evidence point to the same conclusion, even when the individual pieces are themselves sparse and unreliable. This is, of course, exactly what magicians aim for; they create conditions of uncertainty and introduce bias. In doing so, magicians leave the audience with a coherent but largely unsubstantiated body of evidence (the hat was normal and empty at the outset, there were no rabbits nearby)—and a strong sense of confidence—about something that didn't actually happen. (Reasoned evaluation of a magic trick will, of course, lead instead to the conclusion that the sensory evidence was unreliable and the observer has been "tricked," mainly because that is a known characteristic of the genre. But in the real world, similarly unreliable evidence is rarely questioned if it forms part of a coherent picture. This is true of eyewitness reports and it is a pervasive feature in many domains of human decision making, such as criminal investigation, medical diagnosis, strategic warfare, selecting a restaurant, or shopping for a new automobile.) But if the goal is to provide information sufficient for accurate visual identification or resolution of a dispute about things that actually happened, uncertainty, bias, and overconfidence create conditions prone to failure.

Memory is Malleable. The information perceived by an eyewitness is stored in memory, where it is made available for retrieval when called upon to identify a suspect. This type of memory is declarative, in that it consists of consciously accessible semantic and episodic content: the things perceived, their meaning, and sequence over time (31). It is mediated by brain systems different from those involved in visual perception and operates with different dynamics, but its products are similarly influenced by uncertainty, bias, and confidence.

Declarative memories are conceptualized as involving three core processes—encoding, storage, and retrieval—which refer, respectively, to the placement of items in memory, maintenance therein, and subsequent access to the stored information (32). These are not passive, static processes that record, retain, and divulge their contents in an informational vacuum, unaffected by outside influences. The contents cannot be treated as a veridical

permanent record, like photographs stored in a safe. On the contrary, the fidelity of our memories may be compromised by many factors at all stages of processing, from encoding through storage, to the final stages of retrieval (33–40).

Without awareness, we regularly encode information in a prejudiced manner and later forget, reconstruct, update, and distort the things we believe to be true. Uncertain memories of witnessed events may thus be biased readily by information subsequently gathered from numerous sources, including law enforcement, counsel, family, friends, and the press, all of which can reduce the likelihood that an eyewitness correctly identifies the culprit. In addition, the coherence of evidence from these multiple sources increases confidence in that remembered, even though the individual sources may themselves be unreliable and are unlikely to be independent purveyors of information.

The Identification Problem

To appreciate how vision and memory contribute to identification errors—and more generally how an understanding of this science can help to minimize such errors—it's useful to consider the task faced by an eyewitness. I'll use as a representative illustration an actual case of misidentification that played out over the past decade in San Diego, California (41).

In November of 2004, on the day before Thanksgiving, a 16-y-old high school student, known as Erika, was abducted by a man while walking to a friend's house. Erika's assailant threw her into the roadside bushes and sexually assaulted her. Erika punched her assailant repeatedly in the face with her CD player, eventually broke free, and was rescued by a passerby. There were two significant witnesses to this crime: Erika, of course, and a man by the name of Angel Rivera, who happened to be driving by. Both witnesses described the assailant as white, brown hair, mid-20s, about 5 feet, 10 inches, medium build, and wearing a goatee.

After doggedly following leads from the eyewitness accounts, the San Diego County Sheriff detained a 25-y-old construction worker named Uriah Courtney and presented him to the witnesses in a photo lineup (Fig. 1). Both witnesses picked Courtney. In the end, the prosecution's case rested solely on this testimony; not a shred of physical evidence came to light. In 2006, Uriah Courtney was found guilty by a San Diego jury and sentenced to life in prison. When Courtney was permitted to address the court, he maintained that he could not express remorse for a crime he did not commit. To his accuser, he simply said: "I am sorry, Erika, but you were mistaken in your identification of me as your attacker. It was a simple mistake, but one that has had monumental repercussions because now neither one of us are receiving the justice we deserve" (41).

In 2010 the California Innocence Project took up Uriah Courtney's case with the intent of reevaluating DNA from the victim's clothing. Analysis of samples conducted during the original investigation had proved inconclusive. The later analysis found that not only was the evidence incompatible with Courtney, but the DNA instead matched a former convict living not far from the crime scene. Based on this new evidence, Courtney's conviction was vacated and he was released from prison in 2013, after having served 8 y behind bars.

"A Simple Mistake"

Two eyewitnesses confidently testified before the San Diego Superior Court that Uriah Courtney was the perpetrator of a monstrous crime. These witnesses maintained with certainty that they had seen this very person, that they remembered him accurately and could identify him from a single photograph. They maintained not simply that Courtney's was the most familiar or likely face among the lineup photos, but that—against all odds—he was the one. Knowing well the consequences for the accused, and discounting any possibility of error, Erika pleaded to the Court for retribution. How could the eyewitnesses have been so wrong and yet so confident in their convictions? We can answer this question

Fig. 1. "Six-pack" photo lineup from *California v. Uriah Frank Courtney*, considered as a problem of statistical inference. Courtney is shown at *Lower Left*; the other five photos are of people known to be innocent (i.e., lineup "fillers"). Two eyewitnesses described Courtney as possessing a goatee, which means that they would have been biased to pick a lineup participant with that feature. Only two of the five fillers in this lineup (3, 6) have any facial hair at all and Courtney's goatee is the most visually conspicuous. This lineup configuration, in conjunction with the goatee prior, would naturally have led to a high likelihood of picking Courtney. Image courtesy of People's exhibit 10 of ref. 41.

by considering features of the case that could easily have led to uncertainty, bias, and overconfidence.

The viewing conditions during the crime were far from ideal, inevitably leading to uncertainty in efforts to perceive and remember the face of the assailant. The events transpired quickly, meaning that the witnesses had only a brief period to gather visual information. The events occurred in and adjacent to a dark tunnel formed by a freeway overpass, meaning that there was limited light available to see. The actors were moving erratically, meaning that it would have been difficult to scrutinize facial features. In attack, the assailant approached his victim from behind. In retreat, the assailant took measures to block visibility of his face using the brim of his hat, meaning that the witnesses had only partial information some of the time. In addition, the witnesses—particularly Erika—confronted events that would be expected to elicit strong emotional arousal and poorly focused attention. These situational and cognitive factors introduce noise to the process of acquiring accurate visual information, particularly about an unfamiliar face, meaning that any decision that these witnesses would have made based on visual information could easily have been wrong.

Visual uncertainty breeds bias, as observers turn in earnest to prior experiences or predispositions to resolve perceptual ambiguities. In the Courtney case one can distinguish at least three sources of bias present at the lineup identification stage that could have influenced the outcome. Most deliberate and egregious among these is the manner in which the lineup was constructed. A typical lineup consists of a photo of the suspect presented together with five photos of people known to be innocent, called fillers. Fillers are chosen uniquely for each case and drawn, ideally, from a diverse database. Published guidelines for filler selection state that lineups should be constructed to ensure that "the suspect does not unduly stand out," and to "avoid using fillers that so closely resemble the suspect that a person familiar with the suspect might find it difficult to distinguish the suspect from the fillers" (42). This counsel—fillers should be similar to the suspect but not too much so—is clearly open to interpretation and often applied by different agents in different ways.

Consider the Courtney lineup shown in Fig. 1. Erika reported that her assailant possessed a goatee, which means that in the face of uncertainty at the identification stage she would have relied on this prior information to make a decision. Only two of the five fillers in the Courtney lineup have facial hair (one of these marginally so) and Courtney's goatee is the most visually conspicuous. This poorly chosen lineup would have markedly increased the probability of selecting Courtney, even though Erika's initial observations of the assailant were limited by visual noise.

A second source of potential bias in the Courtney identification stems from the fact that the lineup administrator was not blind to the status of the lineup participants. This opens the possibility that the administrator may have covertly conveyed information—through eye movements, body posture, facial expressions, verbal responses—that could have been unconsciously received by a witness bedeviled by uncertainty, and thus influenced judgments of identity.

A third source of potential bias is tied to a well-documented perceptual phenomenon known as the "own-race bias," in which people experience greater difficulty discriminating among faces of a race different from their own (8, 43). Evidence indicates that this is an experience-dependent perceptual phenomenon (44, 45), a product of "perceptual learning" that occurs when people are predominantly exposed to and positioned to make decisions about individuals of their own race. The result is a visual predisposition or bias for details of variation among faces of the commonly experienced race, whereas faces of other races are perceived more categorically. As for other estimator variables (45), the effect of the own-race bias on eyewitness performance can be particularly pronounced under conditions of noise and uncertainty (47). One of the eyewitnesses in the Courtney case, Angel Rivera, was Latino and the six lineup participants were non-Latino Caucasian. (Latinos are ethnically distinct but can be of the same race as non-Latino Caucasians. The own-race bias applies nonetheless because of average differences in facial appearance between the two groups.) The possibility thus exists that Rivera had an experience-dependent predisposition that could have severely limited his ability to perceive, memorize, recall, and discriminate among faces similar to that of the culprit.

Finally, the Courtney case highlights the problem of confidence. Although their testimony was likely flawed because of uncertainty and bias, both witnesses addressed the court with great confidence in their choices (41):

> Prosecution: Are you sure the defendant is the person that attacked you?
>
> Erika: Yes, I'm sure.
>
> Prosecution: Any doubt in your mind?
>
> Erika: No.... I will never forget what he looks like.
>
> Prosecution: Do you have any doubt that the defendant was the one that attacked Erika?
>
> Angel Rivera: Not at all.

When asked to testify, the implicit task of an eyewitness is to tell a coherent story. Witnesses commonly do so by knitting together multiple pieces of information, including their own sensory experiences during the crime, the lineup identification experience, and reports of others. Through this process, the validity of individual pieces of information often becomes less important than the extent to which they support a common interpretation [this is Kahneman's "illusion of validity" (30)]. In this regard, a notable feature of the Courtney case is the fact that two witnesses made the same choice. This outcome would be expected to markedly increase the confidence of each witness because it gives the appearance of independent confirmation, even though the correlated misidentifications have the same root causes in uncertainty and bias. Needless to say, if a jury is not fully aware of these scientific issues, confident testimony of this sort can be extremely difficult to discount.

What to Do

The ability of an eyewitness to identify a suspect is a specific example of a general class of problems in which humans must make decisions about things they've seen before: finding the luggage on the carousel, the car in the parking lot, the stapler on the desk, a weapon in the luggage, or a tumor in the tissue. Whereas applied research suggests methods that might improve performance on such tasks, knowledge of the mechanisms and functional capacities of human vision and memory offers a more principled understanding of why people fail at identification problems. This understanding, in turn, grants the ability to predict conditions under which failure is likely to occur and to develop strategies to mitigate or circumvent those conditions. As we have seen, this understanding points to three broad types of problems associated with human decisions based on vision and memory: uncertainty, bias, and confidence. [It's worth noting that these problems, and the suggested solutions, also apply to the broad class of forensic procedures, known as subjective

feature comparison methods (e.g. forensic fingerprint analysis), which rely on human decisions informed by vision and memory.]

Uncertainty will not go away because it reflects accidental viewing conditions of a time gone by. However, it can be quantified and understood as a factor that correlates with the probability of a correct identification. Promising new approaches in this area use generalized linear models based on manifold variables (e.g., viewing conditions, perceptual/cognitive states) that have known effects on visual uncertainty. Such models have long been used in basic research on sensory and memory function and they may be used to estimate the likelihood of a correct identification given a specific set of conditions, in a manner analogous to their use in medical practice (48, 49).

Bias is arguably a more tractable problem, in that many forms—once recognized as such—can either be accounted for in eyewitness testimony or prevented altogether. Predispositions rooted deeply in a witness' experiential history, such as the own-race bias, can be included as factors in predictive models. Other types of bias, such as those induced by the lineup identification process—nonblinded procedures, poor filler selection—can be eliminated by protocol changes that promote objective identification.

Confidence is born from a deeply ingrained and nearly ubiquitous feature of human cognition: the unconsciously prejudiced gathering of information to support a hypothesis (a process commonly known as "confirmation bias"). Empirical sciences go to great lengths to avoid this human pitfall—scientific conclusions are based on many individual and independent measurements that are themselves held to a high standard of validity—but this is not how people normally develop confidence in their decisions. The phenomenon of "confidence inflation," which refers to the increased confidence expressed by a witness that occurs with the passage of time, surely reflects unconsciously prejudiced gathering of information to support identification. Witnesses talk to other witnesses, listen to media reports of their own actions, and tell their stories to others who appear to believe them, all of which is reinforcing of the original identification and gives the illusion of confirmation by independent sources. In addition, a witness' repeated retrieval of the memory of having picked a particular face from a lineup serves to strengthen the memory of the selected face, which is likely, in turn, to increase the witness' confidence in the decision. The accuracy of a lineup pick never changes, of course, but the false certainty conveyed by a witness with inflated confidence is likely to have undue influence over triers of fact.

Viewed in this way, the solution is to limit access to information. The most effective way to accomplish this is to obtain a measure of confidence at the time of the initial lineup identification: that is, before potential access to other sources of information. Any subsequent expressions of confidence are at risk for being artificially inflated. For these reasons, the NAS committee on eyewitness identification recommended "that law enforcement document the witness' level of confidence verbatim at the time when she or he first identifies a suspect" (4). Studies published since the NAS report was released demonstrate that expressions of confidence made at the time of the initial identification are indeed highly correlated with identification accuracy (46, 50). Seen in this light, the conviction of Uriah Courtney is all the more tragic given that Erika expressed considerable uncertainty in her initial lineup identification (41).

Science in the Courtroom?

Our understanding of human vision and memory has advanced greatly in recent years, shedding much light on the potential benefits and weaknesses of eyewitness testimony. Despite these advances, the legal standard for use of eyewitness evidence in the courtroom remains rooted in the 1977 US Supreme Court ruling in *Manson v. Brathwaite* (51). To protect the rights of individuals charged, in accordance with the Due Process Clause of the United States Constitution, this ruling defines a test for admissibility of eyewitness evidence. Unfortunately, the scope of this test derives from judicial precedents rather than modern science, and is founded on the premise that "reliability is the linchpin in determining the admissibility of identification testimony" (51). Although reliability is surely important, the Court's test consists of a checklist of factors that collectively are not particularly good indicators of reliability (52; but see ref. 50).

More recent state court rulings on admissibility of eyewitness evidence have incorporated science to a greater degree (53, 54). However, in light of newer scientific understanding of why eyewitnesses fail, the NAS committee made a number of specific recommendations intended to further strengthen the value of eyewitness evidence in the courtroom. These recommendations, which include the use of pretrial judicial inquiries and scientific expert testimony, are intended to lay bare conditions that could have led to uncertainty, bias, and overconfidence on the part of an eyewitness. The NAS report (4) also stressed that juries should be made aware of any identifications that occurred before the trial, because expressed confidence at earlier time points is more likely to reflect identification accuracy. Together, these recommended measures should clarify the probative value of the evidence such that judges and juries can either exclude or weight it accordingly.

Summary and Conclusions

It's human nature to report what we see and remember. Not surprisingly, criminal investigations and prosecutions have long relied upon the accounts of eyewitnesses. In adjudication, judges and juries have similarly long embraced self-assured reports of what was seen. This bubble of complacency has been burst in recent years, however, by two pointed facts: (*i*) postconviction DNA analyses reveal that eyewitnesses sometimes identify the wrong people, and (*ii*) the sciences of vision and memory indicate that wrongful conviction based on eyewitness testimony is likely a priori, given conditions of uncertainty, bias, and overconfidence. The NAS report on eyewitness identification (4) has led to practical reforms (25), but the larger message of the report is the promise of a long-overdue partnership between science and law. This is a case in which modern science is now having a profound influence over a critical matter of public policy, legal practice, and judicial standards, and in doing so brings our society to a place of greater justice.

Acknowledgments

This National Academy of Sciences consensus report upon which this review is based was the work of an extremely talented and dedicated group of people that includes committee members and National Academy of Sciences staff. I am grateful for the education and insights that I gained from these colleagues, as well as from the many experts who informed and reviewed the work of the committee.

1 Garrett B (2011) *Convicting the Innocent: Where Criminal Prosecutions Go Wrong* (Harvard Univ Press, Cambridge, MA).
2 Innocence Project (2017) Eyewitness Misidentification. Available at https://www.innocenceproject.org/causes/eyewitness-misidentification. Accessed April 16, 2017.
3 Innocence Project (2017) Cases. Available at https://www.innocenceproject.org/cases. Accessed April 17, 2017.

4 National Research Council (2014) *Identifying the Culprit: Assessing Eyewitness Identification* (National Academies, Washington, DC).
5 Wells GL (1978) Applied eyewitness-testimony research: System variables and estimator variables. *J Pers Soc Psychol* 36:1546–1557.
6 Deffenbacher KA, Bornstein BH, Penrod SD, McGorty EK (2004) A meta-analytic review of the effects of high stress on eyewitness memory. *Law Hum Behav* 28:687–706.
7 Fawcett JM, Russell EJ, Peace KA, Christie J (2013) Of guns and geese: A meta-analytic review of the 'Weapon Focus' literature. *Psychol Crime Law* 19:35–66.
8 Meissner CA, Brigham JC (2001) Thirty years of investigating the own-race bias in memory for faces—A meta-analytic review. *Psychol Public Policy Law* 7:3–35.
9 Fitzgerald RJ, Price HL, Oriet C, Charman SD (2013) The effect of suspect-filler similarity on eyewitness identification decisions: A meta-analysis. *Psychol Public Policy Law* 19:151–164.
10 Steblay N, Dysart J, Fulero S, Lindsay RCL (2001) Eyewitness accuracy rates in sequential and simultaneous lineup presentations: A meta-analytic comparison. *Law Hum Behav* 25:459–473.
11 Steblay NK, Dysart JE, Wells GL (2011) Seventy-two tests of the sequential lineup superiority effect: A meta-analysis and policy discussion. *Psychol Public Policy Law* 17:99–139.
12 Gronlund SD, Carlson CA, Dailey SB, Goodsell CA (2009) Robustness of the sequential lineup advantage. *J Exp Psychol Appl* 15:140–152.
13 Gronlund SD, Wixted JT, Mickes L (2014) Evaluating eyewitness identification procedures using ROC analysis. *Curr Dir Psychol Sci* 23:3–10.
14 Carlson CA, Gronlund SD, Clark SE (2008) Lineup composition, suspect position, and the sequential lineup advantage. *J Exp Psychol Appl* 14:118–128.
15 Clark SE, Moreland MB, Gronlund SD (2014) Evolution of the empirical and theoretical foundations of eyewitness identification reform. *Psychon Bull Rev* 21:251–267.
16 Wells GL (2014) Eyewitness identification: Probative value, criterion shifts, and policy regarding the sequential lineup. *Curr Dir Psychol Sci* 23:11–16.
17 Mickes L, Flowe HD, Wixted JT (2012) Receiver operating characteristic analysis of eyewitness memory: Comparing the diagnostic accuracy of simultaneous versus sequential lineups. *J Exp Psychol Appl* 18:361–376.
18 Meissner CA, Tredoux CG, Parker JF, MacLin OH (2005) Eyewitness decisions in simultaneous and sequential lineups: A dual-process signal detection theory analysis. *Mem Cognit* 33:783–792.
19 Palmer MA, Brewer N (2012) Sequential lineup presentation promotes less-biased criterion setting but does not improve discriminability. *Law Hum Behav* 36:247–255.
20 Lindsay RCL, Wells GL (1985) Improving eyewitness identifications from lineups: Simultaneous versus sequential lineup presentation. *J Appl Psychol* 70:556–564.
21 Police Executive Research Forum (2013) *A National Survey of Eyewitness Identification Procedures in Law Enforcement Agencies* (US Department of Justice, Washington, DC).
22 Carlson CA, Carlson MA (2014) An evaluation of lineup presentation, weapon presence, and a distinctive feature using ROC analysis. *J Appl Res Mem Cogn* 3:45–53.
23 Wixted JT, Mickes L, Dunn JC, Clark SE, Wells W (2016) Estimating the reliability of eyewitness identifications from police lineups. *Proc Natl Acad Sci USA* 113:304–309.
24 Amendola KL, Wixted JT (2015) Comparing the diagnostic accuracy of suspect identifications made by actual eyewitnesses from simultaneous and sequential lineups in a randomized field trial. *J Exp Criminol* 11:263–284.
25 US Department of Justice (2017) Eyewitness identification procedures for conducting photo arrays. Available at https://www.justice.gov/file/923201/download. Accessed April 17, 2017.
26 Wells GL, Lindsay RC, Ferguson TJ (1979) Accuracy, confidence, and juror perceptions in eyewitness identification. *J Appl Psychol* 64:440–448.
27 Wells GL, Murray DM (1984) Eyewitness confidence. *Eyewitness Testimony: Psychological Perspectives*, eds Wells GL, Loftus EF (Cambridge Univ Press, New York).
28 Lindsay RCL, Wells GL, O'Connor FJ (1989) Mock-juror belief of accurate and inaccurate eyewitnesses: A replication and extension. *Law Hum Behav* 13:333–339.
29 Roediger HL, Wixted JT, DeSoto KA (2012) The curious complexity between confidence and accuracy in reports from memory. *Memory and Law*, eds Nadel L, Sinnott-Armstrong WP (Oxford Univ Press, Oxford).
30 Kahneman D (2011) *Thinking, Fast and Slow* (Farrar, Straus and Giroux, New York).
31 Tulving E (1972) Episodic and semantic memory. *Organization of Memory*, eds Tulving E, Donaldson W (Academic, New York).
32 Tulving E (1995) Organization of memory: Quo vadis? *The Cognitive Neurosciences*, ed Gazzaniga MS (MIT Press, Cambridge, MA).
33 Wixted JT (2004) The psychology and neuroscience of forgetting. *Annu Rev Psychol* 55:235–269.
34 Tulving E, Thomson DM (1973) Encoding specificity and retrieval processes in episodic memory. *Psychol Rev* 80:352–373.
35 Dudai Y (2006) Reconsolidation: The advantage of being refocused. *Curr Opin Neurobiol* 16:174–178.
36 Loftus EF (2005) Planting misinformation in the human mind: A 30-year investigation of the malleability of memory. *Learn Mem* 12:361–366.
37 Bjork RA (1992) Interference and memory. *Encyclopedia of Learning and Memory*, ed Squire LR (Macmillan, New York).
38 McGeoch JA (1932) Forgetting and the law of disuse. *Psychol Rev* 39:352–370.
39 Jenkins JG, Dallenbach KM (1924) Obliviscence during sleep and waking. *Am J Psychol* 35:605–612.
40 Underwood BJ, Postman L (1960) Extraexperimental sources of interference in forgeting. *Psychol Rev* 67:73–95.
41 *People of the State of California v. Uriah Frank Courtney*, Superior Court of California, County of San Diego, Case No. SCD189717 (2005–2007).
42 National Institute of Justice Technical Working Group for Eyewitness Evidence (2003) *Eyewitness Evidence: A Trainer's Manual for Law Enforcement* (US Dept. of Justice, Office of Justice Programs, National Institute of Justice, Washington, DC).
43 Malpass RS, Kravitz J (1969) Recognition for faces of own and other race. *J Pers Soc Psychol* 13:330–334.
44 Young SG, Hugenberg K, Bernstein MJ, Sacco DF (2012) Perception and motivation in face recognition: A critical review of theories of the Cross-Race Effect. *Pers Soc Psychol Rev* 16:116–142.
45 Cross JF, Cross J, Daly J (1971) Sex, race, age, and beauty as factors in recognition of faces. *Percept Psychophys* 10:393–396.
46 Wixted JT, Wells GL (2017) The relationship between eyewitness confidence and identification accuracy: A new synthesis. *Psychol Sci Public Interest* 18:10–65.
47 Fiske S, Taylor S (1991) *Social Cognition* (McGraw-Hill, New York).
48 Lindsey JK, Jones B (1998) Choosing among generalized linear models applied to medical data. *Stat Med* 17:59–68.
49 Song L, Langfelder P, Horvath S (2013) Random generalized linear model: A highly accurate and interpretable ensemble predictor. *BMC Bioinformatics* 14:5.
50 Wixted JT, Mickes L, Clark SE, Gronlund SD, Roediger HL, 3rd (2015) Initial eyewitness confidence reliably predicts eyewitness identification accuracy. *Am Psychol* 70:515–526.
51 Manson v. Brathwaite, 432 US 98 (1977).
52 O'Toole T, Shay G (2006) *Manson v. Brathwaite* revisited: Towards a new rule of decision for due process challenges to eyewitness identification procedures. *Valparaiso Univ Law Rev* 41:109–148.
53 State v. Henderson, 27 A.3d 872 (NJ 2011).
54 State v. Lawson, 352 Ore. 724 (Or. 2012).