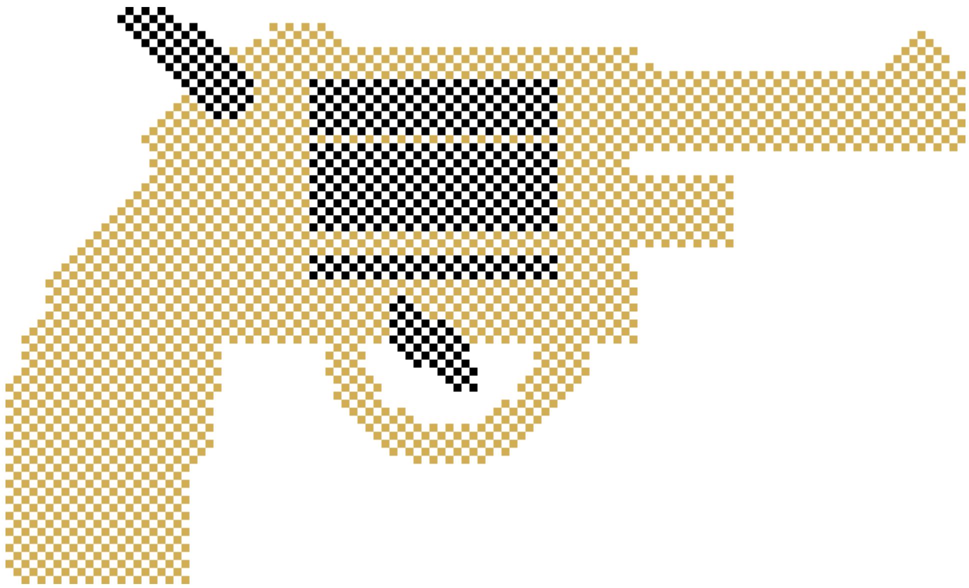


A Simplified Guide To Firearms Examination

Introduction

It's an all-too-common scenario: A person is found dead at a crime scene, the victim of a gunshot wound. Whether it's a cold-blooded robbery/homicide or a heated crime of passion, investigators must uncover the evidence and piece together the clues that will lead to the murder weapon. And with solid detective work and a bit of good fortune, the weapon will hopefully lead to the shooter.

The field of forensic firearms identification, sometimes called ballistics, is at its heart the ability of a firearms examiner to determine if a particular bullet or cartridge case was fired from a specific firearm. This determination can be made thanks to small, often microscopic markings on bullets or cartridge cases that are unique to ammunition fired from that firearm. Although the examiner cannot determine who actually fired a weapon, matching the ammunition to a weapon provides vital facts for the investigation.

In conjunction with this, the examiner has the ability to explain how a firearm functions and what safety features a firearm might have. This can have an impact on investigations of suicides, unintentional shootings and accidental firearm discharge.

Principles of Firearms Examination

The basis for firearms identification is founded on uniqueness: upon close examination, virtually all objects can be distinguished from one another, and the same is true for firearms. Fortunately for criminal investigators, the uniqueness of each firearm transfers to the cartridge case and bullet whenever the weapon is fired. This has been proven through physical sciences including physics, metallurgy, metallography and materials science.

The firearm's surfaces (firing pin/striker, breach, barrel, etc.) that contact the softer cartridge case and bullet contain random, unique, microscopic irregularities that make it different from other firearms - even those of the exact same model. These differences can be used to identify or eliminate a weapon as being used in a crime, if a cartridge case or bullet is recovered at the crime scene. This is done by comparing the markings made on the cartridge cases or bullets when fired, using the firearms examiner's key tool: the comparison microscope.

In conjunction with this, the examiner has the ability to explain how a firearm functions and what safety features a firearm might have. This can have an impact on investigations of suicides, unintentional shootings and accidental firearm discharge.

General Rifling Characteristics

There are several general characteristics associated with firearms that can help lead the investigation. These include the caliber (bore diameter) of the barrel, the number and dimension of the grooved impressions inside a gun barrel, and the direction of the twist of these rifling grooves (clockwise or counterclockwise).

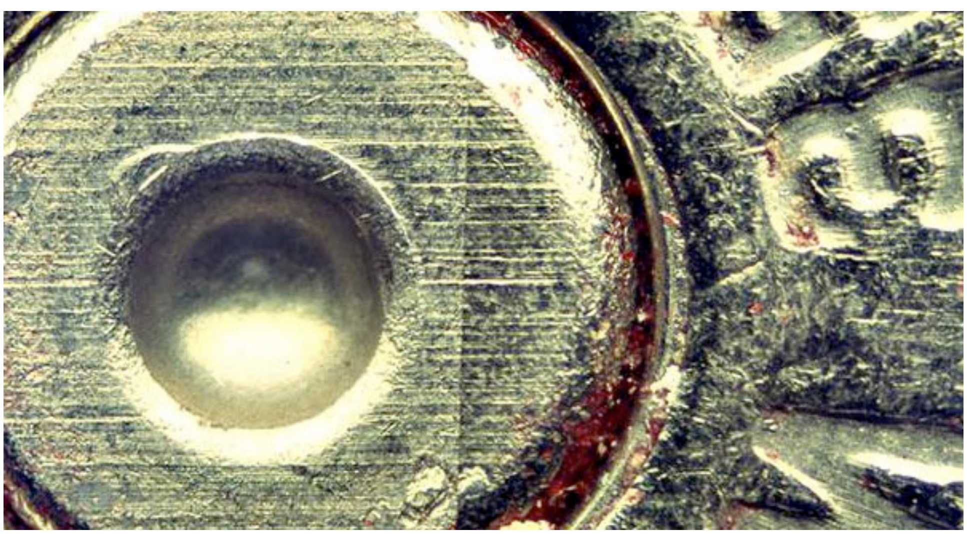
Rifling grooves on the barrel of a revolver. (Courtesy of Scott Campbell, Ron Smith & Associates)

To help stabilize the flightpath of a bullet, manufacturers cut spiral grooves into the gun barrel. This pattern of grooves on the barrel leaves corresponding raised and lowered areas on the surface of the bullets fired from it. Measuring the number and width of these gross impressions can help firearms examiners narrow the range of possible weapons to a particular class of firearm. (Note: Some manufacturers use a technique called polygonal rifling that doesn't allow for this type of assessment due to the rounded profile of the rifling pattern.)

Individual Characteristics

While general characteristics can lead investigators to conclude that the bullet or cartridge was fired from a particular class of firearm, such as a .45 caliber revolver, other more specific marks can help identify the make and model of firearm that was used. These individual characteristics can be marks produced by random imperfections during manufacturing or irregularities caused by use, corrosion or damage.

Comparing groove impressions on a bullet recovered from a crime scene (left) to a bullet fired from a .357 magnum (right) under 20× magnification. (Courtesy of NFSTC)



Comparison of a cartridge case recovered from a crime scene (left) to a cartridge case fired from a .357 Magnum (right) under a comparison microscope at 15× magnification. (Courtesy of NFSTC)

Why and when is firearms evidence examined?

Firearms evidence can usually be found at any crime scene where a weapon has been fired. These include crimes such as murders, armed robberies and aggravated assaults. According to crime statistics from the Federal Bureau of Investigation (FBI), in 2011 firearms were used in 68 percent of murders, 41 percent of robbery offenses and 21 percent of aggravated assaults in the US.

When evidence such as shotshell casings, cartridge cases, bullets and slugs is found at a crime scene—or recovered from victims, buildings, furniture, vehicles, trees, etc.—an examiner can analyze it to determine the type of firearm used. The examiner can also compare shotshell casings, cartridge cases and bullets from different crime scenes to determine if a common firearm was used.

When a firearm is recovered, the examiner can either identify or eliminate it as the firearm used in the crime, provided that (1) it still fires and (2) there is evidence such as a cartridge case or bullet for comparison. If the firearm is identified as the one used in the shooting, the examiner will measure the trigger pressure, determine if the weapon functions properly and ensure that the safety features are working, which can support or eliminate potential defenses such as accidental discharge.

In addition to obvious types of firearms evidence, the evidence left behind could include gunshot residue and powder burns. Examiners can use this evidence to determine distances involved in shootings so they can reconstruct the incident. This can be used to support or refute an account of the shooting.

How It's Done

Firearms Evidence that May be Found

The range of evidence in firearms-related cases can be as small as a piece of a bullet fragment which has rifling marks or as large as hundreds of bullets and cartridge cases and numerous firearms. Even from small samples, information can be developed to indicate the type of firearm used and possibly identify the actual firearm that was used.

Other firearms evidence that could be found at a shooting scene includes shotshell wads and shot pellets; these can indicate the gauge of the shotgun. Wads and pellets can be gathered and preserved in the same manner as bullets and cartridge cases.

By examining wadding materials, the examiner may be able to determine

- the gauge of the shotgun
- the manufacturer or marketer
- a range of possible shot sizes based on impressions in the shotshell wad
- individual characteristics (in some cases)

Gunshot residues fall into two categories. The first type is gathered from the suspected shooter's hands with a collection kit. The purpose of the examination is to determine if a person has recently handled or fired a weapon. Since it doesn't determine which firearm was fired or when, this testing has limited value, and many laboratories have stopped performing these examinations. The second type looks for residues on items such as a victim's clothing in an effort to determine the muzzle-to-target distance. Many times this type of evidence is not visible to the naked eye and requires microscopic examination and chemical testing to develop. The victim's clothing must be handled with care, air dried and stored in paper containers in order to provide useful evidence.

Propellants and other gunshot residues expelled during the firing process. (Courtesy of Jack Dillon)

How the Samples are Collected

Firearms evidence can be recovered in a number of ways and areas. Firearms themselves can be recovered at shooting scenes by crime scene investigators and sent to the laboratory. Bullets, bullet fragments, cartridge cases, shotshell wadding, etc., are normally collected individually after proper documentation/photography and sent to the laboratory. Bullet evidence can also be obtained at autopsy or in an emergency room setting.

In these cases the sample should be marked as a biohazard and then sent to the laboratory. Each laboratory has written procedures for packaging and submitting evidence.

Bullets/slugs that do not strike a person are often imbedded into a nearby surface such as wood/drywall. This evidence is best gathered by cutting out a section of the material and submitting it to the laboratory to allow a firearms examiner to carefully extract it. This prevents adding or destroying any markings that could be crucial to identifying or matching the suspected firearm.

Who Conducts the Analysis

A well-trained firearms examiner should perform the evaluation and comparison of this evidence. These examiners will have received extensive training on all matter of firearms and ammunition manufacturing; evidence detection, recovery, handling and examination procedures; comparison microscope equipment and procedures; courtroom testimony and legal issues; and casework.

The Association of Firearms & Tool Mark Examiners (AFTE), an international group of nearly a thousand examiners, has developed an examiner training course which takes 18 to 24 months to complete. AFTE also offers a certification process for qualified AFTE members in three separate areas: Firearm Evidence Examination and Identification; Toolmark Evidence Examination and Identification; and Gunshot Residue Evidence Examination and Identification.

Most state crime laboratories in the US have a firearms examiner(s) on staff who can perform analysis for police departments within their jurisdiction if the need arises. Some police agencies have their own qualified examiner on staff.

How and Where the Analysis is Performed

Most examinations are performed by crime laboratory employees who are trained to conduct this type of examination. However, there are private laboratories/companies that can also perform this type of examination for a fee; often these are staffed by retired examiners. Whichever is selected, the evidence needs to be submitted for examination along with any firearms collected following the policies and procedures set down by the submitting agency.

Actual items of evidence are submitted to either crime laboratories or private laboratories according to the requesting agency's policies and procedures. These items should be submitted in a manner that follows good chain-of-custody protocols.

The laboratory will have certain items of equipment available to conduct the examinations required. Measuring devices such as calipers and balances are used to weigh and measure bullet evidence. Stereo microscopes are used to determine basic class characteristics of fired bullets, bullet fragments and cartridge/shotshell cases. A comparison microscope is used for the examination of fired bullets, bullet fragments and cartridge/shotshell cases. Equipment used for the examination of firearms include the above items plus special equipment to measure the trigger pull of the firearm and examine the interior of the barrel. Also there must be facilities to test-fire the submitted firearm and recover fired bullets and cartridge cases. Most laboratories use a water recovery method, which is a large tank of water with a port into which the firearm is discharged. There are other systems used as well, such as metal boxes containing cotton waste material.

Examiner using a comparison microscope to analyze two .22 caliber casings. (Courtesy of NFSTC)

FAQs

What kind of results can be expected from firearms examination?

There are four different conclusions that firearms examiners use to report the results of their microscopic examinations:

- The bullet/cartridge case was fired by the firearm
- The bullet/cartridge case was not fired by the firearm
- There are insufficient characteristics present to identify or eliminate the bullet/cartridge case as having been fired by the firearm
- The bullet/cartridge case is not suitable for comparison

What are the limitations of the testing/analysis?

The biggest limitation would be the condition of the evidence. If the evidence (bullets and cartridge cases) is too damaged or mutilated to reveal sufficient individual characteristics, then no comparison can be made.

The lack of a suspected firearm also presents limitations for the examiner's conclusions. However, if bullets and/or cartridge cases are obtained that are in fairly good condition, they can be used to determine the type of weapon used and can potentially be compared to evidence from other crimes in order to help track the shooter.

How is quality control and quality assurance performed?

To ensure the most accurate analysis of evidence, the management of forensic laboratories puts in place policies and procedures that govern facilities and equipment, methods and procedures, and analyst qualifications and training. Depending on the state in which it operates, a crime laboratory may be required to achieve accreditation to verify that it meets quality standards. There are two internationally recognized accrediting programs focused on forensic laboratories: The American Society of Crime Laboratory Directors Laboratory Accreditation Board **http://www.ascld-lab.org/** and ANSI-ASQ National Accreditation Board / FQS **http://www.forquality.org/**

In disciplines such as firearms and tool marks where testing requires analysts to compare specific details of two samples, quality control is achieved through technical review and verification of conclusions. This involves an expert or peer who reviews the test data, methodology and results to validate or refute the outcome. This review encompasses the microscopic work, bench notes and written reports. The percentage of cases that undergo verification may vary depending on the experience of the analyst. In addition, defense attorneys may hire independent firearms examiners to review and reexamine questioned evidence to ensure accuracy of the findings.

The Scientific Working Group for Firearms and Toolmarks (SWGGUN) **http://www.swggun.org/swg/index.php?option=com_content&view=a**

rticle&id=27:swggun-quality-assurance-guidelines&catid=10:guidelines-adopted&Itemid=6 publishes Quality Assurance Guidelines for this discipline on their website.

What does the report look like and how are the results interpreted?

Firearms reports are usually brief and will list the evidence examined and the results of that examination: The bullet/cartridge case was fired by the firearm in question; it was not fired by the firearm in question; there are insufficient characteristics present to identify or eliminate it; or it is not suitable for comparison.

Are there any common misconceptions about the area of firearms examination or any other information that might be important to the non-scientist?

Firearms are part of the American fabric of life. Most individuals have been exposed to them either directly or through the media. As is often the case, many myths and pieces of incorrect information become part of that exposure, often because they are seen in movies or on television. Examples include a person who is shot being thrown back through a door instead of dropping to the ground or the idea that somehow a loaded gun will discharge without anyone being near it. Because of these misconceptions, people can sometimes become confused when presented with scientific findings. It is always best to seek information on firearms evidence from a qualified firearms examiner to ensure complete understanding of what the examination results really mean.

Common Terms

Ballistics - Scientific study of the motion of projectiles; often used as a generic term for the study of bullets from the time they are shot until they impact a target.

Bullet - The projectile that is expelled from a rifled firearm (as opposed to slug).

Cartridge - A complete unfired round of ammunition consisting of a cartridge case, projectile (bullet), primer and smokeless powder.

Cartridge case - The container that holds the cartridge components; usually made of brass, nickel or steel.

Comparison microscope - Two microscopes joined by an optical bridge, which allows the viewing of two samples side by side; it is the primary tool of the firearms examiner.

Firing pin/striker - The working component of a firearm that contacts the ammunition.

Groove - The interior portion of a rifled barrel that is cut to form the rifling; the grooves may vary in number, size and direction of spiral by manufacturer and/or model.

Individual characteristics - Marks present on fired ammunition components that are unique to a particular firearm and distinguish it from all other firearms of the same type; these marks are produced by the random imperfections or irregularities of the firearm surfaces; they are incidental to manufacture and/or caused by use, corrosion, or damage.

Land - The interior portion of a rifled barrel between two grooves.

Magazine - A container for cartridges that has a spring and follower to feed those cartridges into the chamber of a firearm; the magazine may be detachable or an integral part of the firearm.

Pistol - A handgun; the most common is a semi-automatic pistol, which uses a magazine and ejects fired cartridge cases automatically.

Primer - The chemical composition that, when struck by a firing pin, ignites the smokeless powder.

Revolver - A handgun that has a rotating cylinder to hold cartridges for firing; cartridge cases are not automatically ejected when fired.

Rifling Grooves - in the interior of a firearm barrel to impart spin to a bullet; improves flight characteristics and increases accuracy.

Shot Round - pellets used as the projectiles in shotshells or cartridges.

Shotgun - A shoulder-fired firearm normally with a smooth barrel.

Shotshell - Shortening of "shotgun shell"; a complete unfired round of ammunition consisting of a shotshell casing, projectile(s) (shot/slug), wadding, primer and smokeless powder.

Shotshell casing - The container that holds the shotshell components; usually made of plastic, with a thin brass base.

Slug - A term applied to a single shotshell projectile.

Striations - Contour variations, generally microscopic, on the surface of an object caused by a combination of force and motion where the motion is approximately parallel to the plane being marked.

Smokeless powder - The chemical composition that, when ignited by a primer, generates gas; the force of the gas propels the projectile(s).

Striation - The usually microscopic markings on the surface of a fired ammunition component caused by a combination of force and motion; these marks can contain class and/or individual characteristics.

Wadding - Paper or other material in a shotshell that forms a seal between the smokeless powder and the shot.

All glossary terms are from the Association of Firearm and Toolmark Examiners (AFTE) glossary, the Sporting Arms and Ammunition Manufacturers' Institute (SAAMI) glossary, or are supplied from subject matter experts. A more complete collection of terms is available at the National Institute of Justice Firearms Examiner Training Glossary. **http://www.nij.gov/training/firearms-training/glossary.htm**

Resources & References

You can learn more about this topic at the websites and publications listed below.

Resources

Association of Firearm and Tool Mark Examiners (AFTE)
http://www.afte.org/

National Integrated Ballistic Information Network (NIBIN)
http://www.nibin.gov/

Scientific Working Group for Firearms and Toolmarks (SWGGUN)
http://www.swggun.org/swg/index.php

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"Firearms/Tool Mark Examination: The Discipline of Firearm and Tool Mark Examination," IAI website, http://www.theiai.org/disciplines/firearms_toolmark/index.php (accessed Feb. 3, 2012).

Heard, Brian J. **HANDBOOK OF FIREARMS AND BALLISTICS**, Second Edition, Wiley-Blackwell, West Sussex, UK (2008).

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Lyle, D.P., M.D. "Chapter 7: Bodily Harm: Identifying Wounds," **FORENSICS: A GUIDE FOR WRITERS** (Howdunit), Writer's Digest Books, Cincinnati, OH (2008), pp. 118-125.

Lyle, D.P., M.D. "Chapter 16: Firearms Examination: More Than Guns and Ammunition," **FORENSICS: A GUIDE FOR WRITERS** (Howdunit), Writer's Digest Books, Cincinnati, OH (2008), pp. 342-356.

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Forensic Evidence Admissibility and Expert Witnesses

How or why some scientific evidence or expert witnesses are allowed to be presented in court and some are not can be confusing to the casual observer or a layperson reading about a case in the media. However, there is significant precedent that guides the way these decisions are made. Our discussion here will briefly outline the three major sources that currently guide evidence and testimony admissibility.

The *Frye* Standard – Scientific Evidence and the Principle of General Acceptance

In 1923, in *Frye v. United States*[1], the District of Columbia Court rejected the scientific validity of the lie detector (polygraph) because the technology did not have significant general acceptance at that time. The court gave a guideline for determining the admissibility of scientific examinations:

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 the courts will go a long way in admitting experimental 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.*

Essentially, to apply the "*Frye* Standard" a court had to decide if the procedure, technique or principles in question were generally accepted by a meaningful proportion of the relevant scientific community. This standard prevailed in the federal courts and some states for many years.

Federal Rules of Evidence, Rule 702

In 1975, more than a half-century after *Frye* was decided, the Federal Rules of Evidence were adopted for litigation in federal courts. They included rules on expert testimony. Their alternative to the *Frye* Standard came to be used more broadly because it did not strictly require general acceptance and was seen to be more flexible.

[1] 293 Fed. 1013 (1923)

The first version of Federal Rule of Evidence 702 provided that a witness who is qualified as an expert by knowledge, skill, experience, training, or education may testify in the form of an opinion or otherwise if:

a. the expert's scientific, technical, or other specialized knowledge will help the trier of fact to understand the evidence or to determine a fact in issue;
b. the testimony is based on sufficient facts or data;
c. the testimony is the product of reliable principles and methods; and
d. the expert has reliably applied the principles and methods to the facts of the case.

While the states are allowed to adopt their own rules, most have adopted or modified the Federal rules, including those covering expert testimony.

In a 1993 case, *Daubert v. Merrell Dow Pharmaceuticals, Inc.,* the United States Supreme Court held that the Federal Rules of Evidence, and in particular Fed. R. Evid. 702, superseded *Frye's* "general acceptance" test.

The *Daubert* Standard – Court Acceptance of Expert Testimony

In *Daubert* and later cases[2], the Court explained that the federal standard includes general acceptance, but also looks at the science and its application. Trial judges are the final arbiter or "gatekeeper" on admissibility of evidence and acceptance of a witness as an expert within their own courtrooms.

In deciding if the science and the expert in question should be permitted, the judge should consider:

- What is the basic theory and has it been tested?
- Are there standards controlling the technique?
- Has the theory or technique been subjected to peer review and publication?
- What is the known or potential error rate?
- Is there general acceptance of the theory?
- Has the expert adequately accounted for alternative explanations?
- Has the expert unjustifiably extrapolated from an accepted premise to an unfounded conclusion?

The *Daubert* Court also observed that concerns over shaky evidence could be handled through vigorous cross-examination, presentation of contrary evidence and careful instruction on the burden of proof.

[2] The "Daubert Trilogy" of cases is: **DAUBERT V. MERRELL DOW PHARMACEUTICALS**, **GENERAL ELECTRIC CO. V. JOINER** and **KUMHO TIRE CO. V. CARMICHAEL**.

In many states, scientific expert testimony is now subject to this *Daubert* standard. But some states still use a modification of the *Frye* standard.

Who can serve as an expert forensic science witness at court?

Over the years, evidence presented at trial has grown increasingly difficult for the average juror to understand. By calling on an expert witness who can discuss complex evidence or testing in an easy-to-understand manner, trial lawyers can better present their cases and jurors can be better equipped to weigh the evidence. But this brings up additional difficult questions. How does the court define whether a person is an expert? What qualifications must they meet to provide their opinion in a court of law?

These questions, too, are addressed in **Fed. R. Evid. 702**. It only allows experts "qualified … by knowledge, skill, experience, training, or education." To be considered a true expert in any field generally requires a significant level of training and experience. The various forensic disciplines follow different training plans, but most include in-house training, assessments and practical exams, and continuing education. Oral presentation practice, including moot court experience (simulated courtroom proceeding), is very helpful in preparing examiners for questioning in a trial.

Normally, the individual that issued the laboratory report would serve as the expert at court. By issuing a report, that individual takes responsibility for the analysis. This person could be a supervisor or technical leader, but doesn't necessarily need to be the one who did the analysis. The opposition may also call in experts to refute this testimony, and both witnesses are subject to the standard in use by that court (*Frye, Daubert*, Fed. R. Evid 702) regarding their expertise.

Each court can accept any person as an expert, and there have been instances where individuals who lack proper training and background have been declared experts. When necessary, the opponent can question potential witnesses in an attempt to show that they do not have applicable expertise and are not qualified to testify on the topic. The admissibility decision is left to the judge.

Additional Resources

Publications:

Saferstein, Richard. **CRIMINALISTICS: AN INTRODUCTION TO FORENSIC SCIENCE**, Pearson Education, Inc., Upper Saddle River, NJ (2007).

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