

An Analysis of Three Specializations of Forensic Science

Honors Thesis Project

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Introduction

There is not a specific moment where I developed an interest in forensic science. As a child, I went to forensic science summer camps where I learned how to process a crime scene and analyze evidence. Although I was always interested in forensic science, my academic and career goals were oriented around becoming a veterinarian. After 13 years of guiding my education and interests toward going to Oklahoma State University's College of Veterinary Medicine, I was left with no plan B once I decided that veterinary medicine was no longer what I wanted to do. Through the guidance of professors and advisors, I recalled my childhood love for forensic science and decided to change my major from Zoology to something more applicable in forensic science. I settled on a dual-degree in Biochemistry and Microbiology with double minors in Chemistry and Anthropology to provide a background in many of the fields within forensic science. Furthermore, I applied to the Forensic Science Institute at the University of Central Oklahoma to pursue a master's degree in forensic science.

After taking undergraduate courses, founding the OKState Forensic Science Club, and researching the numerous forensic science careers, I found three specializations extremely interesting: DNA analysis, forensic psychology, and firearm analysis. For three of my four years as a student at Oklahoma State University, I worked in two laboratories researching DNA sequencing. From extracting DNA from a sample up to loading the flow cell for sequencing, I have a passion for DNA analysis and research. However, forensic psychology also fascinated me. I took two years of psychology classes in high school, so I have an academic appreciation for forensic psychologists and their work. Finally, firearm analysis is the third specialization I want to explore. I have grown up around firearms, and I am very comfortable around them. True

crime shows like *Forensic Files* highlight the importance and intricacy of firearm analysis, and I became drawn to the microscopy and chemistry involved in this specialty.

Upon acceptance into UCO's Forensic Science Institute, I knew that I would have to pick one of these specialties. I decided to make the topic of my OSU Honors College thesis be an in-depth analysis of each specialization in hopes of finding the one I like the best. Therefore, the following thesis is a research paper about the specialties of DNA Analysis, Forensic Psychology, and Firearm Analysis. Within this thesis, I will discuss a general history of each specialization and summarize the techniques involved. Additionally, I conducted interviews with faculty members at the Forensic Science Institute to learn what each specialization is like from a professional's point of view. They detailed their experience and gave advice for students like me. My research for this thesis was educational, and I chose a specialty to pursue in my graduate studies.

Specializations

DNA analysis

History

DNA was not discovered as the genetic material of living things until 1943 (Cobb). In the past 80 years, research on the structure and function of DNA has allowed for DNA analysis to be applied in forensic science and law. The use restriction fragment length polymorphism (RFLP) and polymerase chain reaction techniques created the ability to not only study a specific person's DNA sequence but compare it to others. Before these techniques were created, crimes were solved using eyewitness testimony and fingerprints, blood, and ballistics, among other forms of trace evidence. The first application of DNA analysis in forensic science was in 1986 by Sir Alec Jeffreys, who had developed RFLP profiling just two years prior. The primary suspect, Colin Pitchfork, was convicted of rape and murder after DNA analysis matched his DNA to that from the crime scene. A second man, who had confessed to the crimes, was exonerated when his DNA was not a match. This historic case was the first to convict and free a person based on forensic DNA analysis (Roewer).

As DNA analysis advanced, the United States Federal Bureau of Investigation (FBI) began work on a database that could store genetic evidence from known offenders and unsolved crimes/missing persons cases. In 1990, a team was established to create CODIS, the Combined DNA Index System. CODIS includes local, state, and federal genetic profiles, referred to as LDIS, SDIS, and NDIS, respectively. Several laws have been signed to give CODIS more authority in law enforcement, with the Justice for All Act expanding the list of offenses to include in the database ("OIG Audit Report"). Profiles uploaded to CODIS are available for any crime laboratory nationwide to access, and as of October 2021, there were over 20 million profiles comprised of

offender, arrestee, and forensic profiles. Since its inception, CODIS has been utilized in 574,343 cases (“CODIS – NDIS Statistics”).

Overview

Every cell of every person, animal, and plant contains DNA, or deoxyribonucleic acid. DNA serves as the genetic blueprint for living organisms, and it encodes everything from protein expression and tissue function to hair color and height. Each person, aside from identical twins, has a unique sequence of DNA due to sections such variable number of tandem repeat sequences (VNTRs) and short tandem repeats (STRs). Differences between these sub-sequences allows for a person to be identified by their DNA. Both VNTR and STR sequences are composed of a varying number of bases and often occur at different locations within a chromosome. Therefore, unrelated individuals are easily distinguishable by analyzing their tandem repeat sequences (Panneerchelvam and Norazmi).

Differences between VNTRs and STRs can be identified through restriction fragment length polymorphism (RFLP) profiling and polymerase chain reaction (PCR), respectively. RFLP analysis uses restriction enzymes to cut DNA at specific and unique sequences. Variation between people leads to fragments of different lengths due to unique locations of the target sequences. Using gel electrophoresis, these different sized fragments can be analyzed for comparison to other samples. In PCR techniques, a small target sequence of DNA is amplified to create an amplicon that is tagged with fluorescent PCR primers. Each STR amplicon is a different length, so their size can be detected in gel or capillary electrophoresis (McDonald and Lehman). This allows forensic scientists to create an STR genotype to compare against suspects or databases (Figure 1). The standard upheld by CODIS tests 13 different STR markers at once because the probability of two

different individuals matching becomes one in a billion (Roewer). In both types of analysis, a suspect's DNA can be compared to evidence found at a crime scene to genetically link them to the crime.

Figure 1



Combined short tandem repeat genotype comparing DNA evidence from the crime scene to that of two suspects.

Interviews

Dwight Adams, Ph.D., is one of the most renowned DNA analysts in the nation. After graduating with his Ph.D. in 1982, he joined the Federal Bureau of Investigation as a Special Agent. His initial years of work involved DNA analysis across varying field labs until he was promoted to a position at the federal lab in Quantico in 1987. During this time, Adams work with his colleagues to create CODIS, the Combined DNA Index System (Forensic Science

Communications). The protocols his team used to develop CODIS revolutionized the field of DNA analysis, and these protocols and techniques are used in labs across the world. Not only was Adams the first FBI agent to testify on DNA analysis in court, but he testified at the local, state, and federal levels over 130 times. His success in the forensic science DNA analysis led the FBI Director at the time, Robert Mueller, to name him the Assistant Director of the FBI and the Director of the FBI Laboratory (Forensic Science Communications). While Adams retired from the FBI in 2006, he continues his passion for DNA analysis as the Director of the Forensic Science Institute.

Since Dwight Adams had an impressive and unique career in DNA analysis, my primary focus was to understand what his experience was like compared to other DNA analysts. Working at the federal level provided Adams with a unique experience. Compared to DNA analysts in local laboratories, Adams worked on less cases. He spent most of his time writing reports, speaking with prosecutors, and testifying in courts across the country. When I asked what benefits the federal laboratory has that someone with an interest in DNA analysis might be drawn to, he said that the FBI always provided him with something different. The work varied often enough, and the cases were always different, so he maintained interest in his job. Adams' time with the FBI was marked by landmark cases, such as The Amerithrax Case, and advancements in software and technology such as CODIS and PCR, respectively. Dwight Adams' career is an enticing glance into one realm of DNA analysis, but federal laboratories are only one type of DNA analysis laboratory.

Contrasting with Dwight Adams, James Creecy, Ph.D., has experience with DNA analysis at the local level. Creecy graduated with a Master of Science in 2005 and worked with the Oklahoma City Police Department as a DNA analyst. Creecy defines DNA analysis as the examination of anything that could contain DNA: saliva, blood, sweat, etc. Such examination includes conducting presumptive and conclusive tests to identify the source of the DNA and

extracting and sequencing the DNA. After the DNA has been sequenced, analysts like Creecy will then write a report of their findings and conclusions. Regardless of the type of crime laboratory, DNA analysts typically perform the same protocols/duties.

During his time with the OKCPD, Creecy would conduct DNA analysis on cases that occurred in his hometown. Creecy noted that a key difference between working for a local police department compared to the work of Adams is that his analysis felt more personal. He described this difference in reference to the bigger goal of the analysis: nationalism versus humanity. When you are so far removed from the crime, Creecy says that the goal is to preserve national integrity; his work, however, was to uphold local humanity because he had a more intimate relationship with the details of the crime. I asked how this affected his ability to stay unbiased and professional, and Creecy said that it changed as his life experience changed. In his initial years as a DNA analyst, Creecy noted that it was easy to remove himself emotionally from his work. He was able to direct his focus on the science and not on the people involved. During our interview, Creecy elaborated that this became more difficult once he had children. Crimes against children, or those involving sexual assault, made it more difficult for Creecy to remain emotionally uninvested.

James Creecy has two pieces of advice for students interested in both forensics in general and DNA analysis. The first is to have a passion for DNA analysis. Laboratory work can become tedious and repetitive, especially for forensics students who are looking for hands-on work. Creecy advises students to know that laboratory work is something you want to do and can envision yourself doing every day. His second guidance is to have developed a strong and confident work ethic. Writing reports and testifying in court are tasks that all types of forensic scientists have. With this comes a level of stress that some students might not be prepared for. Creecy says that, while there is pressure to correctly perform your analysis and testify your findings, the reputation

is on the laboratory not the analyst. For example, Creecy says that if the analysis is incorrect, the error is likely in the protocol not the analyst's work because they are trained to follow the protocol. When testifying, the forensic scientist's goal is to simply educate the jury on what they know, which only includes facts.

Psychology and Profiling

History

While forensic psychology is a relatively young discipline, some of the first applications of psychology in law, especially the use of insanity pleas, date back to the early 1800s. During the early 20th century, psychologist Sigmund Freud discussed a practical application of psychoanalysis in the court system. His argument was rooted in a controversial psychological technique of word-association, in which a suspect could be compelled to admit guilt or innocence through subjective clues. However, Freud's idea of applying psychology to understand a criminal's mind was not too radical. During the first half of the twentieth century, researchers were conducting studies on observation and eyewitness testimony, mental well-being, and the psychological conditions of those involved in court cases. By the end of the 1970s, the American Psychology-Law Society was fostering acceptance of the professional use of psychology in law enforcement and the judicial system (Brigham).

The Federal Bureau of Investigation created the Behavioral Science Unit (BSU) in 1972 as the nation saw a rise in serial homicide and rape cases. The BSU was tasked with interviewing convicted serial killers to learn as much as they could about the minds and behaviors of those who committed violent crimes. Robert Ressler and John Douglas were among the first agents that worked in the BSU, and over the course of three years, they interviewed 36 serial killers. They came up with the organized-disorganized theory in which organized killers premeditate their crimes and leave little evidence while disorganized killers attack at random and are less careful. By 1985, the BSU grew into the Behavioral Analysis Unit (BAU) to include five departments that covered crimes ranging from serial killings and child abductions to corruption and cyber crimes. Agents with a lot of experience in the subject of each unit were promoted to profilers to

work with law enforcement nationwide. The organized-disorganized theory expanded to analyze behaviors before, during, and after the crime to create a more complete psychological profile of potential suspects (Winerman).

Overview

In criminal cases, forensic psychologists are often responsible for interviewing a suspect to assess their mental competency. Psychologists are evaluating the suspect for any disorders that could explain their behavior during the crime; a determination of “insanity” requires a psychological assessment of the suspect’s actions during the crime and throughout their mental development. Furthermore, forensic psychologists serve as expert witnesses to counsel the jury on motive/behaviors or appropriate sentencing. Outside of their duties directly related to a criminal offender, psychologists can provide therapy for victims and research more effective interrogation and rehabilitation techniques and facilities. Forensic psychologists apply their professional psychology training, along with extensive forensic knowledge, to evaluate aspects of criminal and civil cases (Tyler Ward).

Conversely, agents assigned to profiling often do not have advanced degrees in psychology or work as full-time profilers. At the federal level, they begin their careers as agents and get promoted after gaining experience in specific areas such as serial killers, bombs and terrorism, or white collar crimes (Halpern). In some federal agencies, such as the Bureau of Alcohol, Tobacco, and Firearms, agents go through several-month long psychology and behavior training to prepare them for evaluations and consultations with law enforcement, psychologists, and even the criminal offender (“Criminal Profilers”). These agents apply their knowledge of stereotypical behaviors and characteristics from past crimes to ones they have been assigned to

consult on. Law enforcement agencies will provide case reports and evidence for agents to review, and they will create a suspect profile (Halpern).

Interview

Starting at a young age, John Mabry, J.D., wanted to be an FBI agent. During the 1980s, the FBI was hiring people with backgrounds in accounting and law, so Mabry got his bachelor's degree in accounting. He decided to further his education by going to law school, and upon graduation in 1984, Mabry was hired as an FBI agent. He worked as an agent for several years and met with members of the Behavioral Science Unit (BSU) to discuss cases he was working on. The BSU team would help agents by creating a profile of the suspect based on their behavioral and psychological profile. His numerous encounters with the BSU led him to have an interest in profiling, so he put in an application to be assigned to the Serial Homicide and Child Abduction Unit. As the FBI grew and evolved, the BSU became the BAU (Behavioral Analysis Unit); local and state agencies would request support from BAU agents like Mabry. Mabry went on to have a successful career as a profiler within the BAU; he retired after 25 years in the FBI and moved back to Oklahoma City to teach at the Forensic Science Institute at the University of Central Oklahoma.

Forensic science, and the BAU in particular, have become the topic of popular culture in the past few years; the television show *Criminal Minds* focuses on a fictionalized version of the BAU. However, Mabry says that real-world forensic science and profiling is not how Hollywood depicts it to be. Being a profiler is not a specific job within the FBI; it's an assignment for agents with long and successful careers. Unlike the profilers in *Criminal Minds*, Mabry and his team would not travel to the location of every case, but instead consult local police over the phone. In

the consultation, profilers provide a description, or profile, of potential characteristics of the suspect based on psychological similarities between the specific case and previous cases. On the surface, profiling and forensic psychology apply similar psychological techniques to analyze a suspect; however, a Ph.D. or Psy.D. in psychology is not required to become a profiler. Therefore, Mabry advises that students interested in profiling have a desire to be a typical FBI agent. Profilers are not selected until an agent has spent several years in the bureau.

Firearm Analysis

History

Modern forensic firearm analysis began in the mid-1800s. The earliest recorded event of firearm evidence being used in the United States was in Oregon in 1852. When a man was found dead, detectives conducted tests on his shirt using a suspect gun. Their goal was to determine if the hole was from a gunshot or a knife tear, and they concluded that the suspect firearm created holes similar enough to the original to charge the suspect with murder. By the 1870s, firearm experts were providing court testimonies. Throughout the 20th century, many notable events occurred in firearm identification. In 1925, Philip Gravelle helped establish the first independent forensic laboratory, the Bureau of Forensic Ballistics, in New York City. Gravelle also modified a comparison microscope that made examination of ballistics evidence more accurate and efficient. Events like the St. Valentine's Day Massacre and the assassination of President John F. Kennedy further showed that firearm analysis was an effective and necessary application of forensic science (Hamby and Thorpe).

The Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) created the National Integrated Ballistic Information Network (NIBIN) in 1997. Similar to other forensic science databases like CODIS, this database serves to file images of local, state, and federal ballistics evidence. Images are flagged if there is any potential association between them; then, law enforcement agencies can cross-examine the firearms or other evidence in efforts to solve both local crimes and those that cross jurisdictions. As of last year, 307,000 leads were generated with 132,000 confirmed associations. NIBIN currently stores 4.5 million individual images of firearm evidence ("NIBIN"). As for the actual casings and firearms, the ATF's Crime Gun

Intelligence Center (CGIC) manages and analyzes this physical evidence. Violent offenders and sources of crime guns can be identified through the CGIC (“The National Crime Gun”).

Overview

Firearm examiners are often called on to provide expert testimony in court, where they use their knowledge of firearm analysis to link a firearm to a crime. There are many aspects to a firearm that can be used in analysis, including the serial number, lands and grooves within the barrel and the subsequent striations on bullets, and firing pin impressions on cartridge cases. These features can be compared between the bullets/cases found at a crime scene and those from test shots with a suspect firearm. Comparison microscopes are used for this analysis because two cartridge cases, for example, can be analyzed side by side to determine if their individual characteristics match. Both two-dimensional and three-dimensional comparison microscopes are currently used in firearm analysis because they can provide different perspectives on the same piece of evidence. The location and depth of impressions or striations can be measured and compared using both types of microscopes (Mattijssen et al.).

Firearm analysis also entails distance determination, or how far away the firearm was from a specific object when it was shot. The distance can be narrowed down by conducting test fires from different distances because the size and distribution of bullet hole patterns changes with distance. While this type of comparison cannot provide an exact distance, it allows examiners to analyze a smaller range. Firearms emit multiple residues when they are fired, including smoke and gunpowder, and these residues can be detected on objects near the firearm. Examiners use certain chemicals that react with the nitriles and lead found in burned gunpowder

to locate where the firearm was shot. Gunpowder residue is also left on the suspect, so their clothes can be tested to conclude whether they shot a firearm (“Distance Determination”).

Interview

In his early thirties, Eric Law, Ph.D., is one of the youngest members of the faculty at the University of Central Oklahoma. His age should not imply a lack of knowledge; Law holds a B.S., M.S., and Ph.D. all in Forensic Science from West Virginia University, one of the only schools to offer all three programs. Throughout Law’s education, he has been able to conduct extensive research in firearm analysis. His master’s thesis discussed variability in firearm test fires, and his doctoral dissertation reviewed the accuracy of firearm examiner conclusions. Eric Law provides a unique glimpse into the world of forensic science because he has never worked on a case. Instead, he has spent his time researching novel microscopy and imaging software to advance firearm analysis.

Traditional firearm analysts work in crime laboratories to interpret evidence involved in a crime. Submitted evidence includes cases, bullets, or guns, and the analysts use comparison and reconstruction techniques to match evidence to suspect weapons. On the other hand, research analysts like Law have more freedom in the type of analysis they do. Law describes his research experience as the ability to study what interests him about firearm analysis instead of performing the same techniques on real-life cases. Law’s favorite part of research is exemplified by his Ph.D. dissertation. Law enjoys creating new protocols, publishing articles, and answering questions plaguing firearm analysis across crime laboratories. His dissertation researched the efficiency of three-dimensional scans to compare bullets and cases, with the goal of conducting analysis at faster rates with smaller margins of error than with currently used software.

When considering forensic research, one thing to consider is that it is more dynamic than the careers of Dwight Adams, James Creecy, and John Mabry. Law's laboratory is subject to availability of funding and evidence to analyze. Unlike fingerprint analysis, firearm evidence cannot be as easily produced by graduate students or career researchers. Therefore, the type of research that can be conducted is regulated by access to gun ranges or sample bullets and cases. Additionally, the focus of firearm research will likely change over the course of the next five to ten years as new analysis equipment and techniques are developed. Eric Law believes that undergraduate students interested in firearm analysis should get involved in the field: conduct research, present at conferences, and publish articles. He states that research is the best way to learn if a certain field is right for you, and if it is, it creates a competitive advantage when applying for future graduate studies or jobs.

Conclusion

Throughout writing this thesis paper, I have kept an open mind regarding each specialization. DNA analysis is a relatively new field that has arguably become one of the most influential specialties in forensic science. My research has been insightful, and I could see forensic DNA analysis being a rewarding career. Under the guidance of Dwight Adams, I have the potential to research DNA analysis with a pioneer in the field. While James Creecy's laboratory is conducting similar research to other DNA analysts at UCO, his experience in local forensic science laboratories provides a unique perspective that I would really enjoy. In the field of forensic psychology and profiling, I would work with John Mabry and take psychology and behavioral courses. Pursuing forensic psychology would require a doctorate degree, but I believe doctoral research in this specialization would be incredibly fascinating. After writing this thesis, I can confidently eliminate becoming a profiling agent; the consultation side of being in the BAU does sound fulfilling, but I do not want to be an agent. Finally, firearm analysis research with Eric Law would give me the opportunity to test new software and techniques. Once I am in the workforce, I could be analyzing evidence with the same software that I conducted my master's thesis with.

All three specializations are important to forensic science, and the University of Central Oklahoma is carrying out exemplary research in every specialization it offers. At the time of concluding this thesis, I am happy to announce that I have been accepted into Eric Law's research laboratory. For my master's thesis, I will be conducting research on the efficiency and accuracy of portable three-dimensional firearm analysis software that can hopefully be used at crime scenes in the near future. Upon graduation from UCO, I will have the opportunity to work in firearm analysis or general crime scene analysis.

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