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Computerized image processing in the Reginald Denny beating trial

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ABSTRACT

New image processing techniques may have significant benefits to law enforcement officials but need to be legally admissible in court. Courts have different tests for the determining the admissibility of new scientific procedures, requiring their reliability to be established by expert testimony. The first test developed was whether there has been general acceptance of the new procedure within the scientific community. In 1993 the U.S. Supreme Court loosened the requirements for admissibility of new scientific techniques, although the California Supreme Court later retained the general acceptance test. What the proper standard is for admission of such evidence is important to both the technical community and to the legal community because of the conflict between benefits of rapidly developing technology, and the dangers of "junk science."

The Reginald Denny beating case from the 1992 Los Angeles riots proved the value of computerized image processing in identifying persons committing crimes on videotape. The segmentation process was used to establish the presence of a tattoo on one defendant, which was key in his identification. Following the defendant's conviction, the California Court of Appeal approved the use of the evidence involving the segmentation process. This published opinion may be cited as legal precedent.

Keywords: Image Processing, Computer, Segmentation, Court, Admissibility, Evidence, Expert Testimony

1. TECHNOLOGY IN THE COURTS

As the twentieth century draws to a close, we can look back on a revolution in image processing and restoration, or what the public commonly refers to as "enhancement." Motion pictures, television, video, and the more recent processes of digitizing and clarifying images with powerful computers have been both a boon and a curse to courtroom prosecutors. On one hand, these new processes have enabled the identification and conviction of criminals caught on film or video committing crimes. Such was the case in what has become known as "the Reginald Denny beating case" in Los Angeles. On the other hand, modern science and the entertainment industry have raised public expectations about the perceived near-magical powers of law enforcement in the field of suspect identification. Scientific advances in this field have necessitated often complex evidentiary examinations before these new advances can be admitted in courts of law.

Technological advances in one field can inadvertently cause problems or unintended consequences in another. One of the problems caused by rapidly advancing technology is that of creating unrealistic expectations on the part of the public in the capabilities of law enforcement and the courts. Today the public often expects magic in the courtroom. Just as Hollywood writers have the public believing that all homicides are solved in the 44 minutes allotted between commercials, the movie and TV studios have caused much of the public to believe that all police and prosecutors have the latest Buck Rogers and Star Trek type state-of-the-art technologies and tools available. Add to this the 15-second attention span of the MTV Generation and one can appreciate the real problems prosecutors face in presenting criminal trials to today's juries.

Unfortunately, while cutting-edge technology may be available in industry and academia, it is not often available to cash-strapped local governments trying to keep schools, hospitals, and libraries open, while at the same time keeping police officers on the beat. Just because certain high-technology tools may have been used in a few recent highly-publicized cases does not mean that these tools are generally available in most courtrooms. Few prosecutors in the "trenches" have the resources to be able to utilize such tools and techniques. Most line prosecutors still produce argument charts on butcher paper with felt tip markers. But as new technology becomes more prevalent throughout society, it increasingly creeps into our courts. The questions presented to prosecutors are how to use what new technology is available and how best to present it in court, if it can be legally admitted into evidence.

2. LEGAL ISSUES INVOLVING NEW TECHNOLOGY

2.1. Foundations and expert witnesses

Pictures, whether still, moving, or video, are considered "writings" in the law.¹ As such they are subject to the standard rules of evidence that govern all courts. Most commonly, they need authentication, establishing that they are in fact what they appear to be. They also need foundation. Just as realtors say "location, location, location," lawyers using scientific evidence say "foundation, foundation, foundation." Foundation in the law is what it sounds like - - - the basis, the establishment of the lowest element or fact, which supports the rest of the evidence. Writings and pictures must be shown to be reliable and trustworthy, that they are accurate representations of what they show. Any witness may be able to authenticate a simple photograph, for example, even a competent child can testify about what is shown in the photo and that is a true picture. But for scientific and technical work like advanced computerized image processing, an expert witness is needed to lay the appropriate foundation. A person is qualified to testify as an expert if he has special knowledge, skill, experience, training, or education sufficient to qualify him as an expert on the subject to which his testimony relates."² An expert witness may be allowed to testify as to his or her opinion, called an expert opinion.³ Non-expert witnesses are generally precluded from testifying about their opinions. First the witness must be established as an expert, *i.e.*, setting forth his qualifications, credentials, training, education and experience. Then the reliability or validity of the scientific procedure must be established. Expert witnesses are needed to lay the foundations for scientific applications such as image processing and other new technological tools before evidence about the use of such applications may be received in court. What guidelines should be used to determine whether a new scientific procedure should be admitted into court is a question that has been evolving in the courts in recent years. With the explosion in scientific discovery and invention in the late twentieth century, courts need to allow the use of valid new procedures by litigants but at the same time keep out frivolous and unmeritorious contentions, sometimes referred to as "junk science."

2.2 Developing standards for admissibility of evidence

2.2.1. General acceptance test

In 1923 the U. S. Court of Appeals decided a case about an early version of the polygraph, *Frye v. United States* (D.C. Cir. 1923) 293 F. 1013 [54 App.D.C. 46]. The court ruled that evidence about the machine was not admissible because there was no evidence that use of such a machine for this purpose was generally accepted within the scientific community.

"Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs."⁴

Frye made "general acceptance" the exclusive test for admission of scientific evidence. Usually courts don't like to decide things if they don't have to. Appellate courts do not want to burden the lower trial courts with having to determine the validity of every new scientific theory or technique on a case-by-case basis; they would rather leave such determinations to experts in the relevant field. By making general acceptance within the scientific community the exclusive test for the admissibility of new scientific procedures, the trial courts are freed from having to make such determinations.

In 1975 Congress adopted the Federal Rules of Evidence (FRE). These rules codified procedures governing the admissibility of evidence in federal courts. The FRE adopted what many consider a liberal rule regarding the admissibility of evidence.⁵ All relevant evidence is admissible unless made inadmissible by the FRE.⁶ The FRE also provided for expert witnesses to testify about their opinion in certain situations:

"If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise." (Rule 702, FRE.)

In 1976 the California Supreme Court decided a case involving the spectroscopic analysis of voice prints for identification. (*People v. Kelly* (1976) 17 Cal.3d 24 [130 Cal.Rptr.144, 549 P.2d 1240].) The *Kelly* decision set forth general principles for the admissibility of expert testimony based on new scientific procedures and technologies. *Kelly* established a three-pronged test:

1. Establish the reliability of the method used, usually by means of expert testimony;
2. Properly qualify the witness as an expert on the subject; and
3. Demonstrate that correct scientific procedures were used.

Kelly thus adopted the *Frye* standard of general acceptance in the scientific community. Hearings on the admissibility of such evidence using these principles have come to be known variously as "*Frye*" or "*Kelly*" or "*Kelly-Frye*" hearings.

2.2.2. *Daubert* test

In 1993 the United States Supreme Court decided *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, (1993) 509 U.S. ___, 125 L.Ed.2d 469, 113 S.Ct. 2786. The case involved birth defects alleged to have been caused by an anti-nausea drug taken by a pregnant woman. These allegations were based on live animal studies, comparisons of the structure of the drug with structures of other defect-causing substances, and the "reanalysis" of previously published epidemiological studies. The case went to the Supreme Court on the issue of whether the Federal Rules of Evidence adopted by Congress in 1976 had superseded *Frye*. The question to be decided was what is the proper standard for admitting expert scientific testimony in federal courts.⁷ The *Daubert* case was especially important to both the scientific and the legal communities due to the rise of so-called "junk science," *i.e.*, novel theories, approaches, interpretations or procedures supported by one or more "experts," but which have not been adopted by the mainstream of the scientific community. This is not just an academic or intellectual problem. Courts, with limited time or resources for serious lawsuits, need to weed out frivolous ones, particularly those based on supposedly new breakthroughs in science.⁸ Everyone recalls the furor over the discovery of "cold fusion." But others in the scientific community are quick to point out that some of the great scientific advances were made by individuals who were not initially accepted by the rest of their peers. Courts are concerned about the impact of such scientific controversies on juries trying to decide facts in a case. Justice Blackmun, in the *Daubert* opinion, noted the concern of those worried about junk science being allowed into courts if *Frye* were abandoned, that it would result in a "free-for-all" in which befuddled juries are confounded by absurd and irrational pseudoscientific assertions."⁹ He wrote that such concerns were "overly pessimistic about the capabilities of the jury, and of the adversary system generally. Vigorous cross-examination, presentation of contrary evidence, and careful instruction on the burden of proof are the traditional and appropriate means of attacking shaky but admissible evidence."¹⁰ Justice Blackmun also noted the concerns of the other side, that allowing judges to have a screening role for scientific evidence would stifle scientific inquiry and would be inimical to the search for truth. He noted that "there are important differences between the quest for truth in the courtroom and the quest for truth in the laboratory. Scientific conclusions are subject to perpetual revision. Law, on the other hand, must resolve disputes finally and quickly. ... That, nevertheless, is the balance that is struck by Rules of Evidence designed not for the exhaustive search for cosmic understanding but for the particularized resolution of legal disputes."¹¹

In its decision in *Daubert* the Supreme Court held that *Frye* was "too austere" a standard and should not be used in federal trials. The court suggested several factors to guide trial judges deciding on the admissibility of new techniques:

1. Whether the theory or technique can or has been tested;
2. Whether it has been subjected to peer review and publication;
3. In the case of a specific technique, its known or potential error rate and the existence and maintenance of standards controlling the technique's operation; and finally,
4. The theory or technique's general acceptance within the scientific community.¹²

The *Frye* standard therefore can still be an important factor, although it is no longer the exclusive factor, in determining the admissibility of a new scientific procedure. The court said that "a known technique that has been able to attract only minimal support" within the scientific community "may properly be viewed with skepticism."¹³ The court summarized its rule by stating that "general acceptance [*i.e.*, consensus from a typical cross-section of the relevant qualified scientific community] is not a necessary precondition to the admissibility of scientific evidence."¹⁴ *Daubert* thus defined what establishes good science - - - the reliability and validity of its methods.

2.2.3. California standard

In 1994 the California Supreme Court revisited the issue of the appropriate standard in *People v. Leahy*, (1994) 8 Cal.4th 587, regarding the use of the horizontal gaze nystagmus test in drunk driving cases. The question in *Leahy* was whether *Kelly* remained the standard in California or whether the new *Daubert* standard should be adopted. Because the California Supreme Court is often viewed as a leader of state courts nationally, this decision was closely watched.¹⁵ This issue of which standard to follow, *Kelly* or *Daubert*, created some interesting divisions within the California legal community. The Orange County District Attorney, prosecuting defendant Leahy, and the Orange County Public Defender, representing Leahy, both requested the California

Supreme Court to retain *Kelly* as the standard. Both offices were supported by the Los Angeles District Attorney in this request. However, the California Attorney General and the California District Attorneys Association (CDAA) wanted the California court to follow *Daubert*. The Attorney General and CDAA were concerned that the more restrictive *Kelly* test might keep rapidly advancing new scientific developments, such as new DNA techniques for identification from being allowed into evidence.

The California Supreme Court addressed the various concerns and issues addressed in *Daubert*, and the particular concern that retaining *Kelly-Frye* could adversely impact the admissibility of new DNA procedures. It rejected these concerns, noting that the DNA questions were not properly before the court. The court ruled that the *Kelly-Frye* test for admissibility of scientific tests had survived *Daubert* and remained the standard in California courts.¹⁶

3. The Reginald Denny Beating Case - A Case Study

One of the most recent cases decided in California on the issue of admissibility of new scientific procedures was *People v. Williams*, (1996) 46 Cal.App.4th 1767, a decision arising from the conviction of one of the attackers in the Reginald Denny beating case at the start of the Los Angeles riots in 1992. In *Williams* the California Court of Appeal approved the trial court's ruling which had allowed the admission of evidence about the segmentation process of image processing after the trial court had conducted a *Kelly-Frye* hearing.

3.1. Crimes and investigation

The Los Angeles Riots erupted on April 29, 1992 after a jury in Ventura County acquitted four Los Angeles Police Department officers of the videotaped beating of Rodney King. Also caught on videotape was the beating of trucker Reginald Denny, who had the misfortune to stop his gravel truck at the intersection of Florence and Normandie at the time the riots began. This beating became a symbol of the riots because it was broadcast live into people's homes from a television news helicopter. See figure 1. Photos of this senseless assault were on the front pages of many newspapers and on the covers of national magazines. Reginald Denny survived his near-fatal attack, but more than 50 people were killed, more than 2300 were injured, and property damage was over \$1 billion. It took the National Guard to restore calm to the city.

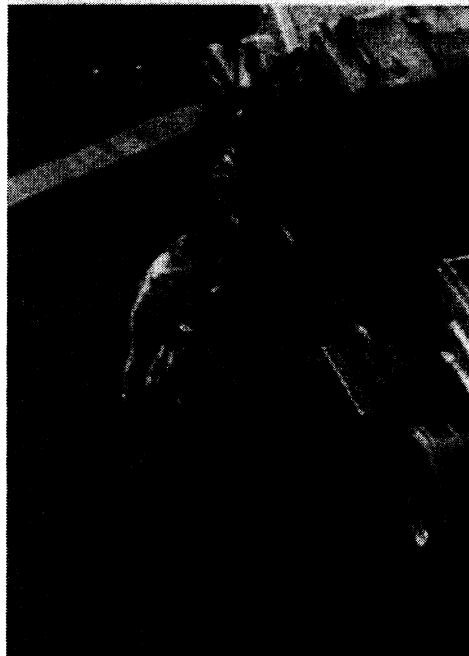


Fig. 1. Damian Williams throwing the brick into Reginald Denny's head.

Following the riots, the Los Angeles Police Department and Federal Bureau Investigation established a joint taskforce, with legal representatives from the Los Angeles District Attorney and the United States Attorney's Office in Los Angeles.¹⁷ The mission of the taskforce was to investigate, identify, and arrest those responsible for crimes against the many victims of violence at Florence and Normandie intersection. The crimes against some of the victims were recorded on videotape, yet a number of those victims were never identified, as they never made police reports. Other victims reported serious crimes committed against them, but the crimes were not seen on video and there was insufficient evidence to identify the attackers.

Bob Tur, a radio-TV journalist, had kept his helicopter circling over Florence and Normandie, and had broadcast the attacks on Reginald Denny and many others, live, as they occurred. Tur had also watched the Denny attack through his binoculars from 70 feet above the street. Alone among local TV station reporters, Tur provided investigators with his footage, and also agreed to testify against the criminals as a percipient witness.

As the investigation of the attacks on Reginald Denny and over twenty-five other victims at Florence and Normandie began, many people thought, "what an easy case, it's all on videotape!" However, experienced investigators know that there is a big difference between having a video of crimes and learning the identity of the perpetrators. Once the criminals are identified, they have to be captured and then prosecuted in court.

After the videotape of the Rodney King beating had become famous worldwide, many people flocked to scenes of natural disasters or police activity with video cameras, with the hope of becoming rich or famous by selling their work to the media. Investigators knew that among the hundreds of people milling around the intersection that fateful day were several video and still photographers who had recorded some of the violence as it occurred. But none of these photographers came forward to assist investigators in identifying the criminals.

Investigators quickly identified one man who had been taking videos of the Denny attack. He was a convicted felon who later said that he had gone there to "capture the excitement." Using a court-issued search warrant, investigators obtained this man's videotape. In addition to a ground-level video of the attack on Reginald Denny, the investigators saw many other vicious attacks on innocent motorists that had been captured by the video photographer but had not been broadcast by news helicopters. Within five days of its formation, the "Flo-Nor Taskforce," as it came to be called, had identified and arrested four men who had participated in crimes at Florence and Normandie. They were identified as Damian "Football" Williams, Henry "Kiki" Watson, Antoine "Twan" Miller, and Gary Williams (no relation to Damian Williams).¹⁸ Investigators could see on the videos that Miller had opened the door of Denny's truck so that another man could pull Denny out of his truck and hurl him to the ground where the others waited. Watson had put his foot on Denny's neck to hold him down while Williams and others prepared to attack Denny. Damian Williams had thrown the brick into Reginald Denny's head, and then had raised his arms over his head as if celebrating a football touchdown. Miller also stole property from Denny's truck. Gary Williams had picked Denny's pockets as he lay on the ground after Damian Williams' near fatal attack.

Because Gary Williams had not directly attacked Denny, a separate case was filed in court against him, charging him with attempted robbery. When investigators obtained additional ground-level videos, they identified Gary Williams as being one of the first attackers of another victim at Florence and Normandie, Fidel Lopez, and Gary Williams was also charged with attacking Lopez. After Lopez had been savagely beaten into unconsciousness and lay helpless on the ground, Damian Williams had sprayed paint onto Lopez' face, chest and exposed genitals. Investigators identified Damian Williams as the man who spray-painted Lopez after they recovered another ground-level video taken by an amateur cameraman, using another court-issued search warrant.

As the cases moved through the courts toward trial, the paramount problem became how to prove that the defendants in court were in fact the attackers captured on the various videos. By the time of trial, defendants in court rarely look exactly like they do at the time they committed their crimes. Variations in weight, hair styles and facial hair are common in such cases. Indeed, defendants themselves may deliberately create such changes in an attempt to evade identification. Few of the known victims could identify their attackers because of the sudden ferocity of the attacks and the fact that so many attackers were involved. Many of the victims had no clear picture of what had actually happened to them until investigators showed them the videos of the crimes committed against them. Bob Tur, the helicopter newsman, was the only percipient witness to come forward at the outset. A later-discovered victim had also seen the Denny attack but had given inconsistent statements to investigators. Certain confidential police informants had identified Denny's attackers from the videos, but faced life-threatening retaliation if they testified in court. A police officer who knew Damian Williams, and had originally identified him on the video of the Denny attack, later came under police investigation for unrelated matters and therefore could not be used as a witness in court.

Part of the identification of Damian Williams came from tracing his distinctive body movements through the videos, as well as his certain distinctive marks on his clothing. Representatives of Nike Shoes immediately identified for investigators the exact model of Nike shoes Williams was wearing in the videos. The specific patterns on the shoes and the pattern of the soles of the shoes were among the features used to track Williams on the videos as he moved from attack to attack. Various features on his and other defendants' clothing were also used to identify them in video scenes where their faces could not be seen clearly.

Investigators had spent hundreds of hours watching the various videos frame by frame, trying to identify other attackers and to pick out distinctive features on the various defendants.¹⁹ Investigators were also handicapped by the poor quality of the tapes they were viewing. Frequently they had second or third generation copies. The tapes were also in VHS mode, generally recognized as a lesser quality medium, especially compared with Beta broadcast tape, such as used by television news cameras.

3.2. Image processing

As the Gary Williams case neared trial the prosecution was referred to a local image-processing company, Cognitech, Inc. Cognitech volunteered its services to see if the identification of the various defendants could be made clearer for courtroom presentation. Cognitech took front and side profile booking photos of Gary Williams and displayed them next to a segment from the Denny segment of Tur's helicopter footage in which Gary Williams was shown turning his head from side to side. A viewer thus could compare a continuous view of Williams in motion with his front and side profiles.

Cognitech then digitized a segment of the helicopter footage of Gary Williams running away from Reginald Denny. The video sequence was processed using image processing algorithms, which improved resolution of details. This was presented on a split screen, next to a digitized segment of ground level video showing Gary Williams running toward Fidel Lopez before he attacked Lopez. Each segment was then looped over and over while displayed next to the other, side by side. The final version allowed a viewer to see how similar the two images were.²⁰ A videotape of these two presentations was given to Gary Williams' defense attorney as part of the prosecution's discovery.²¹ After viewing the videotape with his attorney, Gary Williams pleaded guilty and was sentenced to prison, without going to trial.

Image processing for the identification of Damian "Football" Williams was more complex. First the actual processing work had to be done. Three thousand separate frames of VHS videotape were digitized and analyzed. Prosecutors had to understand what was actually done and how best to convey such complicated scientific procedures to a jury of generally non-scientifically educated citizens. Court exhibits had to be prepared. Before the evidence could be presented to a jury, the methodology had to be approved in a contested *Kelly-Frye* hearing.

Various frames were matched, segmented, or equalized.²² Following the image processing, prosecutors were better able to trace Williams throughout his various crimes on the videos and to show he was the defendant in court. Using the image processing results, prosecutors were able to show the exact moment that one of Williams' companions had placed a bloody handprint on the center of the back of Williams' white T-shirt. This was significant in that it enabled the prosecutors to show the jury how they could track Williams based on the bloody handprint on the back of his shirt. Image processing also brought out a blemish on Williams' right cheek. This is shown in figure 2, taken from a ground level photograph investigators obtained. This blemish helped to trace his movements from crime scene to crime scene. Details of patterns on his Nike shoes were also made more clear, establishing him as the attacker of two more victims shown on the videos. A light tattoo on Williams' right wrist enabled investigators to determine he was the person who spray-painted Fidel Lopez, even though no part of Williams' face was ever seen on the video of this assault. Figure 3 shows Williams bending over Jorge Gonzales, who was knocked unconscious by Williams when Gonzales tried to help another of Williams' victims.

3.3. Rose tattoo

The most significant use of image processing actually came during the trial, while the defense was vigorously challenging the prosecution's evidence that Damian Williams was the man shown on the videos attacking Denny and the other victims in the intersection. Another news photographer, Robert Clark, had been in Bob Tur's helicopter over Florence and Normandie and had taken still photographs of the actual attack on Denny. Clark provided the prosecution with photographs made directly from his negatives during the trial, after the above-described image processing had been completed.²³ Some of Clark's photos were taken

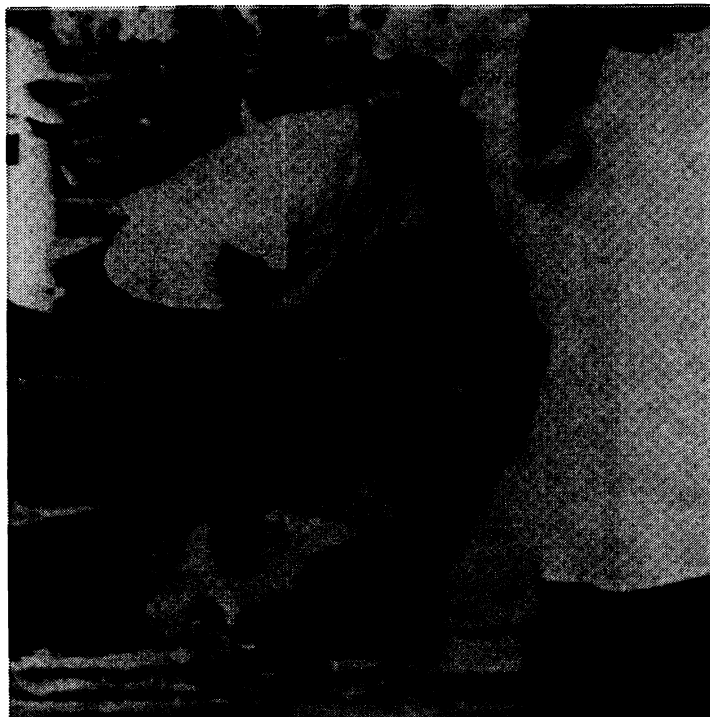


Fig. 2. Damian Williams standing over one of his victims. Image processing made clear a blemish on Williams' right cheek. Note the distinctive patterns on his shoes.



Fig. 3. Close up of Williams spraying paint onto Fidel Lopez from a ground level video. There is a light tattoo around Williams' right wrist. Note the distinctive markings on the shoe.

at the exact moment as particular frames of Tur's videotape. These 35 mm. color photographs, taken with a 400 mm. telephoto lens, showed much more detail than did the videotape of the attack. In particular, they showed the details of a dark image on Williams' left forearm and elbow, as shown in figure 4.

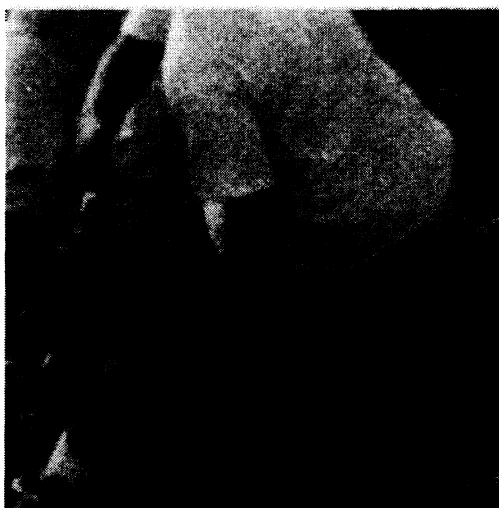


Fig. 4. Williams' left arm just after throwing the brick at Denny

When Williams was arrested on this case, investigators had taken 35 mm. color photographs of various tattoos on his body, including a detailed rose with stem and leaves.²⁴ Clark's photos showed the area of the rose tattoo as a darkened area on Williams' left arm. Clark's photos and the arrest photos of Williams' tattoos were digitized and analyzed by Cognitech. The relevant areas of the photographs were segmented and equalized. After the boundaries of the respective tattoos were mapped, the prosecution was able to show that the boundaries of the darkened area on Clark's photo of Williams' left arm were consistent with the boundaries of the same area of his left arm in the arrest photo.

Because the defense raised a foundational objection to this evidence, the court was required to hold a *Kelly-Frye* hearing on the admissibility of the segmentation process. This hearing, as are most foundational hearings on the admissibility of evidence, was held out of the presence of the jury. The prosecution called Dr. Leonid Rudin of Cognitech to establish that segmentation was a valid scientific procedure and was generally accepted within the scientific community. Dr. Rudin explained that segmentation is a "technique involving computers and mathematical formulas wherein the boundaries and regions of a photographic image are extracted based upon their color or luminance. The image is then 'mapped' through a mathematical formula to create a more discernible image."²⁵ Cognitech's segmentation algorithms were based on mathematical theory developed by J. M. Morel and S. Solimini.²⁶

Following direct examination of Dr. Rudin by the prosecution, and a forceful cross-examination by the defense, the trial court ruled that evidence on the segmentation process was properly admissible in the trial. Dr. Rudin then testified in front of the jury, explaining the segmentation process, and showed how the boundaries of the images of Williams' left arm in Clark's photo were consistent the boundaries of the images in the same area in the arrest photo. Figure 5 shows one of the exhibits used to show this in the trial. During Dr. Rudin's testimony Williams also displayed his left arm to the jury so that they were able to compare the actual tattoo with the images on the photos.

With the assistance of image processing, the jury was ultimately satisfied that it was Damian Williams who had attacked Reginald Denny and other victims at Florence and Normandie.²⁷ Williams was sentenced to a total of ten years' incarceration for his crimes.²⁸

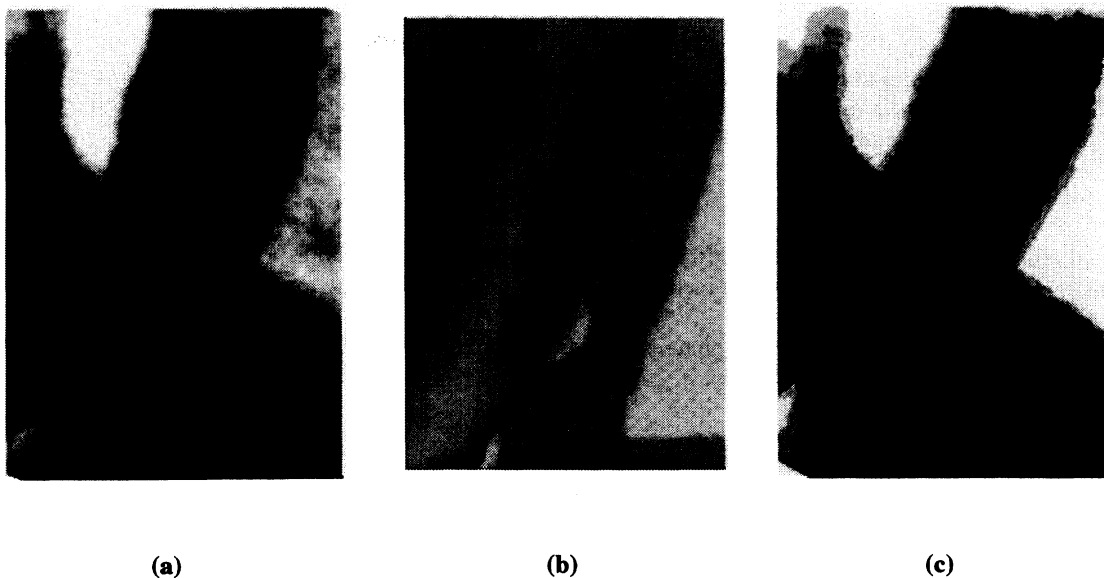


Fig. 5. Image processing of the rose tattoo. Fig. 5(a) is a close up of Fig. 4, from the helicopter view of the Denny attack. Fig. 5(b) was taken after Williams' arrest. Fig. (c) is a computer-generated segmentation of the original photo in Fig. 5(a).

3.4 Appellate review

After Williams was sentenced to prison, he appealed his conviction to the California Court of Appeal. He claimed certain evidentiary errors were made during the trial, which should cause his conviction to be overturned. He particularly claimed that the segmentation process utilized by Cognitech in the analysis of the photographs had not been shown to be generally accepted within the scientific community, and that the trial court erred by allowing the jury to hear such evidence. In the first published opinion on the admissibility of the segmentation process, the Court of Appeal rejected all of Williams' claims of error. In regard to the segmentation process the court ruled:

"The test for determining the reliability of a new scientific technique is whether the technique is '... sufficiently established to have gained general acceptance in the particular field in which it belongs.' [Citation.] The People have met that test. Dr. Rudin testified to the general acceptance of segmentation for identification purposes and cited several supporting texts authored by image processing experts. No evidence was presented in opposition. Moreover, we do not find the lack of documented uses of the procedure in court cases to be fatal to the court's determination of reliability.

Appellant claims that Dr. Rudin's own testimony revealed that the process was unreliable because he was unable to state with precision whether the processed image was a rose or flower tattoo. Appellant misses the point. The question before the court was whether the technique of segmentation was reliable, i.e., whether the process would create a discernible picture of the mark on the arm of the photographed perpetrator. Whether the mark matched appellant's tattoo was for the parties to argue."

(People v. Williams (1996) 46 Cal.App.4th 1767, 1778-1779, footnote omitted.)

4. CONCLUSION

Williams was a published opinion by the Court of Appeal, and may therefore be cited as legal precedent. It is legally binding on trial courts in California, and may be referred to as persuasive authority in courts in other jurisdictions, but it is not binding upon them. The significance of the opinion for image processing professionals is that it approves of the segmentation process as having met the *Kelly-Frye* standards. It should therefore assist in developing the wider use of image processing methods to aid law enforcement identify serious criminals. The decision should help allow this image processing procedure to be admitted into evidence in other trial courts, much like recent decisions on the admissibility of new means of DNA identification have been accepted by the courts. This landmark use of computerized image processing not only helped convict a violent criminal but also established the validity of the procedure in court.

5. ACKNOWLEDGMENTS

The author is grateful to Bob Tur and his wife Marika (who was the camera operator in Tur's helicopter over Florence and Normandie) for use of their video in the preparation of figures in this paper, and to Dr. Leonid Rudin of Cognitech, Inc., for technical assistance in the figures used to illustrate this paper.

6. REFERENCES

1. California Evidence Code § 250 defines "writing" as "handwriting, typewriting, printing, photostating, photographing, and every other means of recording upon any tangible thing any form of communication or representation, including letters, words, pictures, sounds, or symbols, or combinations thereof." See also Federal Rule of Evidence §§ 1001(1) and 1001(2).
2. California Evidence Code § 720(a).
3. "If a witness is testifying as an expert, his testimony in the form of any opinion is limited to such an opinion as is:
 - (a) Related to a subject that is sufficiently beyond common experience that the opinion of an expert would assist the trier of fact; and
 - (b) Based on matter (including his special knowledge, skill, experience, training, and education) perceived by or personally known to the witness or made known to him at or before the hearing, whether or not admissible, that is of a type that reasonably may be relied upon by an expert in forming an opinion upon the subject to which his testimony relates, unless an expert is precluded by law from using such matter as a basis for his opinion." (California Evidence Code § 801. See also Federal Rule of Evidence 702.)
4. *Frye v. United States* (D.C. Cir. 1923) 293 F. 1013, 1014 [54 App.D.C. 46, 47].
5. *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, (1993) 509 U.S. __, __, 125 L.Ed.2d 469, 479, 113 S.Ct. 276, __ .
6. The California Evidence Code contains a similar provision, section 351, which provides: "Except as otherwise provided by statute, all relevant evidence is admissible."
7. Since a number of states use the Federal Rules of Evidence rather than having their own Rules of Evidence, the question was also important as it therefore affected lawsuits in many state courts, as well as in federal courts.
8. As a colorful former Justice of the California Court of Appeal once stated: "I am firmly of the belief that jurors are quite capable of seeing through flaky testimony and pseudo-scientific clap-trap. I quite agree that we should not waste our valuable court time watching witch doctors, voo-doo practitioners, or brujas go through the entrails of dead chickens in a fruitless search for the truth."
9. *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, (1993) 509 U.S. __, __, 125 L.Ed.2d 469, 484, 113 S.Ct. 2786, __.
10. *Id.*
11. *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, (1993) 509 U.S. __, __, 125 L.Ed.2d 469, 485, 113 S.Ct. 2786, __ (footnote omitted).
12. *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, (1993) 509 U.S. __, __, 125 L.Ed.2d 469, 483, 113 S.Ct. 2786, __.
13. *Id.*

14. *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, (1993) 509 U.S. ___, ___, 125 L.Ed.2d 469, 485, 113 S.Ct. 2786, ___ (citation omitted).

15. Because of California's large concentration of high technology industries, particularly in the biotechnology and pharmaceutical fields, there is much civil litigation based upon scientific evidence. Rules governing the admissibility of such evidence in court are thus very important.

16. *Leahy* also was decided on procedural grounds; it discussed how *Kelly* was decided after the California Evidence Code had been adopted, whereas Congress had enacted the Federal Rules of Evidence over 50 years after *Frye* had been decided.

17. The District Attorney's Office prosecutes violations of California laws. The United States Attorney's Office prosecutes violations of federal, *i.e.*, national, law. While assaultive crimes such as those committed against Denny are generally state law violations, the U.S. Attorney's Office had potential jurisdiction because Denny was driving a truck containing gravel that was part of interstate commerce. The author was the District Attorney's representative to the taskforce, and remained with it until the cases were concluded in court.

18. These four defendants were referred to by some as "the L.A. 4." Four other defendants were later arrested and convicted of various crimes at Florence and Normandie that day.

19. All of the videos from ground-level photographers were VHS tapes, as were the initial copies of Tur's helicopter footage provided to the taskforce. VHS videotape has 30 frames per second. Investigators quickly learned that five minutes of VHS videotape thus contained 9000 separate frames. Viewing these in stop action, frame by frame, moving forward and backward to try to see distinctive marks on individuals, when there were many people in a frame, was an agonizingly slow process.

20. The ground level video of the Lopez attack was a second or third generation copy of a VHS video, shot from across a six lane street as dusk settled, with smoke from fires in the air partially obscuring the scene, as 15 to 20 men chased after Lopez.

21. Under the rules of court the prosecution must give to the defense all evidence it intends to use at trial. See, *e.g.*, California Penal Code §§ 1054 *et seq.*

22. Each of these terms, and the process of computerized image processing had to be made clear to the jury. Segmentation was explained to the jury as follows: "An image could be thought to be a pattern that is made of series of a smaller patterns. The smaller patterns occupy areas, therefore, they define certain areas and certain boundaries. The image analysis called segmentation will gauge these areas and find the boundaries and measure them. ... [S]egmentation can also define what's contained within those boundaries; [paraphrasing] it creates a map of the image. ... [M]any different characteristics [may determine what is within the boundaries, including color, shape, and texture.]" (Reporter's Transcript, *People v. Williams*, Case BA 058116, pp. 5917-5918.

Equalization was first referenced as "histogram adjustment, where you simply adjust the distribution of gray levels." (*Id.* at p. 5901.) It was later brought out in more down to earth terms: "[The] equalization process refers to rescaling intensity values. The very simple way to understand equalization is when you turn a knob on your tv set you can make certain things that are dark come out, out of the shadow. When you see a very bright picture, you turn your knob down so ... very bright things show some contrast as well. Equalization is a process that can do both at once." (*Id.* at p. 5934.)

Matching was explained as fusing the two fields of a videotape frame into one frame without artifacts. (*Id.* at p. 5446.)

23. The prosecution had not been able to obtain these previously because of the so-called "news person's privilege." Under this legal privilege, news persons can not be held in contempt for refusing to provide unpublished materials or to disclose their sources. Such a privilege prevents law enforcement from obtaining such materials using a search warrant or subpoena. See, *e.g.*, California Evidence Code § 1070.

24. Investigators had learned that Williams had originally had a tattoo, with the large letters "ETG" (standing for his gang, the Eight Trey Gangsters), on his left forearm and elbow. Investigators had learned that Williams' mother had made Williams get another tattoo to cover over the ETG gang tattoo. This was why he had the rose tattoo. A close examination of Williams' actual arm or the close-up arrest photographs taken of the rose tattoo shows the letters ETG present. Unfortunately, neither Tur's video nor Clark's still photos were able to show the ETG.

25. *People v. Williams* (1996) 46 Cal.App.4th 1767, 1778.

26. J. M. Morel, S. Solimini, *Variational Methods in Image Segmentation*, Birkhauser Boston, 1994.

27. The jury acquitted Williams of throwing a spray-paint can at two Los Angeles firefighters as they passed through the intersection on their way to a fire. The only evidence of these crimes was a very poor quality videotape, shot from a long distance away, at dusk. The paint can hit the windshield of the fire car and caused no harm to the firefighters. Although it was extremely difficult to see what the object was on the video, image processing showed that it was a spray-paint can just like the one Williams used to spray paint onto Fidel Lopez, shown in figure 3.

28. The jury was unable to reach a verdict on Watson. (The jury also was unable to agree that the brick Williams had thrown in Denny's head was a dangerous and deadly weapon!) Watson later pleaded guilty and was placed on probation. In 1996 he violated probation and was sentenced to seven years in prison. Miller had moved to sever his trial from that of Williams and Watson. Following their trial, Miller also pleaded guilty and was placed on probation. Like Watson, he later violated probation and was sent to prison. Image processing was not used in regards to Watson or Miller as identification was not an issue in their cases.