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National Institute of Justice

JOURNAL



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About the Authors

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A single spot of blood on a pink windowsill will tell investigators who broke a windowpane, turned a lock, and kidnapped 2-year-old Molly Evans from her bedroom in the middle of the night. An expert witness will testify that the DNA profile of the blood evidence recovered from the windowsill was entered into CODIS, an electronic database of DNA profiles.¹ That process yielded a "hit," identifying the defendant as the most likely source of the blood inside Molly's room.

But will jurors be able to understand the expert's intricate analysis and use it to reach a verdict? And what—if any—steps can be taken to increase jurors' comprehension of complex DNA evidence?

Questions such as these prompted an NIJ-funded study on the impact of jury trial innovations upon mock jurors' understanding of contested mitochondrial DNA (mtDNA) evidence. (See "How Mitochondrial DNA Compares to Nuclear DNA.") By examining how jurors in different experimental conditions performed on a Juror Comprehension Scale both before and after deliberations, researchers were able to assess whether four specific innovations improved jurors' understanding of this complex evidence and identify which innovations worked best.

Trial Innovations Tested

The four innovations used in the experiment were:

- **Juror note taking.** Mock jurors were given a steno pad and pen for note taking and were told that their notes would be available to them during deliberations.
- **Questions by jurors.** Mock jurors could submit questions to the presiding judge, who obtained answers from an offsite DNA expert.

■ **Mitochondrial DNA (mtDNA) checklists.**

This innovation guided jurors through complex mtDNA evidence by asking them a series of questions. (See “mtDNA Evidence Checklist.”)

- **Multipurpose juror notebooks.** Mock jurors were given notebooks containing paper, copies of the two experts’ slides, the mtDNA checklist, a glossary of DNA terms used in the case, and a witness list.

Selecting the Mock Jury

Jurors were selected from jury-eligible adults called to jury duty in the Superior Court of New Castle County, Delaware. Jurors were randomly assigned to 60 eight-person juries. Each juror filled out an initial questionnaire that queried his or her views on the reliability of certain types of scientific testimony and about science in general. (See “Mock Jurors’ Attitudes About Science and DNA.”)

Researchers then divided the juries into groups of 10 and subjected each group to one of the following conditions:²

Experimental Condition	Jury Innovations
Condition 1	No innovations (control)
Condition 2	Note taking
Condition 3	Question asking and note taking
Condition 4	DNA checklist and note taking
Condition 5	Juror notebook and note taking
Condition 6	All innovations (note taking, question asking, DNA checklist, and juror notebook)

The Mock Trial

The jurors then watched a videotape of an armed robbery trial. Prosecutors presented the testimony of bank employees who could not make a positive identification because the robber wore a blue hooded sweatshirt and a partial mask. However, one teller testified that she saw an unmistakable inch-long,

HOW MITOCHONDRIAL DNA COMPARES TO NUCLEAR DNA

Nuclear DNA, or nDNA, is the genetic material inherited from both parents (one-half from the mother and one-half from the father). It is found in the nucleus of each cell and is unique to each individual (except in cases of identical twins). Nuclear DNA is a powerful identifier and has been used for forensic purposes for decades. Mitochondrial DNA (mtDNA)—which is found in the mitochondria of a cell, outside of the nucleus and separate from nDNA—is inherited solely from the mother and is not unique. Everyone in the same maternal line, for generations, will have the same mtDNA. Its use as a forensic tool, in narrowing the pool of possible donors of a sample, is a more recent development.

horizontal scar on the suspect’s cheek when he wiped his face with his gloved hand.

Police searched the crime scene immediately after the robbery and recovered a blue sweatshirt, a glove, and a small amount of cash, including some of the “bait money.”³ Two human hairs recovered from the sweatshirt hood were analyzed and found to match the defendant’s mtDNA. No other physical evidence was recovered.

Jurors learned that an anonymous caller told police the defendant had robbed the bank. Testimony established that the defendant owned a blue hooded sweatshirt, had a scar on his cheek, and had recently been seen flashing a large roll of cash.

The defendant testified in his own defense and denied committing the robbery. He told a detective that he had never been in that bank and that he was at work when the robbery occurred. He claimed that the excess cash was from a friend’s recent repayment of a loan.

In an attempt to dispute the prosecution’s mtDNA evidence, the defense introduced evidence that the defendant’s wayward half-brother on his father’s side lived in town at the time of the robbery. This fact, however, would have been irrelevant to any juror who understood that mtDNA is inherited only through the mother’s lineage. Researchers made the rest of the circumstantial evidence purposefully ambiguous so that jurors would feel compelled to consider the mtDNA identification evidence

The multipurpose notebook was the most popular innovation: 92 percent of the jurors said that the notebooks—in particular, the expert’s slides—helped them to remember and understand the case.

MOCK JURORS’ ATTITUDES ABOUT SCIENCE AND DNA

Researchers found that the demographic profile (sex, race, and age) of the 480 mock jurors bore striking similarities to those of the entire pool of jury-eligible adults. Most mock jurors had some science or mathematics courses: on average, most had more than nine such courses in high school or college. About half had some job experience involving science or math.

Almost all (89 percent) of the mock jurors held positive attitudes about science. However, a significant minority expressed reservations about science. Negative attitudes about the role of science in their lives were strongly correlated with the level of formal education; jurors with less education tended to express more negative views.

Before the videotape was presented, researchers solicited jurors’ views about DNA. Two-thirds of mock jurors agreed that DNA evidence was “extremely reliable.” Although half of the participants had heard about mtDNA before this trial, most said they had heard only a “small amount” about it.

After the trial, however, almost all of the jurors had a basic understanding of the mtDNA evidence. Solid majorities of jurors (ranging from 66 to 90 percent) exhibited correct understandings of most of the core knowledge items about mtDNA—e.g., where the mitochondria are found in the cell, how samples are compared and matches declared, and how mtDNA compares to nuclear DNA.

Ninety percent of jurors correctly understood that unlike nuclear DNA, mtDNA is inherited solely from one’s mother. Those jurors rejected the defense suggestion that the crime could have been committed by the defendant’s wayward half-brother on his fathers’ side, noting

that the relationship would not account for the presence of the defendant’s mtDNA in the hair strands recovered from the hooded sweatshirt.

On the other hand, some of the participants showed a susceptibility to adversarial exaggerations and misstatements about the scientific evidence:

- A number of jurors were persuaded by the prosecutor’s argument that the likelihood of the defendant’s innocence was equal to the percentage of Caucasian males who could not be excluded as possible contributors of DNA found on the hooded sweatshirt. Because the prosecution’s expert estimated that 99.98 percent of Caucasian males would be excluded as contributors, prosecutors argued that there was only a .02 percent possibility that the defendant did not commit the crime. This rationale erroneously hinged the defendant’s guilt on one piece of evidence—hair found on a sweatshirt at the scene—while ignoring other circumstantial evidence that was not directly incriminating.
- Some jurors also agreed with the defense attorney’s questionable claim that the mtDNA evidence was entirely worthless because people other than the defendant could have contributed the hairs.
- One-quarter of the mock jurors thought that sample contamination was “likely” despite the absence of evidence or argument from either side suggesting contamination of the hair samples or the mtDNA.

As anticipated, the amount of formal education, the number of courses in science and mathematics, and some job experience involving science and mathematics positively correlated with jurors’ correct understanding of mtDNA.

and resolve the issues raised by the prosecution and defense experts.

Expert Testimony on mtDNA

The prosecution's expert testified that the mtDNA profiles of hair from the sweat-shirt and the samples combed from the defendant's head at the time of his police interview were an exact match. He commented that the profile was rare and had not been observed in the Federal Bureau of Investigation's (FBI's) mtDNA database of more than 5,000 samples. He added that 99.98 percent of all Caucasian males would be excluded as potential contributors of the two mtDNA samples. That meant that in addition to other men in the same maternal line as the defendant, only 6 males in a population of 29,000 would have the same mtDNA profile.

The defense expert agreed that the mtDNA samples matched, but said that the FBI's percentage of the population excluded by the mtDNA evidence was too large because the FBI failed to properly account for the possibility of "heteroplasmy" in human hair. Heteroplasmy is a condition where some of a person's mtDNA exhibits a mutation and thus differs (in at least one base pair) from the remainder of the person's mtDNA. By including heteroplasmic individuals as possible sources of the hairs, the defense expert reduced the FBI's percentage of excluded males to 99.80 percent. She projected that 57 males in the locality—as opposed to the prosecution's estimate of 6—could have been the source of the hairs.

After the videotape, jurors completed a second questionnaire about their uses of and attitudes toward trial innovations. They were then allowed to deliberate. Following the return of a unanimous verdict or the declaration of a mistrial (hung jury) in each case, jurors filled out a third and final questionnaire.

Researchers then coded and analyzed jurors' responses to the questionnaires and reviewed the jurors' written notes, copies of the checklist, and notebook materials. Questions posed by jurors

during the trial were also analyzed. All of the jury deliberations were videotaped, reviewed, and coded to assess the use of jury innovations in group deliberations.

Which Innovations Did Jurors Use?

The research showed that jurors used three of the innovations the most—the multipurpose notebook, note taking, and the mtDNA checklist.

The multipurpose notebook was the most popular innovation: 92 percent of the jurors said that the notebooks—in particular, the expert's slides—helped them to remember and understand the case. The second most used innovation was juror note taking: 88 percent of jurors took notes. Two-thirds said their notes helped them remember the evidence. The third most used innovation was the mtDNA checklist: 85 percent of jurors allowed to use the checklist said they reviewed it during deliberations. Most found that the checklist increased their understanding and recall of the evidence. The least used innovation was jury questioning: only 22 percent of the jurors allowed to ask questions actually did.

Which Innovations Enhanced Juror Understanding?

To see whether innovations improved juror understanding of mtDNA evidence, researchers explored how jurors in the different experimental conditions performed on Jury Comprehension Scales⁴ before and after their deliberations, controlling for jurors' educational levels.⁵ In general, researchers found that jury deliberations improved jurors' comprehension of mtDNA.

Prior to deliberations, there were no significant differences in how jurors who were assigned to the various conditions—those who used innovations and those who did not—performed on the Juror Comprehension Scale. Even after deliberations, comparisons of the responses of jurors given no innovations (control group) with those who had them still showed no significant differences in their understanding of mtDNA evidence.

mtDNA EVIDENCE CHECKLIST

1. Was the blue hooded sweatshirt found by the police probably the one worn by the bank robber?
 - Yes
 - No → Then the FBI’s DNA analysis of the hair will not assist you in identifying the robber.
2. Did the FBI correctly identify the mtDNA sequences of the suspect (sweatshirt hood) and known (defendant’s) samples of hair?
 - Yes
 - No → The results of the FBI’s analysis of the hairs’ mtDNA will not assist you in identifying the robber.
3. Did the FBI correctly conclude that the mtDNA sequences of the two hair samples matched?
 - Yes
 - No → The results of the FBI’s analysis of the hairs’ mtDNA will not assist you in identifying the robber.
- 4A. Did the FBI correctly calculate how often the hairs’ mtDNA sequence is likely to occur in the Caucasian population?
 - Yes → 5A. What percent of the Caucasian population can be excluded as possible contributors of the mtDNA found on the sweatshirt hairs?
Answer _____%
 - No → 4B. Did the defendant’s expert correctly calculate how often the hairs’ mtDNA sequence is likely to occur in the Caucasian population?
 - Yes → 5B. What percent of the Caucasian population can be excluded as possible contributors of the mtDNA found on the sweatshirt hairs?
Answer _____%
 - No → Neither expert’s testimony will assist you in identifying the robber.
6. How many Caucasian males in the Middletown area could have contributed the hairs found in the sweatshirt hood? (Check one.)
 - _____ 6 males (prosecution expert estimate)
 - _____ 57 males (defense expert estimate)
 - _____ Other number (your estimate: _____)
7. How likely is it that the defendant was the source of the hairs found in the sweatshirt hood? (Check one.)
 - _____ Extremely likely
 - _____ Somewhat likely
 - _____ Don’t know
 - _____ Somewhat unlikely
 - _____ Extremely unlikely

However, when the postdeliberation responses of jurors allowed to use each particular innovation were compared with the responses of jurors not allowed to use that innovation (both those in the control group and those assigned another innovation), differences emerged. Under this analysis, researchers found that jurors allowed to use juror notebooks performed significantly better on two aspects of the comprehension testing (basic and expanded factual true-false tests) than those not provided notebooks. Jurors provided with an mtDNA checklist also performed better (on an expanded Jury Comprehension Scale) than those without access to the checklist.

Researchers also examined whether actual usage of an innovation improved juror understanding. The results were mixed. Data showed that jurors who took advantage of two innovations—note taking and question asking—did not have higher levels of comprehension; however, jurors who actually used the mtDNA checklist and the juror notebook significantly outperformed jurors who were afforded use of those innovations but declined to use them.

There was also evidence that use of multiple innovations improved juror comprehension. Using the note taking condition as a control, researchers found that jurors allowed to take notes and use a juror notebook did better on the Jury Comprehension Scales postdeliberation than did those allowed only to take notes. The same was true for jurors exposed to all four innovations—they also outperformed those jurors who were only allowed to take notes. Thus, it appears that additional innovations on top of jury note taking improves mock jurors’ comprehension of scientific mtDNA evidence.

Practical Suggestions for Practitioners

Based on the study, researchers believe that the use of certain jury innovations has the potential to improve jurors’ comprehension of mtDNA and other scientific evidence. Methods that provided direct guidance or additional expert information—such as the mtDNA checklist and the juror notebook—best improved juror understanding. This suggests that other jury innovations that

provide a better understanding of expert evidence—such as juror tutorials in complex subjects and court-appointed experts to discuss the parties’ often conflicting scientific evidence—are ripe for evaluation.

The results of the study showed that most juries are capable of comprehending and using different forms of DNA evidence at trial. Nonetheless, researchers acknowledged that some jurors are likely to have trouble with complex DNA evidence.

Researchers offered five ways to facilitate juror understanding of DNA evidence:

- Distribute juror notebooks that contain copies of the expert’s slides, overheads, and charts; a glossary of technical terms; a list of the issues presented by the DNA evidence; and blank paper for note taking.
- Distribute a checklist or inference chart listing the issues presented by the DNA evidence and provide a step-by-step pathway for the jurors’ resolution of those issues.
- Provide a brief, straightforward explanation of forensic DNA without burdening jurors with nonessential technical details about the analysis. Some deliberating jurors complained about “technical overload” of essentially uncontested matters.
- Allay fears of contamination—even in cases where there is no evidence it has occurred. A significant number of jurors believed sample contamination was a problem despite the total lack of evidence or argument by defense counsel to suggest it occurred.
- Encourage jurors to weigh the probative value of the DNA evidence linking the defendant to the crime with the value of other nonscientific evidence. Jurors attempt to combine both types of information to arrive at an opinion regarding guilt, but are unsure how to do so. Attorneys and experts should present simple, understandable approaches to considering the value of different types of evidence.

NCJ 215455

For More Information

- Dann, B.M., V.P. Hans, and D.H. Kaye, *Testing the Effects of Selected Jury Trial Innovations on Juror Comprehension of Contested mtDNA Evidence*, final report submitted to the National Institute of Justice, Washington, DC: August 2005 (NCJ 211000), available at www.ncjrs.gov/pdffiles1/nij/grants/211000.pdf.

Notes

1. The Combined DNA Index System (CODIS) is an electronic database of DNA profiles administered through the Federal Bureau of Investigation. The system lets Federal, State, and local crime labs share and compare DNA profiles. Through CODIS, investigators match DNA from crime scenes with convicted offenders and with other crime scenes using computer software, just as fingerprints are matched through automated fingerprint identification systems. CODIS primarily uses two indexes: (1) the Convicted Offender Index, which contains profiles of convicted offenders, and (2) the Forensic Index, which contains profiles from crime scene evidence. The strength of CODIS lies in solving cases that have no suspects. If DNA evidence entered into CODIS matches someone in the offender index, a warrant can be obtained authorizing the collection of a sample from that offender to confirm the match. If the offender’s DNA is in the Forensic Index, the system allows investigators—even in different jurisdictions—to exchange information about their respective cases.
2. Juror note taking was permitted in all but the control condition because the more advanced techniques (such as question asking and juror notebooks) are unlikely to be offered by a court without the basic reform of note taking.
3. Bait money is cash that tellers are instructed to turn over in the event of a robbery. It contains prerecorded serial numbers, enabling investigators to identify the funds if recovered.
4. Researchers combined eight facts about mtDNA to develop a Juror Comprehension Scale that measured jurors’ understanding of mtDNA.
5. Researchers also controlled for juror membership on a particular jury by using a “nested” analysis. Because mock jurors in the study deliberated with one another, jurors potentially influenced one another. A nested analysis was used because juror’s responses post-deliberation were no longer strictly independent observations.

The use of certain jury innovations has the potential to improve jurors’ comprehension of mtDNA and other scientific evidence.