Welcome back to the Stevenson University Forensics Journal. The overwhelming response from readers of the 2010 Journal was an exciting beginning to what we hope will be a long tradition of scholarly pursuit.

After a brief rest to enjoy the success of our first edition, the editors spent the remainder of 2010 working on the second edition. This year, we are fortunate to have an increasing science presence in the Journal, which have expanded both its breadth and its depth of this subject matter. Other articles were authored by students in the accounting, legal, investigations and IT tracks.

All articles written for this edition of the Journal are authored by master’s degree candidates at Stevenson University. Each submission has been peer reviewed by two current students and undergone the editing process with both faculty and outside editors. After almost a year of waiting for some authors, the realization of publication is here and the commitment to the scholarly process has been realized!

Thank you to the editors, Abigail, Pat, Stephanie and Robert. Your work is an integral part of the success of the Journal. I would also like to thank the administration, faculty and staff for their continued support and enthusiasm for this project.

Carolyn Hess Johnson, Esq.
Editor and Publisher
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CAROLYN HESS JOHNSON, ESQ. is an attorney and a full time Associate Professor of Forensic Studies in the School of Graduate and Professional Studies at Stevenson University. She has worked in private practice, as a Senior Assistant State Prosecutor for the State of Maryland and as an Assistant State’s Attorney in Baltimore City, Maryland.

PATRICIA ELLIS, ESQ. has served in many capacities at Stevenson University, currently as an Associate Dean in the School for Graduate and Professional Studies. Among her accomplishments, she has published and presented at national conferences and has given many workshops. She is currently the Vice Chair for the Executive Board of the Commission for Accelerated Learning and is Editor of its Newsletter.

ABIGAIL HOWELL edited technical proposals, award packages, and various studies for submission to the Secretary of the Navy, Chief of Naval Operations, and Secretary of Defense. Subject matter included: telecommunications systems management and innovations, combat systems maintenance, Occupational Safety and Health Administration compliance, environmental compliance and initiatives, installation management excellence, and base realignment and closure proposals. Adjudication experience includes cases pertaining to Uniform Code of Military Justice violations, combat-related disabilities, physical evaluation board determinations, and military discharge characterizations.

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STEPHANIE WITT is currently a student in the graduate program at Stevenson University, where she is pursuing a degree in Forensic Science. She completed her undergraduate studies in 2008 at the University of Baltimore, with a B.S. degree in Forensic Science. Stephanie works as a graduate assistant in Stevenson’s School of Graduate and Professional Studies.
The study of forensics is relatively new and still rather novel as an academic discipline. At the time that Stevenson University established the forensics programs, we had few firm ideas or principles upon which the program would be based, and these were in an embryonic stage of development. The founding dean, Joyce Becker, provided not only the inspiration for forensic studies at Stevenson but also some concrete beliefs. It would be a practice degree primarily rather than a research-based program, but it seemed essential to build in a capstone thesis similar to those of traditional master's degrees.

Why not, Becker suggested, create something like the “law review” experience in schools of law? Carolyn Johnson, the primary instructor for the thesis course, not only contributed to this basic premise but also took charge of the project in her classes. The students who produced the best work would be invited to improve upon their seminar papers as potential articles for the Journal.

Soon forensic science students were invited into the review to join their forensic studies colleagues. The result has been successful beyond even our most optimistic projections, and we are now ready for the second installment of the Forensics Journal.

Stevenson University aspires to be a national leader in career education, and this scholarly product stakes a claim to be recognized as the premier publication of its kind. On behalf of the entire Stevenson University community, I congratulate all the students, faculty, and staff members who have had a hand in this fine pioneering work.

Paul D. Lack, Ph.D.
Executive Vice President for Academic Affairs
From Stevenson University to Malta: The Path of a Fulbright Scholar

Thomas Coogan, Esq.

What do the following have in common—a United States Senator from Arkansas, a boy from New York, a group of nuns in Maryland, and a small island nation in the Mediterranean where 98% of the population is Christian (Roman Catholic) but who call their god "Allah" (the Islamic word for God)?

The story begins hundreds of thousands of years ago when glacial melting formed the Mediterranean Sea which carved out small islands with tiny fossils for us to find millennia later. In more recent times, say the last 5,000 years, the island was inhabited by builders of stone temples predating both the pyramids and Stonehenge. Discovered and fought over by the Phoenicians, Carthaginians, Romans, Arabs, Normans, Spaniards, the Knights of St. John, French, and English, this island nation finally became independent of Britain in 1964. The English-speaking island nation, the smallest member of the European Union, is Malta (a name believed to be derived from the Graeco-Roman word “melita” which means “honey”).

Shortly after World War II, a United States Senator from Arkansas who experienced the devastation of war, thought it would be a good idea to promote world peace by enabling American citizens to visit foreign countries thus creating cultural exchange opportunities on a personal individual level. Through a series of clever and fortuitous political tactics, including funding the program with surplus military property America left overseas after the war, the United States Department of State began funding these exchanges in 1946. Senator J. William Fulbright established this federally funded program which now bears his name.

Only a year later, in 1947, an order of Catholic nuns, the Sisters of Notre Dame de Namur, founded Villa Julie College at “Seven Oaks,” an 80-acre estate in Greenspring Valley, Stevenson, Maryland, just outside Baltimore. The school is now known as Stevenson University with the gracious original campus in Greenspring Valley and a modern new campus, home to the Forensic Studies program, in nearby Owings Mills, Maryland. Seven years later, Carol and Thomas Coogan had their first child, a boy. The boy grew up always wanting to learn more about other cultures and one day, maybe if he was lucky, living overseas like some of his relatives did after the war. That boy is me, Tom Coogan.

In 1989, after a brief stint with the U.S. Secret Service, earning a master’s degree in forensic science, and then going to law school, I became an adjunct professor at Villa Julie College, and in 2004 became the first Program Coordinator for the new forensic studies master's degree program at Stevenson University. In 2009, I had the good fortune of learning about a Fulbright Program award for Malta, which was seeking a lecturer at its Institute of Forensic Studies at the University of Malta. At first I was concerned I would not speak the Maltese language, but soon learned that while they have their own language, Maltese, which is a Semitic language similar to Arabic or Hebrew but which uses the Latin alphabet (plus a few extra characters), English is an official language and used in school. The Director of the Institute, Dr. Jacqueline Azzopardi, was kind enough to extend an invitation to teach in the event I was given a Fulbright Award. With invitation in hand, and with the support of Dean Joyce Becker, I applied.

While my application was pending, Dr. Azzopardi invited me to attend the University of Malta’s second international criminology conference in October 2009. With the support of President Kevin Manning and Dean Paul Lack of Stevenson University, I had the honor of being a presenter as well as an attendee. My paper and presentation discussion of transnational internet fraud was well received. Several months later I was informed the peer review of my Fulbright application was recommending I be considered for a Fulbright Scholar Award. Final approval was contingent upon positive endorsements by the University of Malta, the U.S. Embassy in Malta, and finally by an independent commission at the Department of State. In March 2010, I learned that the award was approved. And so the adventure begins.

Beginning in late January 2011, I will travel to Malta to begin teaching. An honor to be one of 800 U.S. faculty and professionals elected to go abroad each year on the Fulbright Scholar Program, I hope to learn more about the Institute, the Maltese and European Union legal and justice system, and the history of Malta. I also am looking forward to again eating the national dish, fenek (rabbit), visiting the magnificent St. John’s Cathedral in Valletta (built by the Knights of Malta) and the mysterious walled city of Mdina (built by the Romans and the Arabs), watching soccer and water polo (the national crazes), and taking a day trip to the Maltese island of Comino and visiting the Blue Lagoon where the movie of the same name was filmed. Most of all, however, I am looking forward to seeing the friends I made in Malta and making more friends with the people who, during a period called “the Siege of Malta” during World War II, suffered more bomb attacks than any other ally, including London, yet still managed to survive and thrive, being named in one study as one of the top three places in the world to live.

What do a United States Senator from Arkansas, a boy from New York, a group of nuns in Maryland, and a small Catholic island nation in the Mediterranean who call their God “Allah” have in common? Stay tuned, as in next year’s edition of the Forensic Studies Journal, upon my return from Malta in June 2011, I will let you know.

ABOUT THE AUTHOR

Thomas Coogan, Esq. is the Program Coordinator for the Forensic Studies program at Stevenson University.
A project born of the promise to keep teens off the streets has evolved into an opportunity for Baltimore City youth to learn firsthand about how a criminal case moves through the justice system. The South Baltimore Teen Council has brought together the Baltimore Police Department and the Recreation Department as well as attorneys from the Baltimore City State’s Attorney’s Office and the Office of the Public Defender to create a unique program known as Teen CSI Baltimore.

A staged armed robbery is the setting for the initial investigation. The participants spend ten weeks working through the evidence at the Baltimore Police and Fire Training Center to learn investigation techniques and procedures. Learning to collect, test and preserve evidence from a staged crime scene is only the beginning of the investigative process. After the crime scene investigation, the teens work with lawyers from the Office of the Public Defender and the Office of the State’s Attorney to bring the case to trial. The trial, conducted in an actual courtroom, allows the participants to act as forensic scientists, lab technicians, lawyers, witnesses, officers, the defendant, and jurors.

Marie Sennett serves as the program coordinator. With a Bachelors of Social Work and a Juris Doctor degree, Marie has been advocating for and assisting the underserved throughout her entire professional career. Her extensive professional experience includes having been a nursing home resident advocate, a Public Defender in Manhattan, a Civil Rights Attorney for Prisoners and a Litigation Director as well as an Executive Director for D.C. Prisoners Legal Service Project. She is currently an Assistant Public Defender in Baltimore City.

In the fall of 2010, Carolyn Hess Johnson, the Editor of the Stevenson University Forensics Journal, interviewed Marie Sennett.

WHAT IS THE ORIGIN OF THE SOUTH BALTIMORE TEEN COUNCIL?

In 2004, the South Baltimore Teen Council arose out of a mediation effort with the Community Conferencing Center. The old neighbors and the new neighbors of South Baltimore were at odds on what to do to get the teens off the corners and away from the drug dealers. Throughout the discussions, the teens continually challenged the adults to give them something to do to stay off the streets. The South Baltimore Teen Council was born. The neighborhood association and the Ella Bailey Recreation partnered for fundraising and volunteers to make it a reality.

HOW WAS THE CONCEPT OF TEEN CSI BALTIMORE DEVELOPED?

Three years ago, the South Baltimore Teen Council thought a CSI night would be fun. We conducted a mini murder investigation in a three hour period. The participants were excited about the program and wanted to continue the case by taking it to a mock trial.

The second year we opened it up to other Recreation Centers in Baltimore and ran a six week program to include a trial and investigation techniques. The teens thought that the program was too short. Police Commissioner Bealefeld concurred as the goal was to provide the teens with as realistic an experience as possible.

This year, which is our third, the program was expanded to ten weeks for crime scene investigation, five weeks of legal training, one week of trial preparation, and the trial.

WHAT TYPE OF CASE DID YOU WORK ON LAST YEAR? WHAT WAS THE OUTCOME OF THE CASE?

Last year we had a murder at Silo Point. The man charged was one of the maintenance staff who had a reputation as a heavy drinker with a short temper. He shot someone because they woke him up while he was napping on the job. The jury convicted him of voluntary intoxication but determined he was too drunk to intentionally shoot someone. The teens did a great job presenting the case – both as witnesses and attorneys.

HOW MANY TEENS PARTICIPATE IN THE PROGRAM? IS THERE A SELECTION PROCESS OR ARE ALL APPLICANTS TAKEN?

This year started with fifty teens. All participants are self selecting because it is a huge commitment of time after school. Unfortunately, we had twenty drop out due to the heavy snowfalls this winter which extended the schedule significantly.

HOW LONG DOES THE PROGRAM RUN AND HOW MANY HOURS PER WEEK DO PARTICIPANTS SPEND WITH PROFESSIONALS IN THE PROGRAM?

The program begins the first week of January and runs for seventeen weeks. The teens meet with professionals every Wednesday from 6 to 8 p.m.
HOW MANY HOURS ARE PARTICIPANTS EXPECTED TO WORK ON THEIR OWN TO PREPARE FOR THE CASE?

None, we know better! We are thrilled that some of the teens are looking over the Statement of Probable Cause and the fingerprint evidence on their own. We do not expect them to spend any additional time on preparation work. However, the teens who chose to be the attorneys are doing so and it is thrilling!

HOW ARE CASES CHOSEN, DETAILS WORKED OUT AND EVIDENCE CREATED?

Sharon Talmadge, who supervises the Baltimore City Police Laboratory, determined what evidence would be best for training purposes. Baltimore Police Department Commissioner Fred Bealefeld chose an Armed Robbery gone awry because of the many levels of forensic evidence it would offer the teens. Police Officer Kevin Vaught was the creative writer for the charging documents. The attorneys added salient details through the witness biographies to assist with creating a viable defense to all the prosecution material provided by the Baltimore City Police Department.

WHAT DO PARTICIPANTS ACTUALLY DO IN EACH STEP OF THE PROGRAM?

This is hands-on training at its finest. The teens have learned about investigative techniques by working directly with the staff of the Police Lab. They interrogated each other after learning the technique from a police lieutenant. Reports were written based on what evidence was recovered at the scene, and they learned objections, cross and direct with guidance from the attorneys.

WHAT TYPES OF SCIENTIFIC AND/OR ELECTRONIC EQUIPMENT DO PARTICIPANTS GET TO USE OR EXPERIENCE IN THE PROGRAM?

Everything the Baltimore City Police Laboratory had to offer, with the exception of the gas chromospectography equipment.

IN ADDITION TO THE ATTORNEYS AND LAB TECHNICIANS, WHAT OTHER PROFESSIONALS WORK WITH THE TEENS DURING THE PROGRAM?

Dispatchers, EMTs, Forensic scientists, Detectives, Foot Patrol Officers, Firearms Experts, and Judge Althea M. Handy.

WHY IS THIS PROGRAM IMPORTANT TO YOU?

It is important for the teens to see the positive side of the criminal justice system and the many potential jobs it offers. For example, the teens had no idea that it takes over 20 people to bring a case from a 911 call to trial.

WHAT DO YOU HOPE PARTICIPANTS WILL GAIN FROM THE PROGRAM OVERALL?

Confidence in themselves. This is a huge project for them and to see them smile with pride as they can answer a question such as, “What is Gun Shot Residue and why does it not mean that a person shot a gun?” is amazing. We challenged them to go way beyond their comfort zone and learn something they never thought possible. It gives them the confidence to continue to challenge themselves and grow. That makes it all worthwhile.

ABOUT THE AUTHOR

Carolyn Hess Johnson, Esq. is an attorney and a full time Associate Professor of Forensic Studies in the School of Graduate and Professional Studies at Stevenson University. She has worked in private practice, as a Senior Assistant State Prosecutor for the State of Maryland and as an Assistant State’s Attorney in Baltimore City, Maryland.
Due Process and Employee Rights
John Grimes

In the early part of the 13th century, English barons sought to limit the authority of King John, petitioning him to grant certain liberties to be enjoyed by his subjects. The early agreements, and annulments of those agreements, eventually led to the historic Magna Carta, which bestowed rights on Englishmen. Among those rights was the concept of due process, a principle that protects individual life and liberty from a powerful and potentially abusive government. Simply put, due process equals fairness.

DUE PROCESS

Six-hundred years later, and an ocean away, the Founding Fathers of the United States of America included the model of due process in the Bill of Rights to the United States Constitution, making it a foundation of American liberty. The intent, as in 13th century England, was to protect individuals from government abuse.

Due process eventually emerged in the area of employee rights. As the United States grew and prospered during the Industrial Revolution, people began leaving their farms and other trades in order to work for larger companies. Employers became more and more powerful and the potential for abuse, as well as actual abusive practices against employees, increased. As a result, an equalizing labor movement emerged. Labor unions and employers negotiated, sometimes acrimoniously, on issues involving pay, work hours, conditions, benefits, and treatment. As a result, many labor contracts dictate the manner in which companies deal with employee discipline and how employers conduct internal investigations.

Somewhat paralleling the trends in labor agreements, federal and state laws were enacted to protect the general welfare of the workforce. Laws such as the Fair Labor Standards Act, the Family Medical Leave Act, the Employee Polygraph Protection Act, and the Occupational Safety and Health Act were passed to protect worker's wages, health benefits, privacy, and safety. In concert with labor agreements and employment laws, judicial rulings have inserted due process privileges into the arena of employee rights. Particularly, two United States Supreme Court decisions and an equally significant United States Court of Claims ruling altered how affected employers conduct employee misconduct investigations. The 1967 U.S. Supreme Court case, Garrity v. State of New Jersey, 385 U.S. 493 (1967) and the U.S. Court of Claims case, Kalkines v. United States, 392 U.S. 273 (1973) deal with self-incrimination and immunity from prosecution for public sector employees. The U.S. Supreme Court case, NLRB v. J Weingarten, Inc., 420 U.S. 251 (1975) involves a union employee's right to have a union representative present during an investigatory interview if the response to questioning can lead to discipline.

Employee labor organizations have undertaken educational initiatives to ensure members are aware of their rights pursuant to Garrity, Kalkines, and Weingarten. Employers are compelled and legally obligated to comply with provisions resulting from the rulings. In examining employee and employer initiatives, one can assess whether the rulings have created a disadvantage to employers or whether they have established a fair and acceptable framework for addressing employee dishonesty and misconduct.

Garrity involved a group of New Jersey police officers who were being investigated by the State Attorney General for ticket fixing. Edward Garrity, the Police Chief, and other officers were interviewed by a Deputy Attorney General who warned them that anything they said might be used against them in a criminal proceeding. He also warned the officers that they could refuse to answer questions if their statements would be incriminating; however, the refusal to answer questions would automatically lead to termination pursuant to state law. Garrity signed a “waiver of immunity.” In doing so, he agreed that any statements he made could in fact be used against him in a criminal prosecution. Subsequently, Garrity did make incriminating statements, which led to his conviction in state court. A Supreme Court majority reversed the conviction. Justice Douglas in delivering the majority opinion wrote, “The choice imposed on petitioners was one between self-incrimination or job forfeiture. We think the statements were infected by the coercion inherent in this scheme of questioning and cannot be sustained as voluntary” (Garrity, 385 U.S. at 396). In this decision, the Court held that public employees are not required to forfeit their privilege not to incriminate themselves granted under the Fifth and Fourteenth Amendments of the Bill of Rights (385 U.S. at 496).

In establishing the public sector due process nexus, the Supreme Court majority in Garrity referred to the previous case of Slochower v. Board of Education, 350 U.S. 551 (1956) wherein the Court ruled that a public school teacher could not be terminated for invoking his Fifth Amendment privilege against self-incrimination when questioned by a Congressional committee. The Court concluded that police officers, like teachers and lawyers are not “relegated to a watered-down version of constitutional rights”, (id at 500). Two similar issue Supreme Court decisions followed in 1968, Gardner v. Broderick, 329 U.S. 273 and Uniformed Sanitation Men Association, Inc. v. Commissioner of Sanitation of the City of New York, which reaffirmed Garrity.

In Kalkines, a United States Bureau of Customs employee, George Kalkines, was the subject of an internal investigation for accepting a bribe in the performance of his duties. Concurrently, Kalkines was the subject of a criminal investigation by the United States Attorney’s office for the same bribery allegation. The Customs investigators did
not inform Kalkines that he had a Constitutional right to remain silent. He was advised of the Department’s regulation which required him to cooperate and truthfully answer questions. However, the investigators did not advise Kalkines that if he did make incriminating statements, the statements and fruits would not be used against him in a criminal proceeding (Kalkines, Ct. Cl. 473 F. 2d 436 (1973)). Kalkines became aware of the parallel United States Attorney criminal investigation, so during one interview he requested a delay to obtain the services of an attorney. The Bureau of Customs cited this delay in its determination that Kalkines was not cooperating with the internal investigation, and it became one of the counts that led to his termination (Kalkines). The Court ruled that Kalkines’ termination was not valid and he was entitled to recover lost wages. In reaching its opinion, the Court cited Sanitation Men, Gardner, and Garrity (Kalkines).

Public sector workers are beneficiaries of the rulings handed down in Garrity and Kalkines. Union Employees, both public and private sector, are the recipients of various protections, including rights decided in Weingarten.1 In that case, a store employee, Leura Collins (Collins), who was represented by The Retail Store Clerk’s Union Local 455, was interviewed by a loss prevention specialist and a store manager for suspicion of theft. Several times during the interview, Collins requested that the store manager contact a union representative to be present; however, the manager denied her requests (National Labor Relations Board). At the conclusion of the interview and corresponding investigation, Collins was cleared of the theft allegation. Collins informed her shop steward of the incident, including the store manager’s refusal to contact a union representative. As a result, The Retail Store Clerks Union filed an unfair labor practice violation with the National Labor Relations Board (NLRB) against Weingarten.2

The NLRB sought enforcement for an unfair labor practice order against Weingarten; however, the Court of Appeals for the Fifth Circuit denied the action. In response to a grant of certiorari, the Supreme Court majority ruled that the store manager’s denial of Collins’ request for a union representative to be present during the investigatory interview, while she reasonably believed that the interview could lead to discipline, violated her right to engage in “…concerted activities for mutual aid or protection and constituted an unfair labor practice” (Weingarten, 420 U.S. at 256-258.)3

Union members are entitled to due process protections in the area of employee discipline and the conduct of internal investigations for misconduct. One large employer of union workers is the National Railroad Passenger Corporation, better known as Amtrak, which is classified as a designated independent agency of the United States. Amtrak is unique in that, notwithstanding its federal designation, it was formed by Congress in 1971 as a for-profit corporation organized in the District of Columbia. Even though Amtrak is an independent federal agency, its workers are not federal employees.4 Amtrak employs about 22,000 people, of whom 2,000 employees are non-union members and generally consist of executives, managers, and support personnel. The other 20,000 employees are members of fifteen separate crafts represented by fifteen separate labor unions.

Amtrak’s agreements with the fifteen unions were examined. None specifically mentions rights or privileges afforded by Garrity, Kalkines, or Weingarten. However, the contracts articulate other safeguards with union membership, which prescribe procedures to be followed by Amtrak management when conducting investigations involving employee misconduct. Depending on the craft agreement, the safeguards take effect within 90 to 120 days of employment. The agreement with the International Brotherhood of Boilermakers and Blacksmiths (IBBB) is representative of the fifteen separate agreements and reads in part, “Employees who have been in service more than 90 calendar days shall not be disciplined or dismissed without a fair and impartial investigation…” The agreement further requires that employees be provided advance written notice of the pending investigation, specifying the charges against them (Rule 23, IBBB).

1 Even though union membership has dwindled since the 1950s when union affiliation reached a peak of 33% of all American workers (Whoriskey), Weingarten still has a far reaching effect. Today union membership is approximately 12.3% (Union Members Summary). Public sector union membership is at 7.9 million, which represents 37.4% of the total 21 million public sector employee population. Within the public sector, local government workers had the highest union membership rate of 43.3%, prominently comprised of teachers, police officer and fire fighters (Union Members Summary). Private sector union membership is less than in the public sector and consists of only 7.4 million workers, representing 7.2% of the total private sector workforce of almost 103 million (Union Members Summary).

2 Congress enacted the National Labor Relations Act (NLRA) in 1935 to protect the rights of employees and employers. The NLRA created the NLRB as an independent federal agency vested with the power to safeguard employees’ rights to organize and to determine whether to have unions as their bargaining representative (National Labor Relations Act). The federal equivalent to the NLRB is the Federal Labor Relations Authority (FLRA), created by the Civil Service Reform Act of 1978 (Introduction to the FLRA).

3 Workers who are not a member of a union do not currently enjoy the same Weingarten rights that union employees have. In 2004, in IBM Corp., 341 NLRB No 148, the NLRB overruled an earlier decision and decided that employers can deny a non-union employee’s request to have a co-worker present during interviews, even if the employee believes it could lead to discipline. As of this report, this ruling still stands (Deitch).

4 The author is an Amtrak employee with more than 25 years of service with the Amtrak Police Department and the Amtrak Office of Inspector General.
The fifteen agreements also create a time limitation as to management’s knowledge of an offense and when a charge must be filed. Depending on the craft, the time limits are either 30 or 45 days.\(^1\)

Another independent agency of the United States is the United States Postal Service (USPS), whose employees also enjoy protections granted in *Garrity* and *Kalkines*. In addition, the USPS employs over 580,000 union employees belonging to nine separate unions. The American Postal Workers Union (APWU) is the largest, with approximately 211,000 members (U.S. Postal Service Labor Negotiations Fact Sheet). In a broad effort to keep its members informed of their rights, the APWU published a Special Issue Collective Bargaining Report (Report) titled, “Defending Against Inspection Service and OIG Investigations.” (The USPS employs federal investigators with its Inspection Service and Office of the Inspector General.)

The Report details various situations USPS employees have been involved in and instructs them on how to avoid pitfalls during interviews. For example, with regard to *Kalkines*, the Report instructs members to “seek confirmation of immunity” by asking the name of the Assistant United States Attorney (AUSA) who authorized the granting of use immunity. (Use immunity guarantees that an employee’s compelled statement will not be used against him or her in a criminal prosecution.) The Report further instructs that in the absence of corroboration, a union representative should advise the employee to not sign the *Kalkines* warning form (Defending Against Inspection Service and OIG Investigations).

Other labor organizations have published newsletters and sponsored discussion boards regarding member rights, specifically as they pertain to, *Garrity*, *Kalkines*, and *Weingarten*. For example, the Teamsters, a union representing approximately 1.4 million workers, published on its web page a complete synopsis of *Weingarten*. The publication provides a history of the case and instructions to employees facing an investigatory interview. The Teamsters stress that *Weingarten* does not require employers to inform employees of their right to a union representative, so it is imperative for members to be educated in this regard (Three Decades Of Union Representation).

**EMPLOYEE RIGHTS**

Overall, with 21 million public sector workers and the additional 7.4 million private sector union employees, the three rulings affect over 28 million employees, which represents about 23% of the total American workforce of 124 million (Union Members Summary). The 28 million workers are employed by thousands of employers, including over 89,000 separate governmental entities in the United States (Government Units by Type). They include the federal government, states, counties, municipalities, townships, school districts and special purposes entities (State & Local Government Finances & Employment: Governmental Units).

The federal government is particularly impacted by *Garrity*, *Kalkines* and *Weingarten*. It is the largest single employer in the United States, with approximately 4.4 million employees (Career Guide to Industries, 2010-11 Edition), and is comprised of over 1,300 separate entities that fall under the three branches of government: Executive, Judicial, and Legislative (Federal Agency Directory). The Executive Branch alone consists of fifteen Departments encompassing hundreds of agencies (Federal Agency Directory). Many federal entities are classified as independent or quasi-government agencies. In addition, the government has formed over one hundred Boards, Commissions, and Committees as well as organizations formed under the Judicial and Legislative Branches (Federal Agency Directory). In spite of its vastness, the federal government has made an overarching concerted effort to adhere to the provisions provided in the rulings.

Guidelines to ensure compliance with the three Court rulings have evolved since the decisions. *Garrity’s* influence was apparent when then Attorney General of the United States, Benjamin Civiletti (Civiletti), authored a memorandum to the heads of all departments and agencies in the Executive Branch, providing guidelines concerning warnings required to be given to employees during administrative misconduct investigations. Civiletti recognized that statements made by federal employees during administrative investigations could have value in criminal prosecutions stemming from administrative misconduct activity (Civiletti). The memorandum warns that interviews pursuant to administrative investigations could hamper later criminal prosecutorial efforts. Therefore, Civiletti cautioned that agencies must take steps to assure that statements received during administrative interviews are consistent with protecting Fifth Amendment privileges against of self-incrimination. Civiletti instructed that appropriate warnings be given whenever a federal employee is requested to provide answers to interview questions on a voluntary basis in an administrative investigation. The employee must be warned that any statements made could be used in administrative as well as criminal proceedings. In addition, the employee must be warned that a refusal to answer the questions on the ground that the answers may tend to incriminate cannot result in the employee being discharged solely for remaining silent. However, the silence could be “considered in an administrative proceeding for its evidentiary value that is warranted by the facts” (Civiletti).

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1 The author is aware of a few instances wherein an Amtrak employee who was terminated for dishonesty had his employment reinstated due to a technical violation of the employee discipline procedures established per the applicable contract. Most of these involved a tardy notification of the charge letter, or management’s having knowledge of the offense longer than the 30 or 45 days as specified in the contract.
Similar to the effort agencies undertook to comply with the law from the landmark Supreme Court case of *Miranda v. Arizona*, 384 U.S. 436 (1967), the Civiletti memorandum caused federal agencies to create procedures and guidelines for how they conduct internal investigations. Particularly impacted are the thousands of federal investigators who are charged with the responsibility to investigate federal employees and contractors for misconduct and violations of law. At the forefront of this mission are the Offices of Inspectors General (OIGs).

At about the same time guidelines were being developed to address *Garrity, Kalkines, and Weingarten*, Congress enacted the Inspector General Act of 1978 (IG Act). The IG Act established independent OIGs in Executive Branch Departments, “whose primary responsibilities to the American public are to detect and prevent fraud, waste, abuse, and violations of law and to promote economy, efficiency and effectiveness in the operations of the Federal Government” (Welcome to IGnet). The IG Act of 1978 has been amended several times, creating OIGs in many other agencies and designated federal entities. There are currently seventy-three separate federal statutory OIGs, with 12,600 employees (Fiscal Year [FY] 2009 Results at A Glance). The OIGs are unique in that they are independent, while at the same time a part of the agency they are responsible to for conducting investigations, audits, inspections, and evaluations. The Inspectors General report directly to the agency head, such as a Cabinet Secretary or Board Chairperson, in addition to having a dual reporting responsibility to Congress.

The Council of Inspectors General on Integrity and Efficiency (CIGIE) governs the Inspector General community and has adopted Quality Standards for Audits, Inspections, and Investigations (Welcome to IGnet). The Quality Standards for Investigations provide general conduct guidelines in the performance of investigations, including employee interviews (Quality Standards for Investigations). In addition, CIGIE oversees specialized training through the Inspector General Criminal Investigator Academy (IG Academy). The IG Academy provides courses to augment other basic training OIG investigators have taken. The Advanced Interviewing for IG investigators, Basic Non-Criminal Investigator Training Program, and the IG Public Corruption Investigations Training Program, all offer instruction in conducting interviews of employees in misconduct investigations, highlighting the rulings handed down from *Garrity, Kalkines, and Weingarten* (Training Program Descriptions). For example, the IG Academy currently instructs investigators to provide the following *Garrity* warnings that evolved from the 1980 Civiletti memorandum (Employee Rights and Obligations):

- You are being asked to provide information as part of an investigation being conducted by the Office of Inspector General into alleged misconduct and for improper performance of official duties. This investigation is being conducted pursuant to the Inspector General Act of 1978, as amended.

- This is a voluntary interview. Accordingly, you do not have to answer questions. No disciplinary action will be taken against you solely for refusing to answer questions.

- Any statement you furnish may be used as evidence in any future criminal proceeding or agency disciplinary proceeding, or both.

The above warnings are provided to an employee or contractor when the agency does not want to forgo the option to seek criminal prosecution of an employee, if warranted. The agency is not obligated to provide this warning if the interviewee is voluntarily providing information. It is incumbent upon the interviewee to invoke the protection. According to James Tatum (Tatum), former AUSA for the Eastern District of New York, the burden is on the agency to show that the interview was in fact voluntary if information provided by the interviewee later leads to a criminal prosecution (Tatum). In Tatum’s opinion, if an agency policy requires an individual to cooperate with agency investigators and appear for an interview, then by default any statement is not voluntary, but compelled. Tatum offered that others believe that even if the policy demands that employees cooperate and appear, the investigators can use certain wording to inform the employee that the interview is voluntary. Tatum believes that this difference of opinion will eventually be adjudicated.

Furthermore, if an agency wants to compel an employee to provide information in an administrative investigation, and in effect close off any criminal prosecutorial avenue, the IG Academy instructs that *Kalkines* warnings are activated. OIG investigators are instructed to read the warnings from a form, which is to be signed by the investigator and interviewee (Employee Rights and Obligations). The warnings inform the employee that the inquiry is administrative regarding allegations of misconduct. The employee is informed that he or she has a duty to reply to questions and that disciplinary action, including dismissal, could result if the employee refuses to answer or is untruthful. Finally the employee is warned that neither the answers nor any information or evidence gained by reason of these answers has a duty to reply to questions. No disciplinary action will be taken against you solely for refusing to answer questions.
According to Tatum, the decision to relinquish prosecution and seek administrative remedies is usually determined by the agency investigators in conjunction with investigative counsel and supervision. In Tatum's experience, prior to proceeding with the use of Kalkines warnings, the investigator would discuss the case with the AUSA and seek a formal declination of prosecution. At this point, the AUSA would strategize with the investigators to ensure the decision is the right one. However, Tatum does not recall a time when he did not accept the direction of the agency investigator (Tatum), since Kalkines is a “win-win” for the agency. If the conduct under investigation is minor and the main objective is termination and not prosecution, then Kalkines can be utilized to compel the employee to provide information or be subject to discipline for insubordination (Tatum).

Tatum emphasized that once Kalkines warnings are provided, the compelled statement or any fruits of the compelled statement cannot be used in a criminal trial. Any independent evidence used in a criminal proceeding creates a “heavy burden” for the prosecution to prove that this evidence was not the result of the compelled statement. The lesson: OIGs must conduct a thorough investigation prior to interviewing the subject-employee (Tatum).

Regarding Weingarten, OIG investigators are instructed to notify the employee that he or she is entitled to union representation only if the interview may result in disciplinary action, and only if the employee requests the representation (Employee Rights and Obligations). Issues have developed as to the role of the union representative during an interview. In the 1999 Supreme Court case of National Aeronautics and Space Administration, et al., Petitioners, v. Federal Labor Relations Authority, et al., 527 U.S. 229 (199), a NASA OIG investigator allowed the union representative to be present during an interview pursuant to Weingarten. However, the investigator did not allow the representative to participate. The FLRA determined that NASA and its OIG committed an unfair labor practice. The Supreme Court affirmed the FLRA decision. As a result, OIG employees are instructed on methods to allow the union representative’s participation in an interview while still achieving interview objectives (Employee Rights and Obligations).

Laws, regulations, and labor agreements have introduced the principles of due process to employee rights. Additionally, the Court decisions in Garrity, Kalkines, and Weingarten catapulted Fifth and Fourteenth Amendment due process protections into the workplace for a large segment of the American workforce. In concert with the Court decisions, the American Civil Liberties Union (ACLU) asserts that employer abuses can only be prevented by incorporating the protections guaranteed in the Bill of Rights into employment rules and law (The Rights of Employees). Employers certainly have a responsibility to all employees and stakeholders to manage a safe and secure workplace while protecting company assets, which includes ensuring that employees who are involved in dishonesty and misconduct are properly disciplined. Even the ACLU recognizes that employers have every right to expect workers to do their jobs, and must take appropriate action when workers fail to do so (The Rights of Employees). Employers have to balance this obligation with the duty to treat employees fairly and to comply with laws, labor agreement, regulations, and judicial rulings that provide due process protections to their workers.

A person’s livelihood and the welfare of his or her family can depend on continued employment. In a presentation to the Montgomery Bar Association, Kimberly Ashbach, Esq. cites decisions indicating public employees enjoy a property interest in their jobs (Ashbach). Despite the property interest notion, employment-at-will laws in effect in virtually all states provide that in the absence of a contract or union agreement, workers are employed at the will of their employer. With the exception of established unlawful discriminatory practices in addition to various state common law exceptions, employees may be terminated at any time for any reason, or no reason at all. Regardless of employment-at-will, in the interest of due process, a solvent employer will probably be, and arguably should be, held to a standard that a termination must be for some cause.

CONCLUSION

Employers have had to adapt and take measures to ensure compliance with the three rulings as well as other laws and regulations. Undeniably, some of these measures are comprehensive and continuous, and maybe even burdensome, such as the ongoing effort expended by the federal government to train its investigators. However, it can be argued that by embracing the value of due process in the workplace and committing to efforts in training and policy development, the employer is actually placed at an advantage. By complying with the rules, employers are striving to ensure that professional and thorough investigations of employee misconduct are consistently conducted. This practice should result in employees’ receiving fair treatment and assist in preventing costly reversals of unlawful and unfair employment actions. It will be interesting to observe if future Court rulings will result in due process protections being extended to the over 100 million private sector and non-union employees who are not now included.
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Civiletti, B. R. Memorandum to the Heads of All Departments and Agencies in the Executive Branch. 4 June 1980.


Rule 23 Discipline-Investigation-Appeal. IBBB. Agreement with the National Railroad Passenger Corporation. 22 October 2010.


Tatum, James. Personal interview. 23 November 2010.


ABOUT THE AUTHOR
John E. Grimes III, CFE is the Chief Inspector with the Amtrak Office of Inspector General. Mr. Grimes has over 35 years of law enforcement experience, 25 of which has been investigating white collar crime. He is on the Board of Directors for the Maryland Chapter of the Association of Certified Fraud Examiners. Additionally, Mr. Grimes is currently a student in the Masters of Forensics Studies-Legal Track at Stevenson University. He earned his undergraduate degree in Business/Accounting from the College of Notre Dame of Maryland.
Determining the Effects of Ranging Reagent Grade Solvents on Thin-layer Chromatography Ink Analysis Using Solvent System I (Ethyl Acetate: Ethanol: Water)

Julia Wikoff

INTRODUCTION

A field of significant importance within Forensic Science is questioned documents. A document with any doubt as to the author, date written, or age is a questioned document, and may include printed materials such as letters, drivers’ licenses, contracts, passports, lottery tickets, and checks. Writings or markings found on larger objects such as walls or doors are also included in this field. A document examiner must be skilled in non-destructive techniques such as non-flash photography and microscopy as well as destructive techniques such as thin-layer chromatography [4]. Examinations of questioned documents can involve determining the type of paper and/or ink used to write the document as well as determining the author of the document.

Crimes involving questioned documents include larceny, forged wills, identity theft, ransom notes, traced signatures, altered medical records, watermarks, signatures on legal documents, pre- and post-nuptial agreements, and death threats. Questioned documents could be typed or written in ink, pencil, marker, blood, or other bodily fluids. Most altered documents are written with “white-collar criminal intent” [2], but some are written with darker purposes including kidnapping and murder. A document examiner must consider all the characteristics of a document including “the writing medium used and the surface it is written upon, the age of the paper or ink, and watermarks” [2].

Questioned documents are commonly encountered in the forensics field. If ink from a writing instrument, printer, or typewriter is used to create the document, then thin-layer chromatography can be used to determine the manufacturer of the ink. The separation of the ink components is viable on a chromatography plate by the appearance of individual colored bands. The retention factor, Rf, can be used to identify a specific ink by using a library of previously run Thin-layer Chromatography (TLC) plates. The United States Secret Service Forensic Science Division currently has the largest library of ink types with a collection of over 10,800 ink samples.

The American Society of Testing and Materials (ASTM) created a “Standard Guide for Test Methods for Forensic Writing Ink Comparison” in 2008 [1]. These guidelines are followed to determine if the ink formula can be identified, if two separate writings have a common origin, and to date the ink. Dr. Neumann and Dr. Margot published Consideration on the ASTM Standards 1789-04 and 1422-05 on the Forensic Examination of Ink. They noted that the ASTM standards stated that appropriate materials need to be chosen to minimize variability, but did not provide details regarding these materials [3]. The guidelines do not specify the solvent grades needed for Solvent System I: (ethyl acetate: ethanol: water) (70:35:30).

Two main types of inks are currently on the market today. Two-thirds of the available inks are non-ballpoint inks. These water-based inks are visualized as glossy and fluid on a paper; they commonly bleed through a thin piece of paper. Since the inks are water-based, the dyes are dissolved in ethanol: water for analysis. One-third of available inks are ballpoint inks. These glycol-based inks leave metallic appearing striations on paper and commonly leave a well when writing because pressure must be exerted to release the ink. The glycol-based inks are dissolved in pyridine.

This study was conducted to determine if different grades of solvents in Solvent System I produce inconsistent chromatography plates. The separation and clarity of the ink components and the reproducibility of the Rf values were both studied to determine the solvent system combination that produced the best results.

MATERIALS AND METHODS

Sample and Solvent System Preparation:

A total of fifty black and blue inks were chosen for analysis. Twenty-five of the chosen inks were ballpoint and twenty-five were non-ballpoint. The brand, color, and classification of each ink can be seen in Tables 1 and 2. Five Kimble glass Ink Opticlear® 12 X 35 mm vials were labeled according to the classification of each ink. The inks chosen were available on scribble sheets, labeled in binders and written on using the matching ink. A micro-punch was used to collect between four and eight 1 µm micro-punches of each ink for each of the five glass labeled vials.
**TABLE 1: BLACK INKS**

<table>
<thead>
<tr>
<th>BLACK INK NUMBER</th>
<th>BRAND</th>
<th>SECRET SERVICE CLASSIFICATION NUMBER</th>
<th>TYPE OF PEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bic</td>
<td>I-518</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>2</td>
<td>Formulab</td>
<td>I-520</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>3</td>
<td>Formulab</td>
<td>I-711</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>4</td>
<td>Fisher</td>
<td>I-724</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>5</td>
<td>Bic</td>
<td>I-917</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>6</td>
<td>Anja</td>
<td>I-1433</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>7</td>
<td>Formulab</td>
<td>I-1950</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>8</td>
<td>Carters</td>
<td>I-2325</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>9</td>
<td>Chemoline</td>
<td>I-2330</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>10</td>
<td>Chemoline</td>
<td>I-2332</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>11</td>
<td>Chemoline</td>
<td>I-2334</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>12</td>
<td>Fisher</td>
<td>I-2346</td>
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<td>13</td>
<td>Hartley</td>
<td>I-2374</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>14</td>
<td>Bic</td>
<td>I-54</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>15</td>
<td>Anja</td>
<td>I-289</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>16</td>
<td>Berol</td>
<td>I-393</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>17</td>
<td>Berol</td>
<td>I-417</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>18</td>
<td>Berol</td>
<td>I-435</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>19</td>
<td>Anja</td>
<td>I-508</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>20</td>
<td>Anja</td>
<td>I-534</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>21</td>
<td>Anja</td>
<td>I-615</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>22</td>
<td>Anja</td>
<td>I-1180</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>23</td>
<td>Anja</td>
<td>I-1425</td>
<td>Nonballpoint/Recorder</td>
</tr>
<tr>
<td>24</td>
<td>Berol</td>
<td>I-1897</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>25</td>
<td>Berol</td>
<td>I-2160</td>
<td>Nonballpoint/Felt tip</td>
</tr>
</tbody>
</table>

**TABLE 2: BLUE INKS**

<table>
<thead>
<tr>
<th>BLUE INK NUMBER</th>
<th>BRAND</th>
<th>SECRET SERVICE CLASSIFICATION NUMBER</th>
<th>TYPE OF PEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anja</td>
<td>I-338</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>2</td>
<td>Chromex</td>
<td>I-605</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>3</td>
<td>Chromex</td>
<td>I-1333</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>4</td>
<td>Anja</td>
<td>I-1432</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>5</td>
<td>Chromex</td>
<td>I-2425</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>6</td>
<td>Fisher</td>
<td>I-2506</td>
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</tr>
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<td>7</td>
<td>Fisher</td>
<td>I-2507</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>8</td>
<td>Jensens</td>
<td>I-2554</td>
<td>Ballpoint</td>
</tr>
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<td>9</td>
<td>Bic Erasable</td>
<td>I-2749</td>
<td>Ballpoint</td>
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<tr>
<td>10</td>
<td>Bic Erasable</td>
<td>I-5466</td>
<td>Ballpoint</td>
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<tr>
<td>11</td>
<td>David Kahn</td>
<td>I-5799</td>
<td>Ballpoint</td>
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<tr>
<td>12</td>
<td>Bic</td>
<td>I-7348</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>13</td>
<td>Bic</td>
<td>I-8522</td>
<td>Ballpoint</td>
</tr>
<tr>
<td>14</td>
<td>Eberhard Faber</td>
<td>I-156</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>15</td>
<td>Berol</td>
<td>I-412</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>16</td>
<td>Chromex</td>
<td>I-471</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>17</td>
<td>Papermate</td>
<td>I-642</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>18</td>
<td>Magic Marker</td>
<td>I-778</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>19</td>
<td>David Kahn</td>
<td>I-892</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>20</td>
<td>Anja</td>
<td>I-1435</td>
<td>Nonballpoint/Felt tip</td>
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<tr>
<td>21</td>
<td>Chromex</td>
<td>I-1460</td>
<td>Nonballpoint/Felt tip</td>
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<td>22</td>
<td>Berol</td>
<td>I-1821</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>23</td>
<td>Marvy</td>
<td>I-5612</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>24</td>
<td>Hunt</td>
<td>I-6641</td>
<td>Nonballpoint/Felt tip</td>
</tr>
<tr>
<td>25</td>
<td>Bic</td>
<td>I-7466</td>
<td>Nonballpoint/Felt tip</td>
</tr>
</tbody>
</table>
One drop of pyridine was added to the vials containing ballpoint ink punches and one drop of ethanol:water (1:1) was added to the vials containing non-ballpoint ink punches. The vials were undisturbed for approximately five minutes to let the ink components dissolve in the solvents.

Between two and four grades of each solvent used in Solvent System I were chosen for analysis. The variety of grades available for each solvent can be seen in Table 3. Twenty-four solvent system combinations were created using the different grades available for each solvent in Solvent System I [SSI]. Table 4 shows the twenty-four combinations of the three solvents. Each SSI combination was prepared the day of use using 70 mL ethyl acetate, 35 mL ethanol, and 30 mL water with the appropriate solvent grades. The total mixture was split into two graduated cylinders of 60 mL and 75 mL.

**TABLE 3: SOLVENTS USED**

<table>
<thead>
<tr>
<th>SOLVENT LETTER</th>
<th>SOLVENT</th>
<th>MANUFACTURER INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solvent A</td>
<td>Denatured Ethanol</td>
<td>EM Science; Lot# 41074</td>
</tr>
<tr>
<td>Solvent B</td>
<td>Anhydrous Ethanol</td>
<td>J.T. Baker; Lot# B28752</td>
</tr>
<tr>
<td>Solvent C</td>
<td>200 proof Ethanol</td>
<td>Spectrum; Lot# Yw3109</td>
</tr>
<tr>
<td>Solvent D</td>
<td>Tap Water</td>
<td>From Sink in Laboratory, D.C.</td>
</tr>
<tr>
<td>Solvent E</td>
<td>Distilled Water</td>
<td>Distilled at the USSS FSD</td>
</tr>
<tr>
<td>Solvent F</td>
<td>HPLC grade Water</td>
<td>Burdick and Jackson; Lot # CR194</td>
</tr>
<tr>
<td>Solvent G</td>
<td>A.C.S. grade Ethyl Acetate</td>
<td>J.T. Baker; Lot# G39B19</td>
</tr>
<tr>
<td>Solvent H</td>
<td>HPLC grade Ethyl Acetate</td>
<td>Acros; Lot# B0518555</td>
</tr>
<tr>
<td>Solvent I</td>
<td>RO/DI (Reverse Osmosis and Deionized) Water</td>
<td>De-ionized Water from CVS</td>
</tr>
</tbody>
</table>

**TABLE 4: THE TWENTY-FOUR SOLVENT SYSTEM COMBINATIONS**

<table>
<thead>
<tr>
<th>#</th>
<th>TRIAL</th>
<th>COMPONENT 1 (ETHANOL)</th>
<th>COMPONENT 2 (WATER)</th>
<th>COMPONENT 3 (ETHYL ACETATE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ADG</td>
<td>Denatured</td>
<td>Tap</td>
<td>A.C.S. grade</td>
</tr>
<tr>
<td>2</td>
<td>BDG</td>
<td>Anhydrous</td>
<td>Tap</td>
<td>A.C.S. grade</td>
</tr>
<tr>
<td>3</td>
<td>CDG</td>
<td>200 Proof</td>
<td>Tap</td>
<td>A.C.S. grade</td>
</tr>
<tr>
<td>4</td>
<td>AEG</td>
<td>Denatured</td>
<td>RO/DI (lab grade)</td>
<td>A.C.S. grade</td>
</tr>
<tr>
<td>5</td>
<td>BEG</td>
<td>Anhydrous</td>
<td>RO/DI (lab grade)</td>
<td>A.C.S. grade</td>
</tr>
<tr>
<td>6</td>
<td>CEG</td>
<td>200 Proof</td>
<td>RO/DI (lab grade)</td>
<td>A.C.S. grade</td>
</tr>
<tr>
<td>7</td>
<td>AFG</td>
<td>Denatured</td>
<td>HPLC grade</td>
<td>A.C.S. grade</td>
</tr>
<tr>
<td>8</td>
<td>BFG</td>
<td>Anhydrous</td>
<td>HPLC grade</td>
<td>A.C.S. grade</td>
</tr>
<tr>
<td>9</td>
<td>CFG</td>
<td>200 Proof</td>
<td>HPLC grade</td>
<td>A.C.S. grade</td>
</tr>
<tr>
<td>10</td>
<td>ADH</td>
<td>Denatured</td>
<td>Tap</td>
<td>HPLC grade</td>
</tr>
<tr>
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<td>BDH</td>
<td>Anhydrous</td>
<td>Tap</td>
<td>HPLC grade</td>
</tr>
<tr>
<td>12</td>
<td>CDH</td>
<td>200 Proof</td>
<td>Tap</td>
<td>HPLC grade</td>
</tr>
<tr>
<td>13</td>
<td>AEH</td>
<td>Denatured</td>
<td>RO/DI (lab grade)</td>
<td>HPLC grade</td>
</tr>
<tr>
<td>14</td>
<td>BEH</td>
<td>Anhydrous</td>
<td>RO/DI (lab grade)</td>
<td>HPLC grade</td>
</tr>
<tr>
<td>15</td>
<td>CEH</td>
<td>200 Proof</td>
<td>RO/DI (lab grade)</td>
<td>HPLC grade</td>
</tr>
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<td>16</td>
<td>AFH</td>
<td>Denatured</td>
<td>HPLC grade</td>
<td>HPLC grade</td>
</tr>
<tr>
<td>17</td>
<td>BFH</td>
<td>Anhydrous</td>
<td>HPLC grade</td>
<td>HPLC grade</td>
</tr>
<tr>
<td>18</td>
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<td>200 Proof</td>
<td>HPLC grade</td>
<td>HPLC grade</td>
</tr>
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<td>Denatured</td>
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<td>Anhydrous</td>
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<td>CIG</td>
<td>200 Proof</td>
<td>Distilled (CVS)</td>
<td>A.C.S. grade</td>
</tr>
</tbody>
</table>
Preparing the Chamber:

Two 11 inch by 11.5 inch General Glassblowing Company Laboratory Apparatus glass tanks were used to perform the thin-layer chromatography. The graduated cylinder containing 75 mL of SSI mixture of choice was poured into the glass tank. The tank was then rotated to allow the mixture to make contact with every area inside the tank. The mixture was poured out and then the graduated cylinder containing 60 mL of the same SSI mixture was poured into the tank. A piece of 46 inch by 57 inch Whatman Filter Paper (Catalog number 1002-917) was cut to the size of the chamber and placed against one wall. The tank was rotated to saturate the filter paper and the glass top was placed on top of the tank for a minimum of 30 minutes to allow equilibrium within the chamber to be reached.

Spotting and Running the TLC Plates:

One color of ink was spotted on each plate. Two plates of black inks were spotted and run in the chamber, followed by two plates of blue inks. The inks were spotted in the order listed in Tables 1 and 2. The ballpoint inks were followed by the non-ballpoint inks. The ballpoint inks were extracted with pyridine; the non-ballpoint inks were extracted with ethanol and water (1:1). The amount of extraction solvent depended on the amount of ink extracted from each ink sample. Spotting capillaries were used to transfer the ink to the plates; the intensity of the color in the capillaries was consistent for each ink. The color of the ink should be visible, but not opaque. The inks spots were consistent for each type of ink and were spotted on the plate directly above the pencil line at 1 cm. The pencil line served as a guide to create a linear line of ink spots across the plate. The procedure was repeated for the same inks, as two plates were run for both black and blue inks.

The TLC plate was placed in the Isotemp® oven for two minutes to allow the ink to dry. The plates containing black ink samples were placed into the tank at the same time with tweezers. Then the glass top was placed on top of the tank. The plates were left in the tank until the solvent front reached the 5 cm line. The plates were then removed from the tank and left to dry in the hood. While the plates were drying, the blue inks were tested in the same manner. After the plates were dry, they were photographed. Photoshop was then used to measure the total distance the solvent front traveled and the distance that each ink component traveled up the plate.

RESULTS AND DISCUSSION

Photographs of the black ink TLC plates from each solvent system were analyzed by three different examiners. The questioned document examiners rated the plates on the separation and clarity of the dyes on a scale from one to three, the former representing poor results and the latter representing good results. The examiners were asked to look at the bands that were close together on the chromatograph; an example of these dyes is shown in Figure 1, ink two. Examples of separation ratings of three and one are shown below in Figures 1 and 2. It is important to note that over-concentrated spots were not examined because separation could be due to the concentration of the ink. The examiners were then asked to choose the solvent system that gave the best separation and clarity to set as the standard solvent system. The grades given by the three examiners can be found in Table 5. Two examiners agreed on the grade of every solvent system. The difference in grades did not differ by more than one point. This showed consistent grades between the examiners. The bolded values represent the best solvent system combination chosen by that examiner. Two examiners chose solvent system AFG as giving the best separation and clarity of the ink components.
Eight plates spotted with the twenty-five black inks and eight plates spotted with the twenty-five blue inks were setup according to the previously stated methodology. All of the plates were run in solvent system combination AFG. The plates were photographed and the Rf values were measured. The average Rf value was calculated for each ink component visible on the chromatograph. As some ink components were not visible on individual plates, the number of Rf values for each component ranged from 2-8. The standard deviation was then calculated for each Rf value; the 95% interval was then calculated using the average +/- two standard deviations.

The previously run 24 solvent systems were then viewed to determine any Rf values inconsistent with the 95% range. The number of inconsistencies above and below the 95% interval of the average Rf value were tallied and appear in Table 6. If no inconsistencies were present, the space was left blank. The total number of inconsistencies was determined for each solvent system. The eighth blue ballpoint ink was not included in the remainder analyses because a mis-labeling error was found for the classification number I-2554. No comparisons were completed on those inks that were labeled as “not visible” when viewing each plate. The number of outliers ranged from a minimum of 9 to a maximum of 184. However, the chosen solvent system, AFG, contained 23 outliers. Uncontrollable factors such as different plates and the humidity could have affected the Rf values.

### TABLE 5: GRADING OF PLATES

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<tr>
<th>TRIAL</th>
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<tr>
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TABLE 6: RF VALUES OUTSIDE 95% RANGE OF AVERAGE RF VALUES FROM AFG PLATES

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<th>BLACK NBP OVER</th>
<th>BLUE BP OVER</th>
<th>BLUE NBP OVER</th>
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<td>18</td>
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The number of total inconsistencies, found in Table 6, was compared to the average grade of each solvent system. The average grade was computed using the three grades found in Table 5. The side-by-side comparisons can be found in Table 7. The average grade and total inconsistencies of the RF values were compared side-by-side to determine any trends. The solvent system combinations were then placed in order by the number of total inconsistencies. There was a general trend that showed plates with smaller numbers of outlying RF values had a lower score for separation and clarity. However, not all plates had the same correlation. Both the plate with the smallest number of outliers and the greatest number of outlying RF values had the poorest score for clarity and separation.
TABLE 7: AVERAGE GRADE IN COMPARISON TO TOTAL Rf INCONSISTENCIES

<table>
<thead>
<tr>
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<tr>
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</tr>
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The plates were photographed under UV light at 254 nm and 366 nm. The photographs of solvent system combinations AFG and CFG were compared to determine if the fluorescent bands differed. AFG was determined as the solvent system combination showing the best separation and clarity, while CFG was determined to be the solvent system combination showing worst separation and clarity and the highest number of Rf discrepancies. Figures 3 and 4 show black inks under 366 nm for solvent systems AFG and CFG respectively. Figures 5 and 6 show black inks under 254 nm for solvent systems AFG and CFG respectively. The images show that the fluorescent bands are relatively identical for the best and worst solvent systems. These show results that various light sources should be used to view TLC plates, even if different solvent grades are used.
CONCLUSION

The results show that solvent grades do have an effect on the separation and clarity of the ink components as well as deviations from the Rf values; however, these two effects do not go hand-in-hand for each solvent system combination. Once a laboratory has chosen the grade of solvents used for thin-layer chromatography, they must keep consistent solvent grades. The results also show that plates must be run on the same day in the same tank for the results to stay consistent for comparison. Alternate light sources should be used to view TLC plates; the fluorescent bands can be viewed using any combination of solvent grades for Solvent System I. Laboratories need to stay consistent with the grade of solvents that they use for thin-layer chromatography. If possible, the manufacturer of the solvents should also stay consistent.

REFERENCES


ABOUT THE AUTHOR

Julia M. Wikoff was born and raised in Southern Maryland. She earned her BS in chemistry and minor in biology from Stevenson University (2006). During her time as an undergraduate at Stevenson, she worked for two years on research projects lead by Dr. Timothy Dwyer and Dr. Tracey Mason. She is currently working on her master’s degree in Forensic Science at Stevenson University. For the past year, she has been working as an intern in the Forensic Science Division at the United States Secret Service. She also works as a graduate assistant for the chemistry department at Stevenson University.
Aviation Security: Quantifying Risk and the Precious Price of Air Travel
Ed Lugo

Often an airport security incident or near incident is exposed on national television, and with each event a security procedure is implemented and a new cost is passed on to the consumer (Thomas 44). Regardless of country or airline, a missed security step could become international news and have a ripple effect on one or several economies. Considering that in the United States nearly one billion security screenings occur during an average 12-month period, significant sums are expended to maintain a safe air travel environment (Gardner and Anderson 218). Why then does it seem that security is disorganized and responds on what appears to be a per incident basis? With the extraordinary number of air travelers, safety strategies must be better planned and effectively measured. Flight safety and the concerns of the traveling public are disconnected and the process used to establish air travel safety is deficient. The effort of this research is to quantify effective airport security strategies and related costs.

In the aviation industry, there is a synergistic relationship among business, security, and civil liberties. The United States commercial and civil aviation industry accounts for approximately 5.6% of the gross domestic product (GDP) and $1.3 trillion per year in economic activity (FAA Air Traffic Organization 7). Independent of an individual’s decision to board an airplane, aviation protection cost decisions influence every person in the United States. Current efforts in security research are moving toward establishing a scholarly involvement in the study of aviation security as it relates to national security (National Research Council 10). The controversial method of racial/ethnic profiling, while not overtly acknowledged in many countries, has become a powerful tool in international aviation security (Thomas 205). Profiling is used to determine the probability that an individual from a specific region or race is more or less likely to be a terrorist (Sweet 293). Defending the concept that the traveling public would be better served with overt profiling violates successful legal limitations that constrain United States security professionals. Tangible terrorist security or near incident costs include loss of life, industry revenue, credibility, and professional reputation. Non-tangible fees include privacy violation concerns, loss of trust, increased fear, etc.

In 1927, Charles A. Lindbergh’s transatlantic flight demonstrated that air travel could be practical and profitable. With the establishment of the Federal Aviation Act of 1958, the FAA came into being, and with it came “two competing and divergent goals” to “promote” and “regulate” the aviation industry (Thomas 42). This conflict set the tone for controversial decisions and significant speculation as to whom the FAA represented, the airline industry or the American public. The conflict was not resolved until 1996 with the passage of the FAA Reauthorization Act, Title IV, which changed the charter from promoting the aviation industry to enhancing its safety and security (Thomas 45).

The act of using an aircraft as a weapon of mass destruction (WMD) is not a recent innovation. On February 22, 1974, Samuel Byck killed a Maryland Aviation Administration police officer at Baltimore Washington International Airport (BWI), shot several pilots and bystanders, and gained access to a Delta Airlines DC-9. His intent was to divert the plane to Washington D.C. His goal was to use the plane to deliver the bomb in his briefcase by crashing into the White House. The incident ended when Byck committed suicide during the police standoff (Sweet 152).

After the catastrophic events of the World Trade Center terrorist attacks (9/11), the Air Transportation Safety and System Stabilization Act legislation earmarked $15 billion for the industry, of which $3 billion was obligated for airline security (Thomas 77). On November 19, 2001, the Aviation and Transportation Security Act (ATSA) was passed; ATSA mandated the creation of the TSA under the control of the Department of Transportation (DOT). It marked the first time that aviation security would be a direct and independent responsibility of a federal agency (Title 49 U.S. Code 449). Of note is that ATSA defined the primary responsibilities of TSA as based upon two assumptions, “that all passengers are equally suspicious and should receive the same scrutiny and that the principal purpose of airport security is to keep dangerous objects off airplanes” (Richardson et al. 67). These assumptions have resulted in cost prohibitive security functions because of the pool of potential suspects.

Monetary damage from events on 9/11 has reached $80 billion, of which less than half was covered by insurance (Richardson et al 38). In the event of another terrorist disruption of a metropolitan port, it is estimated that the one-month trade losses to the ports of New York and New Jersey would be $16.2 billion, with an estimate of $22.8 billion should the incident occur within the port of Los Angeles and Long Beach (Richardson et al 232). With the potential for another successful plot, the question of where and how to appropriately spend allocated security funds becomes a primary necessity.

In March 2003, the TSA was transferred from DOT administration to the newly established Department of Homeland Security (DHS). The TSA is now responsible for coordinating all aspects of implementing and maintaining aviation safety. With the establishment of DHS and the transfer of TSA, it formally marked the “federalization” of airport security (Richardson et al. 67) and it placed the responsibility of “policing” passengers, employees, and airlines under the auspices of a federal agency with enforcement authority.

Although the TSA has an enforcement unit known as the Federal Air Marshals (FAM), their responsibilities are restricted to “detect, deter, and defeat hostile acts targeting U.S. air carriers, airports, passengers, and crews” (TSA Law Enforcement Programs). The primary enforcement agency responsible for investigating acts of terror against the United States is the Federal Bureau of Investigation (FBI). Located within the Department of Justice (DOJ), “The mission of the FBI is to uphold the law through the investigation of violations of federal...
criminal law; to protect the United States from foreign intelligence and terrorist activities...in a manner that is responsive to the needs of the public and is faithful to the Constitution of the United States” (Federal Bureau of Investigation. FBI About Us).

For the purpose of establishing costs related to aviation security, the research emphasis of this report is placed on federal agencies that have actionable responsibilities and not those charged with intelligence gathering. Information obtained from intelligence gathering agencies requires a vetting process that often conflicts with how, when, and where investigative information can be used. These considerations require time to determine value, meaning and prosecutorial merit; i.e., can the information be used in the judicial process? In testimony before the 9/11 Commission, DOT representatives indicated that there was limited value on threat information from the intelligence community. “[DOT] officials...told the Joint Inquiry that although they receive threat information from the Intelligence Community, they do not always receive the information that adds context to the threat warnings...This lack of context prevents them from properly estimating the value of the threat information and taking preventive action” (Strasser 501-502).

Most terrorists conduct target vulnerability assessments. During testimony to the 9/11 House-Senate Joint Inquiry, FBI Director Robert Mueller stated in part, “With their training complete it appears that the pilots (9/11 hijackers who trained at flight schools) began conducting possible surveillance flights as passengers aboard cross-country flights....” (Strasser 388-389). The FAA applied innovative security systems stress testing called “Red Team,” this testing was initiated after the bombing of Pan Am Flight 103 in 1988 (Thomas 58). Team members intentionally placed, hid, and attempted to carry on restricted items, both in their carry on items and on their person. Unfortunately, the test results found gaps in the process of inspection, the training of inspectors, and the assumption of considering every flyer a terrorist. These gaps were so severe that internal political pressure directed the suspension of Red Team Testing. Testing abruptly ended when FAA administrators decided to suppress findings regarding airports that yielded especially poor testing results. As a direct consequence, Red Team was directed to desist from conducting additional follow-up inspections (Thomas 57-59). Due to the disconcerting results, FAA executive officers were concerned that the test results would negatively affect airline ticket sales.

The acts of 9/11 highlighted the importance of innovative aviation safety and placed an emphasis on careful research and review of security measures. It was not until the successful use of commercial aircraft that experts realized a fully loaded airliner with a ready cargo of victims and fuel could be an effective WMD (Thomas 32). As a result it is essential to design and implement creative security measures and strategies that aid in preventing the future use of aircrafts as weapons.

The initial general responsibilities of TSA to treat all passengers with equal suspicion and to keep dangerous objects off airplanes, provides a one-dimensional and obsolete approach to aviation safety. It is to avoid violation of the Fourth Amendment that the traveling public is treated with equal suspicion. The Fourth Amendment to the Constitution limits the power to make arrests, search people, search property, and confiscate objects and documents. These restrictions are the foundation of U.S. search and seizure law and are based on a reasonable expectation of privacy (Siegel 97). The key word is reasonable. The rights of an individual to privacy are critical, but the rights of the public are also important especially in an air travel environment. In order to maintain a balance of rights and privileges granted to individuals and those of the rest of the general public, law enforcement may search all individuals and packages entering an aircraft based on government administrative functions (Sweet 261). Today, security expenditures require accountability: “…a detailed analysis of each security measure that considers their [sic] cost and effectiveness with respect to expected lives saved... enabling... assessment of each security measure in a rational, consistent, and transparent manner” (Stewart and Mueller 2).

In 2006, the TSA established Behavioral Detection Officer (BDO) training (DHS. Train Police Officers to Spot Terrorist related Activity). The purpose of the program was to establish a curriculum that prepared TSA officers to identify suspicious activity that could be terrorist related. Though not openly acknowledged, a facet of profiling terrorist activity rests on an interpretation of what the observing officer determines to be suspect. Profiling is divided into two generally practiced categories, soft and hard. Soft profiling considers racial or ethnic origin as one of several risk assessment considerations. A current effort via TSA and the airline industry is the Secure Flight Program, which falls within passenger pre-screening procedures (TSA Secure Flight Program). The program is an automated identification process with a focus on identifying and comparing information provided by the traveler to the airline. Common information such as name, date of birth, and current travel history is compared with watch-list information. This process is preset with the initial determination being computer based. Should the information provided trigger pre-established security concerns, the passenger is flagged for additional screening. Hard profiling is the use of racial or ethnic origin as the only determining factor. The application of soft or hard profiling is based on what individual nations deem acceptable practices. Due to the sensitivity of potential privacy and civil rights violations, hard profiling is generally not accepted in the United States.
The Israeli National Airline (EL AL) system divides passengers into five types: naive passenger, partly naive passenger, framed terrorist, terrorist, and suicide terrorist. EL AL security emphasizes the identification of people who would be a threat rather than the detection of objects that could be used to commandeer an aircraft (Sweet 292). Israeli security efforts reflect the most aggressive policies in the world. The pre-flight interview process searches for deception, and is administered by officers trained in behavioral analytics. This interview process is based on the application of profiling by trained security agents who interpret the traveler’s interpersonal response and behavior when asked specific questions regarding travel preparation and intentions (Sweet 289 & 293). An aggressive aviation security posture serves Israel well, but would receive considerable resistance in the United States due to potential civil rights violations. With the high volume of flights in the U.S., every security proposal must undergo a cost-benefit analysis. Applying the same procedures used at Israel’s Ben Gurion International Airport would be time-consuming and cost-prohibitive in the United States.

One of the first balanced security countermeasures using mitigation planning was the hardening of cockpit doors. The cost for hardening each cockpit door is $30,000 to $50,000 (Stewart and Mueller, 11). Without access to the flight deck, a key control element necessary for a successful terrorist hijacking is removed. The hardening of the cockpit doors provides an empirical approach to understanding what is of value and protecting it. A parallel countermeasure has been the arming of airline pilots. The value added of having a weapon available for the pilot is negligible. In order for the pilot to use the weapon, the assailant must breach the cockpit. Having a weapon may provide a greater sense of control, but it represents an attitude that addresses threat without taking into consideration the concerns created by the presence of the weapon. When taking into consideration the potential costs of weapon purchase, weapon training, and the possibility of an accidental discharge, the cost of a hardened door represents a cost-effective solution.

Since the establishment of the United States airline industry, changes in security measures have mostly occurred on a post incident basis. This is common when individuals making security decisions are unfamiliar with threat assessment and provide a reactive response as opposed to a proactive one. What may initially appear as common sense and cost-effective security solutions become another compartmentalized solution with a limited nexus to long-term security strategies. In consideration of varying emergencies, it becomes logistically necessary and cost-effective to have an all-purpose plan or response strategy ready for implementation. Assessment of critical factors provides a clearer understanding of what is at risk and subsequently determines the probability that something will happen (Richardson et al. 128). Measurement criteria to determine threat, vulnerability, consequences, and risk assessment should be established prior to solution selection and implementation. The use of a principal formula for calculating risk provides a tool that helps the public understand the cost of security.

Risk management is not a recent trend as it has been used by military, safety, and security professionals for decades. In 211 B.C., documented and translated ancient writings on the understanding of risk assessment indicate preparations taken prior to an event will reduce risk. An interpretation of Sun – Tzu, The Art of War, demonstrates “…there will be no unforeseen risk in any battle” (Huang 162). Although the interpretation of Sun - Tzu writings is often objectively oriented, the preceding quote refers to the analysis of a target and designing a strategy to attack or defend based on that analysis. In conducting risk assessments, there are three primary considerations: threat, consequence, and vulnerability. The following formula is an assessment tool utilized within the security industry:

\[
\text{Threat} \times \text{Consequences} \times \text{Vulnerability} = \text{Risk}
\]

<table>
<thead>
<tr>
<th>Threat (X)</th>
<th>Consequences (X)</th>
<th>Vulnerability</th>
<th>Risk (TXCV=R)</th>
</tr>
</thead>
</table>

Threat is the understanding from where danger or harm may come (Thomas 136). Consequences are the ramifications of a successful attack or threat (Richardson et al 131). Vulnerability measures the likelihood of a successful attack on an identified asset (Richardson et al 132). When applying these variables during assessment, a quantifiable determination of risk is calculated.

Once the calculations are conducted, a matrix is established to consider probability and severity of occurrence. When combined, the formula and matrix aid in identifying what is acceptable or unacceptable relative to level of risk.
TABLE 2

<table>
<thead>
<tr>
<th>Probability Level</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Frequent</td>
<td>Likely to occur</td>
</tr>
<tr>
<td>B Probable</td>
<td>Will occur several times</td>
</tr>
<tr>
<td>C Occasional</td>
<td>Likely to occur sometime</td>
</tr>
<tr>
<td>D Remote</td>
<td>Unlikely but possible</td>
</tr>
<tr>
<td>E Improbable</td>
<td>Highly unlikely</td>
</tr>
</tbody>
</table>

SEVERITY LEVELS OF AN UNDESIRED EVENT:

<table>
<thead>
<tr>
<th>Severity Level</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Catastrophic</td>
<td>Death - System Loss</td>
</tr>
<tr>
<td>2 Critical</td>
<td>Severe injury, major system damage</td>
</tr>
<tr>
<td>3 Marginal</td>
<td>Minor injury, minor system damage</td>
</tr>
<tr>
<td>4 Remote</td>
<td>Isolated injury, isolated system damage</td>
</tr>
<tr>
<td>5 Negligible</td>
<td>Less than minor injury</td>
</tr>
</tbody>
</table>

PROBABILITY LEVELS OF AN UNDESIRABLE EVENT:

<table>
<thead>
<tr>
<th>Probability Level</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Frequent</td>
<td>Likely to occur</td>
</tr>
<tr>
<td>B Probable</td>
<td>Will occur several times</td>
</tr>
<tr>
<td>C Occasional</td>
<td>Likely to occur sometime</td>
</tr>
<tr>
<td>D Remote</td>
<td>Unlikely but possible</td>
</tr>
<tr>
<td>E Improbable</td>
<td>Highly unlikely</td>
</tr>
</tbody>
</table>

TABLE 3

<table>
<thead>
<tr>
<th>Probability of Occurrence</th>
<th>Severity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catastrophic</td>
<td>1</td>
</tr>
<tr>
<td>Critical</td>
<td>2</td>
</tr>
<tr>
<td>Marginal</td>
<td>3</td>
</tr>
<tr>
<td>Negligible</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Probability of Occurrence</th>
<th>Severity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Frequent</td>
<td>1A</td>
</tr>
<tr>
<td>B Probable</td>
<td>1B</td>
</tr>
<tr>
<td>C Occasional</td>
<td>1C</td>
</tr>
<tr>
<td>D Remote</td>
<td>1D</td>
</tr>
<tr>
<td>E Improbable</td>
<td>1E</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unacceptable</td>
<td>1A, 1B, 1C, 2A, 2B, 3A</td>
</tr>
<tr>
<td></td>
<td>Reduce risk through countermeasure</td>
</tr>
<tr>
<td>Undesirable</td>
<td>1D, 2C, 2D, 3B, 3C</td>
</tr>
<tr>
<td></td>
<td>Management evaluation required</td>
</tr>
<tr>
<td>Acceptable</td>
<td>1E, 2E, 3D, 3E, 4A, 4B</td>
</tr>
<tr>
<td></td>
<td>With constant management attention</td>
</tr>
<tr>
<td>Acceptable</td>
<td>4C, 4D, 4E</td>
</tr>
<tr>
<td></td>
<td>Without review</td>
</tr>
</tbody>
</table>

On February 17, 2010, Cable News Network broadcast new TSA security countermeasures applicable to trace evidence testing, i.e. Explosive Trace Detection (ETD) scanners (Meserve and Ahlers). Using the tables listed to the left, this new application can be quantified using the assessment components. First and foremost, the possible threat of transporting an explosive device must be identified. Failure to do so will result in consequences that are catastrophic, including complete detection system failures (Table 2 / Severity level 1). The next step is to identify system vulnerabilities which include explosive detection capabilities solely reserved for baggage. These vulnerabilities have been known to produce significant false positives and invalid alerts. Finally, the ultimate risk is the successful transportation of explosive substances onto aircrafts. Considering the fact that it has already been demonstrated, the necessary actions begin at the probable level (Table 2 / Will occur several times), and include a security level pre-determined as catastrophic. The risk level assessment required would be 1B – Unacceptable, indicating mandatory use of the countermeasures (Table 3 - Reduce risk through countermeasures). In the new trace evidence function, TSA demonstrates a more analytical approach to risk assessment. Although information is limited, it appears trace detection is applied only after a passenger has been moved for secondary inspection. This means the passenger has triggered pre-established security protocols that warrant a more in-depth inspection.

Ultimately, the cost of aviation security is borne by the American public, be it in the purchase of a ticket or the information provided during booking and pre-flight. Addressing air travel risk, mitigation, and security requires a plan, application of recounted threat vulnerability assessments, and selection of appropriate countermeasures. The Federal Emergency Management Agency (FEMA) provides several independent study programs that address emergency incident response and vulnerability assessment. Under FEMA, the Emergency Management Institute (EMI) offers free to low-cost training and awareness opportunities that address a wide range of interests in vulnerability assessment (FEMA). Fortunately, aviation security practices are evolving to be more accountable through scientific threat assessment and calculation. The traveling public is better served when cost is commensurate with value and risk.

The magnitude of terrorist incidents is increasing. The consequences of another terrorist attack are great. Calculated and measured responses are the only alternative. Experts acknowledge that those involved in terrorist activity will get "lucky" despite the best security efforts. Aviation safety will continue to fall within an area of government administrative function. The responsibility for protecting the flying public requires cost-effective and proactive applications of science and security, while securing rights and privileges granted under the U.S. Constitution.
REFERENCES


ABOUT THE AUTHOR

Edwin is a teacher of Criminal Justice, Public Safety, and Policing Science. He had a long career with the United States Secret Service that began in 1985 and ended as the Special Agent in Charge of the Baltimore, Field Office (2007 – Retired).

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Computer Forensics and Child Pornography Investigations
Danielle Sutton

Computer forensics can be utilized in a wide variety of ways to investigate computer crimes, resulting in innovative investigative and prosecutorial issues due to the unique attributes of computers. The growth of the information age and the Internet has led to a dramatic increase in Internet usage by child pornographers, making it easier to create, access, and distribute child pornography using digital media. Child pornography cases can be difficult to investigate; however, computer forensics plays a key role by assisting in the successful prosecution of perpetrators as well as protecting those wrongly accused of creating, accessing and distributing child pornography.

Child pornographers no longer use print photographs, videotapes, and magazines as their preferred mode to distribute child pornography images. The Internet has become their primary means for communicating and sharing illicit images. Child pornographers’ distribution methods have become more sophisticated; therefore, law enforcement personnel and investigators have had to become more knowledgeable and adept in the field of computer forensics. Computer forensics is the merger of two distinct and complementary disciplines, law and computer science. This combination affords investigators the opportunities to collect and examine data from computer systems, networks, wireless communications and storage devices in such a way as to produce admissible evidence in a court of law.¹

As defined by Ty E. Howard (2004), Assistant District Attorney, Chester County District Attorney’s Office, computer forensics is the study of computers and computer-related media for evidence of criminal activity. Computer forensics investigations are generally conducted to learn more information and to obtain electronic evidence from computers since the Internet is commonly used for criminal activity. Computer forensics investigations retrieve data that criminals mistakenly believe they have deleted from their computer.

When files are deleted, computers do not actually delete any contents; rather, computers delete the directory of the files. Until the data is actually overwritten by other data, investigators can still locate the information to solve crimes. Internet browsing activities can be also traced by review of cache, which saves information regarding websites that users visit with the computers (Sassinsky, 2002).

Various sources report that at least 80% of all computer crime cases involve child pornography (Wells et al., 269). “Child pornography is prohibited by federal statutes, which provide for civil and criminal penalties for its production, advertising, possession, receipt, distribution, and sale. Defined as the visual depiction of a minor—a person less than 18 years of age—engaged in sexually explicit conduct, child pornography is unprotected by the First Amendment, as it is intrinsically related to the sexual abuse of children.”²

Computer forensics is used to preserve and extract the electronic data found in server logs or on the hard drives of the confiscated computers. Every entry on a computer is captured in the server log or hard drive like a piece of a puzzle; the forensic investigator’s job is to connect the pieces to solve the puzzle. Forensic investigators specialize in recovering and analyzing, and presenting data from computers for use in investigations or as evidence. The forensic investigator’s duties entail “confiscating computers, determining the details of intrusions into computer systems, recovering data from encrypted or erased files, and recovering e-mails and deleted passwords.”³ Investigators use both traditional and undercover tactics to investigate child pornography cases. According to Liberatore, Levine, & Shields (2010), the forensic investigator is used to link observed criminal behavior on the network with evidence of that behavior on a specific machine.

According to Dr. Louise Shelley (1998), Professor in the Department of Justice, Law, and Society at the School of International Service at American University, and founder and Director of the Transnational Crime and Corruption Center (TraCCC): The internet provides a wide variety of opportunities for those who trade and distribute pornography to interact. This activity includes e-mail, websites, internet relay chat, file transfer protocol sites, usenet, electronic bulletin boards, online services and other forms of technology such as listserv and iphones. Criminal investigations reveal that these forms of electronic communication have been exploited by those who traffic child pornography. The Internet has opened up new opportunities for gathering evidence and data collection in sex crimes that occur via the World Wide Web.⁴

¹ http://www.us-cert.gov/reading_room/forensics.pdf
² See chapter 110 of Title 18, United States Code.
³ See 18 U.S.C. §2256(8). Actual or simulated sexual intercourse, including genital-genital, oral-genital, anal-genital, or oral-anal, whether between persons of the same or opposite sex; bestiality; masturbation; sadistic or masochistic abuse; or lascivious exhibition of the genitals or pubic area of any person.
⁴ http://www.bls.gov/oco/ocos157.html
Traditional methods of investigating child pornography cases could include responding to complaints of citizen reports of image discoveries. However, child pornography cases often involve undercover operations, digital evidence collection, and multiple law enforcement agencies when it has been transmitted via the internet. Forensic investigators face numerous problems when investigating child pornography cases because the cases often present unique challenges. Nontraditional methods include undercover stings where law enforcement officers assume the identity of a child pornography collector interested in photographs or infiltrating a child pornography electronic bulletin board service.

Electronic bulletin boards require users to dial into a computer system using a modem and enter a password to access the data. Electronic bulletin boards allow users to post and read messages on the computer as a group; the board functions as media for the exchange of information among large groups of people. As a hybrid, electronic bulletin boards combine features of electronic mail with private computer conferencing. The user has the ability to transmit, read and share electronic messages, files and other data which are then available to all other users of the bulletin board. The use of bulletin boards is a common vehicle to disseminate child pornography because the content owner exercises and maintains control over who can and cannot access the digital media and who may enter the computer site.

“Operation Nest Egg” was an ongoing and joint investigation led by the Criminal Division’s Child Exploitation and Obscenity Section (CEOS), the U.S. Attorney's Office for the Southern District of Indiana, United States Postal Inspection Service (USPIS) and Immigration and Customs Enforcement (ICE). Launched in February 2008, this operation targeted 26 defendants later charged in the Southern District of Indiana, as well as approximately 500 additional individuals located throughout the world for their involvement in an online group dedicated to trading images of child pornography. This multi-agency investigation was a byproduct of “Operation Joint Hammer.”

As a result of Operation Nest Egg, both European and American defendants were charged with conspiracy to advertise and distribute child pornography.

Collecting evidence to prosecute child pornography cases can be a tedious task. In cases where offenders are reported to possess images of child pornography on a computer, it is possible that images will have been deleted by the time investigators examine the computer. Computer forensic investigators with specific training may be able to locate files that have been deleted, and in most cases deleted information can be retrieved and used as evidence (Hardy & Kreston, 2002).

A forensic investigator’s job in a child pornography investigation is to identify, collect, preserve, and analyze the data retrieved in a way that preserves the integrity of the evidence collected so it can be used effectively to either prosecute or dismiss the case. Forensic investigators must understand the type of latent evidence they are looking for in order to structure their search. Child pornography crimes can involve a broad spectrum of criminal activity, from child pornography to theft of personal data. The forensic investigator must ensure that the correct investigative format is used when conducting a forensic investigation. Chain of custody policies and procedures must be followed at all times to ensure that the investigation is not compromised. The forensic investigators must ensure that the files are not deleted, damaged, or encrypted while in their possession and they must be familiar with the evidence recovery process.

Gillespie (2005) reports that two basic types of data are collected in computer forensics. Persistent data is the data that is stored on a local hard drive (or another medium) and is preserved when the computer is turned off. Volatile data is any data that is stored in memory, or exists in transit, that will be lost when the computer loses power or is turned off. Volatile data resides in registries, cache, and random access memory (RAM). Since volatile data is ephemeral, it is essential an investigator know reliable ways to capture it.

Evidence gathered in a forensic investigation is not limited to what is found or extracted from magnetic media such as hard drives, floppy drives, and tapes. Investigators are faced with several challenges with regard to the collection of digital forensic evidence. According to Cohen (2006), digital forensic evidence collection is the method by which the evidence is “identified, collected, transported, stored, analyzed, interpreted, reconstructed, presented and destroyed through a set of processes.” Child pornographers’ computers are often seized as proof that the defendant produced, possessed, received, and/or distributed child pornography.

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1 United States component of an ongoing global law enforcement operation targeting transnational rings of child pornography trafficked through the Internet and U.S. mail.
2 “Operation Joint Hammer” was initiated through evidence developed by European law enforcement and shared with U.S. counterparts by Europol and Interpol.
Human fallibility remains the greatest challenge facing forensic investigators. When a mistake is made during the investigation with regard to evidence collection and processing, it could have an effect on the entire outcome. For a successful prosecution, the government’s attorney must ensure that the testimony provided by the technical expert is:

- Based upon sufficient facts or data.
- The product of reliable principles and methods.
- Applied to the facts of the specific case in question.

Forensic evidence is not just what is found inside the computer; it is also what is seen on the outside of the computer, such as visual observations on a computer monitor, printouts, passwords written down, handwritten notes, system logs, and proxy servers or firewalls. Both forensic and digital evidence collected in child pornography cases is either admitted or not admitted at trial based upon its probative and prejudicial value. Black’s Law Dictionary defines probative value as the extent to which the evidence leads to a deeper understanding of the issues in the case, while prejudicial value is the extent to which it leads the finder of fact to believe one thing or another about the matter at hand.

Proactive value is determined by the quality of the evidence being presented, and should the collection process be error – prone, the value of the evidence is questionable. Tainted evidence, faulty chain of custody procedures, and reports written or presented by an expert who is inarticulate or lacks technical expertise decrease the value of the recovered evidence.

Defense attorneys can and do present valid and reasonable challenges to digital evidence based on how it is presented in court. In many cases, the challenges come into play as a result of evidence contamination and conflicting testimony by court-recognized, but inarticulate or inadequately prepared experts. All digital evidence must be presented in court by an expert witness because digital evidence is basically hearsay evidence. The expert witness will relay the “existence, content, and meaning to the investigators” (Cohen, 2006).

Digital evidence is hearsay evidence because it is presented by an expert who asserts facts or conclusions based on what the computer recorded, not what the investigators directly observed themselves. Identifying digital evidence is an important part of a forensic investigation. There is a vast amount of information resident on a computer which may result in some evidence being overlooked during the course of the investigation. Relevant information is located in several different areas within the computer such as storage drives, deleted files areas, and secondary and removable storage devices.

Forensic investigators are equipped with the essential tools to remove crucial components from the computers. It is important that the forensic investigator choose the correct software or hardware to ensure an uncontaminated investigation. Nelson, Phillips, Enfinger, and Steuart (2008), suggest that the following questions be posed when considering which computer forensics tools to use:

- What operating system do the forensics tools work on?
- Is the tool versatile?
- Can the tool analyze more than one file system?
- Does the tool have any automated features that can help reduce the time to analyze data?
- What is the vendor’s reputation for providing product support?

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6 United States v. Snyder, 189 F.3d 648 (7th Cir. 1999). James Snyder was convicted of producing, receiving, and distributing child pornography, as well as possessing child pornography with intent to sell. Mr. Snyder engaged in a sexual affair with a minor child. After the minor was interviewed by the FBI and was able to describe the abuse and identify Mr. Snyder’s house, a search warrant was obtained and served on Mr. Snyder. The computer-related evidence seized from Snyder’s house was “analyzed by the FBI crime lab . . . [and] verified that Snyder’s computer was capable of downloading and uploading images from the Internet, and that it could be hooked up to a camera. [The FBI] also recovered several pornographic images from the computer, even though they had been deleted.” Id. at 644.

7 United States v. Simons, 29 F. Supp. 2d 324 (E.D. Va. 1998). Mark Simons was an employee of the Foreign Bureau of Information Services (“FBIS”) component of the CIA. While the network administrator was doing a routine check of the agency’s firewall, he noticed a lot of activity from one workstation going to a pornographic site, against established agency rules. The computer was seized as evidence and Mr. Simons was charged with violating 18 U.S.C. § 2252A (a) (2) (A), Receiving Materials Containing Child Pornography, and 18 U.S.C. § 2252A (a) (5) (B), Possession of Material Containing Child Pornography. Mr. Simons unsuccessfully challenged the seizure on grounds that the search was a violation of the Fourth Amendment. The court held that, in applying the holding in Katz v. United States, 389 U.S. 347 (1967), the court must consider “whether the employee searched had a reasonable expectation of privacy. The person must have had an actual or subjective expectation of privacy and the expectation must have been one that society recognizes as reasonable.” United States v. Simons, 29 F. Supp. 2d at 326-27. The FBIS has a specific policy providing for computer audits and given this policy, the court concluded that Mr. Simons did not have a “reasonable expectation of privacy with regard to any Internet use.” Id. at 327.

When using software programs, investigators must ensure that the evidence is removed from the seized computer in accordance with the law. Many computer software programs and tools have the ability to identify digital coding and illicit videos and photographs. When these codes are shared online between computers, investigators can detect the Internet Protocol address responsible for sending and receiving the illicit images.

According to Howard, hashing is a step in the forensic investigation which involves authenticating and identifying the electronic information discovered through the imaged computer media. Hashing authentication ensures that the forensic image and the original computer media are identical. Hashing is:

• “The process of taking computer data as a string of information, processing this string through a specially-designed mathematical function which transposes each character of the string into another character, and converts it to another (usually smaller) string known as the hash value.”

• Known as the “electronic fingerprint in a forensic investigation.”

• Allowing investigators to identify essential evidence by comparing the hash values to the values of the files that are under review for potential criminal activity.

• An exceptional tool used to discover illegal material stored on a computer since the hash value of the information is easier for the investigator to identify because the information is not stored by a file name or type which can be easily changed. When hashing is used the information cannot be altered in any way.

Forensic evidence is widely used in court proceedings; however, handling of computer evidence and chain of custody must be meticulous. Problems occur with the mishandling of computer evidence when traces of important evidence are hidden. A simple misunderstanding or miscommunication can cause a mistaken conviction of an innocent person. During the recent case State of Connecticut v. Julie Amero in Norwich, Connecticut, Amero was wrongly convicted of “the delinquency of minors because a spyware-infected school computer in her class displayed pornographic sites’ pop-ups during her lecture. Amero’s conviction, which was later overturned, demonstrated a lack of technical awareness within the legal system” (Peisert, Bishop, & Marzullo, 2008). It is obvious that the judicial system has not adequately defined the parameters of computer forensics evidence and its admissibility.

Computer or cyber crimes in child pornography cases require the same prosecutorial rigor as any other crime. Forensic investigators must gather all essential evidence in accordance with official policies and procedural standards. The general approach ensures all rules are precisely followed and the chain of custody remains intact thus ensuring the investigator possesses sufficient information to either convict or exonerate the accused child pornographer of the allegations. The fact remains that with the boom of the internet and the convenience of exchanging child pornography from the comfort of their homes, child pornographers have found an easy way to peddle the illicit images of children. The overall goal of evaluating forensic evidence is to determine the truth and prosecute the pornographers responsible for trafficking child pornography via the World Wide Web.

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10 Ty E. Howard, Don’t Cache Out Your Case: Prosecuting Child Pornography Possession Laws Based on Images Located in Temporary Internet Files, 19 Berkeley Tech Law Journal. 1227, 1234 (2004); Richard Hardy & Susan S. Kreston, Computers are Like Filing Cabinets... Using Analogy to Explain Computer Forensics.
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ABOUT THE AUTHOR
Danielle Sutton is currently a student in the graduate program at Stevenson University where she is pursuing a degree in Forensic Studies-Investigative track. She is employed as an Compliance Analyst with the Maryland Board of Physicians. She completed both her undergraduate and graduate studies at the University of Baltimore where she received a B.S. degree in Criminal Justice in 2006 and her M.A. degree in Legal and Ethical Studies in 2008.
Osteological Analysis of Remains from the Richards’ Family Vault
Congressional Cemetery, Washington, D.C.
Erin N. Cullen
Dr. Douglas W. Owsley, Mentor

INTRODUCTION

Analyses conducted in the field of Physical Anthropology combined with historical research provide a more holistic approach to the interpretation of archaeological or burial excavations. Osteological research, in particular, adds a critical dimension to the understanding of the past, which the material culture alone cannot usually provide—namely the health and physique of a population. Osteological analyses also aid in identification by assessing demographic information, including age, sex, ancestry, and pathological conditions of an individual.

In the article Mortuary Display and Status in a Nineteenth-Century Anglo-American Cemetery in Manassas, Virginia, Barbara J. Little, Kim M. Lanphear and Douglas W. Owsley examine a series of skeletal and dental remains from the Weir Family, who were wealthy plantation owners. Similar to the Richards family from the Congressional Cemetery, the Weir family remains were also in very poor condition. While the bones were fragmentary, the dental remains were able to, “contribute substantially to the assessment of socioeconomic status” (1992:404). The authors explain the importance of dental pathology and the fact that it is, “influenced by diet, oral hygiene, and individual health” (1992:404).

Accordingly, these critical findings were essential in establishing a scientific hypothesis for the Richards family. While the majority of skeletal remains from the Richards family are extremely fragile and friable, the dental remains are fairly intact and provided definitive insights as to the nature of dental care available to a wealthy 19th century family in the mid-Atlantic region.

As part of assuring that a comprehensive osteological analysis was performed, carbon and nitrogen stable isotopes were examined for certain individuals in the vault. Stable isotope analysis can be used to identify human skeletal remains in that it can reveal dietary patterns evident from the carbon and nitrogen isotopic signatures left in human bone after food is consumed. Carbon present in human bone collagen is directly obtained from consumed food, making it a desirable source for stable isotopes (Ubelaker 1999:141). Although diets cannot be fully “reconstructed” using this type of analysis, stable isotopes can help establish similarities or differences in consumption patterns (Larsen 1997:270). In this particular study, the chemical analysis performed tested the human bone for two stable isotopes, carbon and nitrogen, in the bone collagen.

Research by Larsen indicates that each stable isotope can reveal information about the plants that were consumed by the individual – as well as animals and the plant elements the animal consumed – which may have been incorporated into the individual’s diet. While maize had been available and readily consumed since the early Colonial period, a dietary shift to a more wheat based diet was evident near the end of the 19th century.

The purpose of this research is to understand the health and dietary patterns of wealthy individuals in the Washington, D.C. area from the mid-19th to the early 20th century. The skeletal identification and analysis of mid-late 19th century burials has been studied for many individuals of lower or middle status, throughout the Mid-Atlantic region. The analysis of high status individuals is not as common, in part, because many of these individuals are interred in more elaborate, generally inaccessible, and identifiable resting places (e.g., vaults), not in open fields which are “hot spots” for archaeological excavations.

In the case of the Richards family, the restoration of the deteriorating family vault combined with the need to remove family remains in advance of the restoration provided the unique opportunity to conduct the osteological analysis. All individuals from the Richards Family vault were systematically documented and removed by the Smithsonian Institution, under the supervision of Dr. Douglas Owsley, Division Head of the Physical Anthropology Department. The osteological analysis documented herein was performed by the author in collaboration with the Smithsonian Institution, the Historic Congressional Cemetery, Joseph Richards III, and Stevenson University.

BACKGROUND

Physical Anthropology

Physical Anthropology is the subfield of anthropology that deals with human and nonhuman primate evolution, the biological bases of human behavior, and human biological variability and its significance. The techniques in this field can be used to assist in the recovery of remains, assess demographic information (age, sex and ancestry) and analyze pathological conditions (trauma or disease). They can also be used in modern day criminal investigations and on historic and pre-historic archaeological excavations, where human skeletal remains are found. When the application of the science of physical anthropology and human osteology are used in a legal setting, the term forensic anthropology is deemed appropriate.

Historic Congressional Cemetery

The individuals examined in this study are part of an archaeological endeavor, and were excavated from the Richards family vault in the Historic Congressional Cemetery, in Southeast Washington, D.C. The vault is located to the east and slightly south of the cemetery’s present day chapel. Congressional Cemetery “was founded in 1807 by a group of citizens residing in the eastern section of the new federal City of Washington” (Breitkreutz 2003:7). The cemetery later became the sole place of burial in Washington for members of Congress.
There are a handful of vaults in the Congressional Cemetery that are undergoing renovation. Built in the 19th century, many of these vaults are in need of restoration and repair. The mortar has weakened in between the bricks and ground erosion is occurring. Prior to commencing the renovation process, all human skeletal remains must be removed from the vaults, so as not to damage the aging, fragile remains.

Richards’ Family Vault

Construction of the Richards family vault dates from January 1854. The vault remains and contains 16 burial chambers (four rows of four), half of which are above ground. The dates of death for individuals interred in this vault range from 1851 (a burial which was moved into the vault from another location after the construction was completed) to 1952. The latest burial to be analyzed in this study dates to 1920.

The patriarch of the family, Mr. Alfred Richards, was a well-known brick maker and one of the pioneers in the manufacture of brick in the city of Washington, D.C. As of 1894, the year that Mr. Richards passed away, it has been observed that there were few squares in the city, if any, which did not bear witness to his industry and enterprise. Mr. Richards lived a long and prosperous life. Throughout his life he married three times. His first wife was Elizabeth Jane Catherine Richards who died in 1851; his second wife was Grace Louise “Gracy” Montgomery Richards who died in 1865; and his third was Mary Alice Stewart Richards who died in 1892. When Alfred Richards died in 1894, he was survived by six sons and four daughters, some of whom were later interred in the Richards family vault, along with several of his grandchildren.

The Richards family vault, one of the most intact vaults in the cemetery because of prior repairs, is undergoing renovation. Joseph Richards III, one of the descendants of Mr. Alfred Richards, contacted Dr. Owsley, and requested his assistance in the identification and analysis of the Richards’ ancestors.

OSTEEOLOGICAL ANALYSIS

Skeletal Analysis

Accurate age, sex and race determinates are essential when analyzing skeletal remains, especially when comparing samples from various series. Demographic profiles developed from morphological, metric and multivariate statistical data provide a basis for studying trends and patterns of mortality and morbidity within and among families and populations. The initial step in obtaining the necessary basic data for these is determining an individual bone inventory for each skeleton, no matter how fragmentary the bone or how many elements are missing.

Methodology

The skeletal and dental analyses of individuals from the Richards family vault were conducted in a manner consistent with the normal procedures used by Dr. Owsley and his team for analyzing historical remains. The protocols for analyzing each set of skeletal remains include an inventory of the bones present and their condition, teeth present and their condition (including taphonomic changes), and the stages and planes of dental wear. The skeletal and dental inventories were documented using the format created by Dr. Owsley. This tool uses a coding system to assign conditions to each bone, such as presence or absence and number of fragments, and allows the analyst to code dental disease (caries), abscesses, calculus, degree of decomposition, and antemortem tooth loss. The dental wear analysis is based on stages described by Smith (1984), and planes of wear as determined by generally accepted anatomical terminology. The skeletal analysis included determination of pathological conditions, coded using forms constructed by Dr. Owsley. This record documented and included generalized pathology caused by infectious processes, osteoarthritis, fractures, and other forms of trauma and disease.

In addition to the inventories, each set of remains was assessed to confirm the demographic information including age, sex, and ancestry. Each factor was assessed using several determinants of morphological variations as outlined in Bass (1992) and Ubelaker (1999). The age of almost all the existing remains was determined using historical documentation, and confirmed using factors such as epiphyseal union, long bone growth and dental development for subadult individuals; and the amount of tooth wear and presence of osteoarthritic changes in all other individuals. Sex was originally identified for a majority of the individuals from this series by documentation provided by Joseph Richards III and the Historic Congressional Cemetery. It was confirmed using dimorphic differences such as the prominence of the mastoid process, the overall projection of the mandible, the gracile or robust attributes of long bones, and the pubis length and sciatic notch width of the innominates. Ancestry of these individuals is known to be Caucasian and was confirmed when the evaluation of dental remains revealed dental traits including cusps of Caribelli, a prominent feature for individuals of European ancestry.

Results

The skeletal analysis conducted for the Richards family vault (1) confirmed prior historical information that was obtained regarding the age, sex, ancestry and cause of death for a handful of individuals that were analyzed, and (2) provided information regarding lifestyle and general physical and dental health, as well as medical care available to this wealthy 19th century family. Appendix A provides demographic information for the individuals interred in the Richards family vault. The osteological analysis was performed with guidance and assistance from both Dr. Owsley and Kari Bruewelheide from the Smithsonian’s National Museum of Natural History, Division of Physical Anthropology.
Age and Sex

This series consisted of three adult females, one elderly male, one sub-adult male, two female children, three infants (one female and two undetermined), and one fetus that was not assessed for sex. Ages ranged from five months in utero to 72 years old. The names and ages of eight of the individuals interred in the vault were provided by both Joseph Richards III and the Historic Congressional Cemetery (Appendix A). The sex of seven individuals was confirmed using various methods that examine the morphological features of the pelvic region, size of the mastoid processes, robusticity of the long bones, and morphological features of the mandible. An age range was identified for all of the individuals exhumed from the vault and was used in combination with available historical information to identify each individual. Ages of the children were determined using tooth crown development and stages of dental wear, evidence of lambdoidal suture closure, long bone diaphysis lengths, and epiphyseal union.

Ancestry

Of the individuals analyzed from the Richards’ vault, ancestry was confirmed for only one member of the family. The lingual surfaces of the maxillary right first and third molars of Burial 2 have cusps of Carabelli, which are most commonly found in individuals of European ancestry. Various meetings and discussions with the descendants of Mr. Alfred Richards confirmed that all individuals were of European ancestry.

Dentition

An analysis of the dentition of the adults from the Richards family demonstrates that this population, while having poor dental health and a high rate of dental disease, had the means to obtain dental care to prevent further destruction of their teeth. Four of the adults (Burials 2, 5, 7 and 15) in this series present evidence of dental caries in the form of cavities; three of them (Burials 5, 7 and 15) received restoration work, which included a variety of gold and amalgam fillings. The eldest individual from this series, Alfred Richards (72 years old), was completely edentulous. He was buried with a full set of vulcanized rubber dentures with porcelain tooth sections, which is typical of late 19th century dental care (Swank, 2010).

An evolution in the field of dentistry is seen in the adults analyzed from this series, beginning with the earliest individual interred in the vault (1851) to the more recent (1920). The percentage of dental caries is determined from the number of teeth present from each burial. Beginning in 1851, Elizabeth Jane Catherine Richards exhibited dental caries in the form of cavities on 40% (four out of 10) of her teeth, yet no dental restoration was done to correct or prevent their destruction. By 1865, there is evidence of dental restoration in the form of gold fillings on two teeth from Grace Louise Montgomery Richards, who exhibited cavities on 80% (four out of five) of her teeth. Mary Alice Richards, who died in 1892, suffered from extreme dental disease, with 77% (20 out of 26) of her teeth exhibiting dental caries in the form of cavities. Eight of the 20 decayed teeth were restored with gold fillings, and seven were restored with amalgam fillings. By 1920, the restoration work observed on 29% (seven out of 24) of the teeth from Paul Harvey Cushing Richards consists of only amalgam fillings, some containing copper. The evolution of dental restorative material used to restore the function, integrity and morphology of the missing tooth structure is visibly apparent in the individuals from the Richards’ family vault.

Pathology

Pathological conditions can result from infectious processes, age-related degeneration, heredity, traumatic injury, and dietary inadequacy (Ubelaker, 1999:96). The examination of skeletal pathology is useful for determining nutritional deficiencies, disease and trauma. Evidence of these various conditions is apparent on four of the individuals from this series, ranging from mild to severe. Half of the pathological findings are apparent on the adults from the Richards family vault, and two of the children show pathology, one of them with a severe nutritional deficiency. Burial 1 (Marion Grace Richards, aged 39 years) exhibits fusion of the third and fourth cervical left arches of the vertebrae, most likely a congenital anomaly or less likely a healed fracture. Burial 12 (an unidentified child, aged 5 to 6 months) shows a defined growth arrest line, likely from a severe illness or malnutrition.
Although brushite formation has destroyed many skeletal remains from the adults in this series, select individuals show pathological conditions associated with aging, congenital conditions, and trauma. Burial 6 shows marked anterior angular kyphosis of the T8 to T12 vertebrae, compression of the T9 vertebra, signs of arthritis, extensive ossification of rib costal cartilage and slight entheseophytes (bone spur) formations. This individual also shows a hereditary congenital defect, known as tarsometatarsal coalition, in which the third right metatarsal was joined with the third right phalanx, a condition usually present during childhood or early adolescence. This condition probably would not have caused significant pain or discomfort. The historical documentation as to an illness related to the cause of death of Alfred Richards was also apparent during a pathological analysis. The death certificate of Alfred Richards (provided by the family) stated that his cause of death was related to pulmonary edema and diabetes mellitus. Antemortem amputation of four of his toes (three right metatarsals and a left proximal phalanx) was likely caused from complications associated with his diabetes mellitus. Burial 7 exhibits milder signs of aging with only slight arthritis, and a congenital anomaly in which she has an extra vertebra and 13th ribs. Burial 15 did not exhibit any pathological conditions on the skeletal remains themselves; however, both the brain and stomach contents of this individual were mummified. The stomach contents revealed evidence of grape seeds, scientifically known as Vitis riparia, which were identified by Jun Wen, a specialist in the Department of Botany at the Smithsonian’s National Museum of Natural History.

This skeletal analysis assembles a composite picture of the general health and well being of the Richards family during life, although it should not be considered representative of the population as a whole in the Washington, D.C. area from the mid-19th into the early-20th century. Comparative analysis with other wealthy families in the region is required to gain insight into the life of the upper-class of this time period. This skeletal analysis does provide information about this particular family. The wealth of the Richards family is apparent from the dental restorations that were received, and the health care that was provided. It is also evident that these individuals were not routinely engaged in heavy physical labor. The majority of their pathological conditions are either congenital anomalies or normal signs of the aging process, with the exception of Alfred Richards, who had diabetes mellitus, which contributed to his death.

CARBON AND NITROGEN STABLE ISOTOPE ANALYSIS

The use of stable isotope analysis to evaluate food consumption has proven very useful in the reconstruction of past subsistence practices. However, it is important to remember that this technique should not be used as an independent method of diet reconstruction, specifically “because the interpretation of isotopic compositions is based on the comparison of values measured in human bone collagen with those measured for items identified as having been consumed, and because isotopic compositions can only be used to distinguish certain food groups rather than individual food items” (Keegan, 1989:224). This analysis is useful in refining dietary reconstructions and should be used in combination with other sources of evidence.

According to Katzenberg (2003), carbon and nitrogen stable isotopes are those most commonly studied in human remains. This is likely due to the fact that these isotopes have proven to be the most useful for studying the movement of nutrients through food chains, indicative of the fact that they are the building blocks of organic molecules. Traces of stable carbon isotopes (13C and 12C) and stable nitrogen isotopes (14N and 15N) can be found in human bone long after death, assuming the bone has not been severely destroyed from taphonomic or postmortem changes. Because these isotopes “do not decay over time” (Katzenberg, 2000:307), as contrasted with unstable isotopes (14C), they are ideal for dietary testing.

Since the human body’s main sources of basic building blocks such as amino acids and fatty acids are derived from what we eat and drink, the isotopic signatures of the most abundant elements in our body, namely hydrogen, nitrogen, carbon and oxygen contain a record of the isotopic make-up of our dietary intake (Meier-Augenstein, 2007:153). The carbon and nitrogen stable isotopes analyzed in human bone collagen from this series, provide information on the dietary aspects of the individuals represented. The values expressed show the amount of carbon and nitrogen that each individual has consumed from living organisms throughout their lifetime. These values are expressed as ratios, where the proportion of 13C to 12C is compared to an accepted “standard,” and hence given a value of $\delta^{13}C\%o$. Similarly, the ratio of 14N and 15N is expressed as $\delta^{15}N\%o$. The percentages are expressed in parts per thousand (‰) because their absolute differences in isotopic abundances are relatively small (Keegan, 1989:225).

Bone collagen is considered well-preserved, and should be used for testing when the ratio falls between 2.9 and 3.6 (Ubelaker and Owsley 2003:134). In stable isotope analysis, it is important to remember the values of plants at the base of the food webs and their significance in dietary analysis. Values of $\delta^{13}C\%o$ are represented on the negative side of the number scale. Conversely, $\delta^{15}N\%o$ values are represented on the positive side of the number scale.

According to Ubelaker and Owsley (2003), who researched isotopes to examine the diets of American colonists, stable carbon isotopes quantified from preserved tissue indicate whether a diet was based on plants with a C3 photosynthetic pathway and/or the animals that consume them, or on plants with a C4 pathway and/or the herbivores that consume them. Their research determined that this was a useful method of distinguishing immigrants from those born in the continental United States. The plants with a C3 pathway include all trees and shrubs and most leafy-plants growing in temperate climates, such as wheat, rice, trees, nuts, fruits and root crops (Ubelaker and Owsley,
Grasses such as maize, millet and sugarcane are characterized as C4 plants. A typical δ13C value for individuals consuming primarily C3 plants is roughly -20‰. A less-negative value of δ13C reflects a greater consumption of C4 plants, the animals that have consumed them, and/or the consumption of marine foods (Ubelaker and Owsley, 2003:130). Carbon values as high as -6‰ have been identified in bone collagen, from consumers of C4 plants. In stable isotope analysis, this means that a more negative value of δ13C‰ would likely indicate a diet richer in perhaps wheat or rice, and a less negative value of δ13C‰ would likely indicate a diet more consistent with corn or sugar. High levels of δ15N‰ are usually associated with a higher trophic level or location in an ecological food web. This is because the values represent protein intake primarily from animal sources, “making them better suited to distinguishing habitat-specific differences in diet” (Keegan, 1989:229). Individuals with a diet richer in plant foods are more likely to have lesser δ15N values than those from coastal areas consuming abundant seafood or diets higher in meat (Ubelaker and Owsley, 2003:131).

Methodology

In this study, stable isotope analyses were conducted using bones or bone fragments with solid cortical or dense bone, due to its high concentration of collagen. The isolated or fragmentary bone elements were carefully documented prior to chemical testing, because this process necessitates destruction of the bone piece. Bone samples were analyzed from seven of the 11 individuals exhumed from the vault. Isotope samples of the infants and young children (under the age of three years) were not analyzed, because an individual’s actual diet is not reflected until they have been weaned.

Dietary patterns were examined for six of the seven individuals interred in the Richards family vault, by analyzing the carbon and nitrogen isotopic signature in their bone. Testing was conducted by Christine France, a Physical Scientist from the Smithsonian’s Museum Conservation Institute, and results were analyzed by the author. The skeletal elements selected for testing were chosen after a thorough examination was conducted of all skeletal remains.

Results

Appendix B summarizes information on age, sex, and data from isotopic analysis for each of the seven individuals from the Richards’ family vault. Information on the relative preservation of collagen is provided in the carbon to nitrogen ratio obtained during testing. One value, 3.96 from 51RICHARDS-CC-01, exceeds the acceptable value range of 2.9 to 3.6. Accordingly, this value was considered potentially less reliable and was excluded from the analysis. All other values obtained from this study fall within the acceptable range.

As illustrated in Appendix B, the δ13C‰ values range from -12.78‰ to -16.37‰ (with a mean of -13.97‰). Individuals with a date of death ranging from 1851 to 1892 have a less negative δ13C‰ value, indicative of a diet more reliant on C4 based plants, such as maize. One individual, Alfred Richards (51RICHARDS-CC-06) who died in 1894, has a δ13C‰ value of -14.64‰. This value is consistent with someone who consumed a mixed diet of wheat and maize. The remains of Paul Harvey Cushing Richards (51RICHARDS-CC-15) who died in 1920, have a δ13C‰ value of -16.37‰. This is the highest negative value in the series, illustrating a much heavier reliance on wheat based foods. An increase in the importation of wheat and the advancement of wheat production, milling and transportation at the turn of the century (USDA, 2009:1) resulting in greater access to wheat products, is the most likely cause for these findings.

There is less variation in the δ15N‰ values, which range from 11.32‰ to 12.81‰ (with a mean of 12.07‰). Human consumers of terrestrial plants and animals typically have δ15N‰ values in bone collagen of about 6‰ to 10‰ whereas consumers of freshwater or marine fish may have δ15N‰ values of 15‰ to 20‰ (Schoeninger, DeNiro and Tauber, 1983). The individuals selected for analysis from this series seem to have a varied diet, comprised of both marine foods and maize or animal protein from corn fed domestic animals. A slight decrease in the δ15N‰ values was also apparent in individuals ranging from a date of death of 1884 to 1920. This decrease could indicate either the prevalence towards a more marine based diet, a decline in the consumption of protein from meat, near the end of the 19th and into the early 20th century, or simply, the differences in dietary preference of each individual. The interpretation of dietary aspects is limited to the sample size of individuals tested from this series. Dietary patterns of wealthy individuals at the turn of the century could possibly be revealed by increasing the sample size and comparing the diets of Richards family members to other individuals of similar socioeconomic status residing in the mid-Atlantic region.

CONCLUSIONS

The osteological analyses conducted for the Richards family members provides valuable insights into the overall health and dietary patterns of these wealthy individuals in the Washington, D.C. area from the mid-19th to the early 20th century. The wealth of the Richards family is apparent from the dental restorations conducted and the health care that was provided. Although Alfred Richards’ overall health was deteriorating at the time of his death, his socioeconomic position enabled him to receive significant medical treatment (e.g., dentures, amputation of toes). It is evident that Richards family members were not hard laborers – suggesting an existence primarily in the home – and that a majority of their pathological conditions are either congenital anomalies or normal signs of the aging process, with the exception of Alfred Richards, who had a known disease, which contributed to his death. The evolution of dental restorative material used to restore
the function, integrity and morphology of the missing tooth structure is visibly apparent in the individuals from the Richards’ family vault. Four of the family members received significant dental work – the need for which may have been driven by consumption of items reflective of the family’s wealth (e.g., sugar).

The dietary habits reconstruction of individuals from the Richards family vault holds considerable potential in revealing a typical dietary pattern of wealthy individuals at the turn of the century in the mid-Atlantic region. A decrease in δ¹³C‰ and δ¹⁵N‰ values towards the end of the 19th century shows a transition from a more corn-based diet to one more reliant on wheat products – which itself is reflective of the evolution of food processing technology. The decrease in δ¹⁵N‰ around the same time period points to either a prevalence towards a more marine-based diet or a decline in the consumption of protein from meat.

The results of this work suggest the following future related research activities: 1) expand the examination to other individuals of the same socioeconomic standing who are interred at the Congressional Cemetery to determine if the patterns identified herein can be corroborated; 2) focus on dietary patterns at the turn of the century to determine evidence of any significant change in carbon and/or nitrogen isotopic signatures; and 3) specifically examine the material artifacts associated with the Richards family vault to determine any conclusions regarding burial display at the turn of the century.

REFERENCES


ABOUT THE AUTHOR

Erin N. Cullen is a recent graduate from Stevenson University, receiving her Masters in Forensic Science. Since 2002 she has worked for Anne Arundel County’s Lost Towns Project as an archaeologist and Laboratory Director. After discovering a few historic burials throughout the county she became very interested in Forensic Anthropology. Attending Stevenson University gave her the opportunity to pursue her interests, and also allowed her to obtain a prestigious internship at the Smithsonian’s Natural History Museum in Washington, D.C. where she conducted her thesis research.
APPENDIX A: DEMOGRAPHIC INFORMATION FOR INDIVIDUALS INTERRED IN THE RICHARDS FAMILY VAULT

<table>
<thead>
<tr>
<th>BURIAL #</th>
<th>NAME (HISTORIC DOCUMENTATION)</th>
<th>FAMILY RELATION TO ALFRED RICHARDS</th>
<th>DATE OF DEATH</th>
<th>AGE IN YEARS</th>
<th>ANCESTRY (HISTORIC DOCUMENTATION)</th>
<th>SEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Marion Grace Richards</td>
<td>Daughter with Second Wife</td>
<td>1863</td>
<td>3</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>2</td>
<td>Elizabeth Jane Catherine Richards</td>
<td>First Wife</td>
<td>1851</td>
<td>25</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>3</td>
<td>Grace Louise Helen Richards</td>
<td>Grandaughter from Third Wife</td>
<td>1908</td>
<td>7 months 21 days</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>4A</td>
<td>Ida Richards</td>
<td>Daughter with Third Wife</td>
<td>1884</td>
<td>4</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>4B</td>
<td>Unknown</td>
<td>Unknown</td>
<td>N/A</td>
<td>fetus</td>
<td>White</td>
<td>N/A</td>
</tr>
<tr>
<td>5</td>
<td>Grace Louise Montgomery Richards</td>
<td>Second Wife</td>
<td>1865</td>
<td>39</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>6</td>
<td>Alfred Richards</td>
<td>(Patriarch)</td>
<td>1894</td>
<td>72</td>
<td>White</td>
<td>M</td>
</tr>
<tr>
<td>7</td>
<td>Mary Alice Richards</td>
<td>Third Wife</td>
<td>1892</td>
<td>48</td>
<td>White</td>
<td>F</td>
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<td>8</td>
<td>Unknown</td>
<td>Unknown</td>
<td>N/A</td>
<td>3-4 months</td>
<td>Probable White</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td>Empty Chamber</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>10</td>
<td>Daughter of Joan Richards Galliher</td>
<td>Unknown</td>
<td>1952</td>
<td>N/A</td>
<td>White</td>
<td>F</td>
</tr>
<tr>
<td>11</td>
<td>Edward Noble Richards</td>
<td>Son with Third Wife</td>
<td>1908</td>
<td>33</td>
<td>White</td>
<td>M</td>
</tr>
<tr>
<td>12</td>
<td>Unknown</td>
<td>Unknown</td>
<td>N/A</td>
<td>5-6 months</td>
<td>Probable White</td>
<td>N/A</td>
</tr>
<tr>
<td>13</td>
<td>Empty Chamber</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>14</td>
<td>Empty Chamber</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>15</td>
<td>Paul Harvey Cushing Richards</td>
<td>Grandson from Third Wife</td>
<td>1920</td>
<td>13</td>
<td>White</td>
<td>M</td>
</tr>
<tr>
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<td>Empty Chamber</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Note: Burials highlighted in [ ] were not exhumed from the vault. Burials highlighted in [ ] were empty and no skeletal remains were evident.

APPENDIX B: STABLE ISOTOPE ANALYSIS

Stable Isotope Results for the Richards Family Vault in Congressional Cemetery, Washington D.C.

**Stable Isotope Results for the Richards Family Vault in Congressional Cemetery, Washington D.C.**

**Date of Death and Carbon in Bone Collagen**

**Date of Death and Nitrogen in Bone Collagen**
The following will examine contemporary pattern and practice of law enforcement use of search warrants as investigative mechanisms. This examination will focus on who may apply for a search warrant, the process used to obtain a search warrant, a brief survey of examples of specialized search warrants, and a sampling of representative scenarios in which the various types of search warrants are used. The discussion will include applicable elements of statutory law, case law, and the Constitutional law underpinnings that form the basis of the legal theory and practice involving search and seizure (by warrant) in the United States. No attempt will be made to address the broader aspects of search and seizure law. Similarly, the multiple exceptions to the warrant requirement (consent, exigency, etc.) will not be discussed.

Several key precepts are helpful at the outset. First, the origins, type, utilization and limitations applicable to search by warrant in the United States apply solely to criminal investigations – search by warrant is not a discrete component of the discovery process in civil litigation. Second, a search warrant is an investigative tool, the usage of which is limited to sworn federal, state, and local law enforcement officers (including, in limited aspect, attorneys acting as sworn public prosecutors); in short, government actors. Private citizens, even those engaged in criminal investigations, are not authorized to search by warrant.

A search warrant is defined as “an order signed by a judge or magistrate authorizing the place to be searched and the persons or things to be seized” (Gardener and Anderson 416). The term warrant, applied in the context of a search by government actors, is found in the text of the Fourth Amendment to the United States Constitution. As with many of the Constitutional limitations on state power the founding fathers wove into the Bill of Rights, they were reacting, at least in part, to abuses of the Constitutional limitations on state power the founding fathers foreclosed the use of general warrants in the republic they were creating.

The language “no Warrants shall issue, but upon probable cause” (U.S. Const. Amend IV) refers (obliquely) to the concept of separation of powers between the three branches of government the framers were intent upon establishing. In the micro, nowhere is the separation of powers more distinct. In every case involving search by warrant, the executive branch (law enforcement) can only act with the concurrence of the judiciary (the issuing magistrate).

The legal standard of probable cause, dominant in both arrest and search and seizure law, is defined as:

> [t]he evidentiary criterion necessary to sustain an arrest or the issuance of an arrest or search warrant; less than absolute certainty or “beyond a reasonable doubt” but greater than mere suspicion or “hunch.” Probable cause consists of a set of facts, information, circumstances, or conditions that would lead a reasonable person to believe that an offense was committed and that the accused committed that offense (Siegel 228).

In the context of applying for a search warrant, the probable cause standard ensures that law enforcement officers present facts or allegations to support their assertion that a) a crime has been committed, and b) there is reason to believe that (specific) items related to the crime are located within a particular location identified and described within the warrant.

As stated previously, a search warrant may only be obtained by sworn law enforcement officers acting under color of law, and only in connection with violations of the criminal law. For federal officers, the procedures for obtaining search warrants are described within Rule 41 of the Federal Rules of Criminal Procedure, found in Title 18 of the United States Code. Each state maintains their own individual statute(s) and local rules and procedures governing the issuance and service of search warrants, although each are subordinate to, and must align with, the minimum requirements set by the Fourth Amendment. For example, in the State of Maryland the governing rules are codified within section 1-203 of the Maryland Rules of Criminal Procedure.

Before entering a private premises with a search warrant, “law enforcement officers are obligated to knock, identify themselves, state their purpose, and await a refusal or silence before entering” (Gardner and Anderson 280). This operational rule, often mandated by statute, has a twofold purpose. First, by knocking and announcing their presence, officers serve notice on the inhabitants of their imminent intent to enter. In cases where the officers have inadvertently presented themselves at a premises other than that named in the warrant (i.e., a mistake of fact—a not uncommon occurrence), their notice before entry may provide an
opportunity for clarification. Second, and more importantly, notice to those inside the premises may alleviate their fears that those entering (often, by force) are there for an unlawful purpose, thus minimizing the likelihood that the inhabitants will respond with force in an attempt to repel them.

But, exceptions to the knock and announce rule are commonly granted. In situations where the law enforcement officer applying for the warrant (usually referred to as the “affiant”) articulates a reason why “knock and announce” may result in 1) enhanced jeopardy to the safety of those serving the warrant, or 2) the likelihood that the evidence being sought will be destroyed or altered, the issuing magistrate may issue a “no knock warrant.” As the name implies, a no knock warrant gives those serving the warrant authority to enter the premises, often via the use of force, without giving advance notice.

Aside from conventional search warrants which require police to knock and announce themselves in the daytime, there are also other types of search warrants, such as nighttime search warrants. As stated above, in Rule 41 of the Federal Rules of Criminal Procedure, the judge can allow a search warrant to be executed at another time, besides daytime, if there is good cause. Usually, a good cause for obtaining a nighttime search warrant is that the police need to search a place as soon as possible because there is a risk of a person destroying evidence. Another type of search warrant is the anticipatory search warrant. This type of warrant allows police officers to apply for a search warrant in “anticipation” that a (particularized) unlawful act or condition will occur at some time in the future at a specific place (the place to be searched). A common example is a scenario where police demonstrate probable cause to believe that a shipment of contraband is to be delivered to a specific place, while the time of the delivery remains unknown. Armed with an anticipatory search warrant, the police are then free to wait until they believe the delivery has occurred (often referred to as the “triggering event”) – the warrant would become operative and service of the warrant would follow.

Another specialized form of search warrant is often referred to as the “sneak and peek” warrant (also dubbed the covert entry warrant). The key distinction of a covert entry warrant is that the relevant operational activities (entry, search, egress) occur surreptitiously and without notice. “Sneak-and-peek warrants permit law officers to make an entry into premises for various reasons” (Gardner and Anderson 307). Very often, this type of warrant is utilized to secretly install audio or video surveillance devices inside a premise where illegal activity is occurring – activity well shielded from public view.

Search warrants must also be obtained for wiretapping and electronic surveillance. Regulations regarding wiretapping are found in Title III of the Omnibus Crime Control and Safe Streets Act of 1968 (the Act), found in Title 18, Part 1 of Chapter 119 in the United States Code. Like all search warrants, warrants authorizing the monitoring and recording of wire communications must be approved by a judge that has authority in the jurisdiction where the monitoring and recording (the “search”) will occur. The application for this type of warrant must include the substantive facts comprising the probable cause, along with the unique factual circumstances that make the wiretap necessary – generally, the assertion that the evidence being sought cannot be accessed by other (conventional) investigative means. The application must also describe the specifics of the wire carrier from which the communication is to be intercepted. Any person who intercepts or discloses a wire or oral communication without authorization or approval shall be fined no more than $10,000 or imprisoned no more than five years, or both (Omnibus Crime Control and Safe Streets Act of 1968). Before this Act, there were no regulations on wiretapping. The Omnibus Crime Control and Safe Streets Act of 1968 was a result of a Supreme Court case in 1967 called Katz v. United States. In Katz, FBI agents attached an electronic device to a public telephone booth to listen and record a telephone conversation made by Katz. The Supreme Court found that:

the Fourth Amendment protects people, not places. What a person knowingly exposes to the public, even in his own home or office, is not a subject of a Fourth Amendment protection… but what he seeks to preserve as private, even in an area accessible to the public, may be constitutionally protected (Katz v. United States, 389 U.S. 347 (1967)).

In other words, information that a person wants to keep private must be treated as information that has an expectation of privacy from warrantless searches.

The courts have also ruled that thermal-imaging devices, used to “see” into a person’s home or private facility is a violation of that person’s expectation of privacy, and therefore requires a search warrant. In Kyllo v. United States, federal agents used thermal-imaging devices (without seeking a search warrant) to scan Kyllo’s home to determine if there were high-intensity lamps used to grow marijuana inside the house. Following Kyllo’s conviction and subsequent appeals, the Supreme Court reversed, stating in part:

[w]e think that obtaining by sense-enhancing technology any information regarding the interior of the home that could not otherwise have been obtained without physical “intrusion into a constitutionally protected area”… constitutes a search – at least where (as here) the technology in question is not in general public use (Kyllo v. United States, 533 U.S. 27 (2001)).

Recently in August 2010, the U.S. Court of Appeals for the District of Columbia Circuit has ruled on the use of Global Positioning Systems (GPS) that federal officers have placed on vehicles without a search warrant. In United States v. Maynard, the FBI planted a GPS on a car while
it was on private property and tracked its position every ten seconds for a month (U.S. v. Maynard, n.d.). The Electronic Frontier Foundation (EFF) and the American Civil Liberties Union (ACLU) supported the position that this was a violation of privacy and required a search warrant.

In an amicus brief filed in the case, EFF and the ACLU of the Nation’s Capital argued that unsupervised use of such tactics would open the door for police to abuse their power and continuously track anyone’s physical location for any reason, without ever having to go to a judge to prove the surveillance is justified (U.S. v. Maynard, n.d.).

By allowing this, federal officers would be allowed to essentially track any person’s location at any time. In the end, the U.S. Court of Appeals for the District of Columbia Circuit generally agreed with this.

In August of 2010, the court agreed that such round-the-clock surveillance required a search warrant based on probable cause. The court expressly rejected the government’s argument that such extended, 24-hours-per-day surveillance without warrants was constitutional based on previous rulings about limited, point-to-point surveillance of public activities using radio-based tracking beepers. Recognizing that the Supreme Court had never considered location tracking of such length and scope, the court noted: “When it comes to privacy... the whole may be more revealing than its parts” (U.S. v. Maynard, n.d.).

Even more recently on September 7th 2010, the Third Circuit Court of Appeals in Philadelphia helped with the issue of whether the government can use cell phone records to track a person’s location without first obtaining a search warrant. Yet again, the EFF supported the notion that the discretion to deny government requests for cell phone location data. The Court further agreed with EFF that location information that can be used to demonstrate or infer that someone or something was in a private space such as the home may be protected by the Fourth Amendment, rejecting the government’s argument that the privacy of location records held by phone companies is never constitutionally protected (Bankston, 2010). But in United States v. Arnold in 2008, the court ruled in favor of the government when concerning searches of laptops at the border. On April 21st, the Ninth Circuit held in United States v. Arnold that the Fourth Amendment does not require government agents to have reasonable suspicion before searching laptops or other digital devices at the border, including international airports” (U.S. v. Arnold, n.d.). This decision would almost allow the border patrol to search everything without having probable cause. The EFF shows dislike towards this decision by stating on their website that “[t]he opinion is almost certainly wrong to classify laptop searches as no different from other property searches... [and] [t]his Arnold opinion fails to protect travelers in these traditional Fourth Amendment ways” (U.S. v. Arnold, n.d.).

Furthermore, courts have repeatedly held that the use of drug and bomb detection dogs in scanning vehicles, containers and people in public venues does not constitute a search, and therefore a search warrant is not required. “[T]he U.S. Supreme Court and ‘most lower courts have granted particular deference to the olfactory abilities of police drug detection dogs” (Gardner and Anderson 323). While the use of a scanning dog in a public venue does not, of itself, constitute a search, an affirmative result of such a scan is often considered as sufficient probable cause to initiate a search. “A dog’s positive alert alone generally constitutes probable cause to search a vehicle” (Gardner and Anderson 323).

Now that topics such as how to get a search warrant, different types of search warrants, and instances when search warrants are not needed have been discussed, it is time to discuss what happens when a search warrant is not properly obtained. Evidence not properly obtained most likely will be inadmissible at trial under the exclusionary rule. The exclusionary rule is “[t]he judicial rule that states that evidence obtained in an illegal search and seizure cannot be used in trial” (Janda, Berry, and Goldman A-28). This exclusionary rule only applies to government officers and officials. This rule does not apply to private persons performing searches. The exclusionary rule only applies to criminal cases. Even if the evidence is obtained illegally, it can still be used in a civil trial to prove a party’s case. The exclusionary rule was essentially created by Weeks v. United States in 1914. Weeks v. United States made evidence illegally obtained by federal agents inadmissible in federal criminal proceedings. Then, in the 1949 case Wolf v. Colorado, the Supreme Court ruled that illegal searches and seizures were unconstitutional and states could make their own rules to protect against evidence seized illegally, but failed to extend the exclusionary rule to the states. Then, in the seminal 1961 case, Mapp v. Ohio, the Supreme Court expanded the protections afforded by the exclusionary rule to include the states. The Supreme Court in Mapp stated:

[there is no war between the Constitution and common sense. Presently, a federal prosecutor may make no use of evidence illegally seized, but a State’s attorney across the street may… Thus the State, by admitting evidence unlawfully seized, serves to encourage disobedience to the Federal Constitution which it is bound to uphold… (Mapp v. Ohio, 367 U.S. 643(1961)).
Later the exclusionary rule was modified by the Supreme Court case *United States v. Leon* by creating the “good faith” exception. In *Leon*, the Court acknowledged that inadvertent error (on the part of law enforcement) does not negate the admissibility of evidence otherwise seized properly. Within the good faith exception, “[m]ost states permit the use of evidence obtained under a search warrant that has a technical error unknown to the law officers executing the warrant” (Gardner and Anderson 414).

There are, however, sanctions built into the law in cases where officers fail to act in good faith. One example that directly impacts the search and seizure arena is what has come to be known as the “fruit of the poisonous tree” rule. The term fruit of the poisonous tree is a legal metaphor, related to the exclusionary rule, which refers to evidence gathered from improper police conduct. For example, evidence gained as the result of an illegal search and seizure will be inadmissible at trial, regardless of its (otherwise) probative value. This doctrine encourages officers to properly gather search warrants.

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U.S. Const. amend. IV


**ABOUT THE AUTHOR**

Justin grew up in the small town of Norrisville, Maryland. Since his teen years, Justin has worked for the family business, Hill’s Tree Service. He graduated from Stevenson University in December 2008 with his bachelor’s in Paralegal Studies. Justin then obtained a master’s degree in Forensic Studies at Stevenson University and graduated in August 2010. In his free time, Justin enjoys playing the blues harmonica. He is constantly learning new techniques and songs on the instrument.
Cyber Forensic Examiners, security network experts and intrusion analysts are challenged by cyber criminals and network hackers on a daily basis. As a result, companies are focused on reducing vulnerabilities by enlisting the services of cyber forensic experts. These experts search for malicious activity occurring on a computer system.

The cyber criminal conceals malicious activity by data hiding, obfuscation, and steganography. With the availability of virtually unlimited tools, including freeware and open-source applications which enable just about anyone to embed chunks of data and information into various file types, the act of examining and discovering indicators of possible malicious activity becomes a complex undertaking.

This paper provides a brief overview of common data obfuscation and steganography methods, how those methods thwart the digital examination process, and how cyber forensic examiners mitigate the data obfuscation effect. It explains an objectives-based approach for cyber forensic investigators. Best possible detection and subsequent removal techniques of obfuscated data are discussed and vulnerabilities of existing digital forensic tools are identified.

STEGANOGRAPHY

Steganography is the “art of hiding sensitive information within innocuous communications” (Frith 4). It affords cyber criminals and system users a mechanism to disguise information, avoid disclosure, and prevent compromise by unauthorized individuals.

Data are stored in a digital format represented by a binary number called a bit. Each bit can have only one value, either 1 or 0, which indicates the bit's state as either on or off respectively. By modifying the series of 1’s and 0’s through “mathematical manipulation” (Sheetz 48) of the digital data stream, hiding data within the stream becomes possible. This is known as steganography. Multiple techniques exist for applying steganography to various file formats.

Two of the most prevalent methods of steganography are text encoding and image encoding. Text encoding uses three techniques according to Bret Dunbar, “line-shift encoding, word shift encoding, and feature-shift encoding” (Dunbar, 5).

Line-shift hides data by shifting each line of white space in a text-based file up or down by a minimal amount. This “equates to a value for encoding a secret message” (Dunbar, 5). “Word-shift encoding” (Dunbar, 5) operates in a similar manner to line-shift encoding, but rather than modifying the vertical shifting of words, it uses the “horizontal spaces between words to equate a value for the hidden message” (Dunbar, 5). However, it is only possible in text formats that support “variable spacing” (Dunbar, 5) such as .doc, .docx, and .pdf formats. “Feature-specific encoding” (Dunbar, 5) hides data by changing the attributes and traits of the text in a given file, “such as the vertical or horizontal length” (Dunbar, 5) of the characters themselves, to create the value necessary for embedding additional data.

Encoding secret data into image files is more complicated than its text-based counterpart; however, it provides the ability to store larger data amounts, with minimal change to the host file. Image file bits form pixels, the basic building blocks for image file formats. Comprised of three separate 8-bit values that represent Red, Green, and Blue (RGB) respectively, the larger the number of pixels, the more detailed the image’s resolution, and consequently, the larger available storage capacity for hidden data.

DATA HIDING

The Least Significant Bit (LSB) technique is the most common method to hide data in image files. As the name denotes, using the LSB of each byte (made up of 8 bits) of data can allow for the storage of “3 bits of data in each pixel for 24-bit images” (Dunbar 6). In this example, a 24-bit image file with a resolution of 640 x 480 will equate to 307,200 pixels and allow for 921,600 bits of data to be embedded into a single image. This is a significant amount of data as this number correlates to approximately 115,200 characters.

Data may also be hidden by “appending the secret text to the end of file (EOF) tag” (Cheddad 733). A simple command to perform this process could be:

```
C> copy Picture.jpg /b + secret.txt /b newimage.jpg
```

This command copies the contents of the Picture.jpg image file, appends it with the text in the secret.txt text file and assembles a new image file, newimage.jpg, which contains the assembled data. When viewing the new image file in a photo application, the application simply ignores the data following the EOF tag; however, when the image file is viewed with a text application, such as Notepad, the secret embedded text is revealed and can be readily identified by the human eye. This EOF method is transitory in nature as any subsequent modification to the host image file will cause the appended data to disappear.

Similar to the EOF approach is to “append hidden data into the image's extended file information field (EXIF),” which stores manufacturer information such as camera model, timestamp, image resolution, native format, etc. Just as with the previous method, however, any modification to the host file will delete the appended data.
Registry hiding and slack space hiding are alternative methods. On any Window-based host system, the registry is the “central repository for configuration data that is stored in a hierarchical manner” (Wong n. pag.). The registry is accessed on a constant basis by the host system to reference required and pertinent information in the execution of system tasks and processes. Registry key values support binary data types; those types used by the system to run executable code, thus a valuable archive location for malicious use. By using the binary support in key values, entire binary executables could be stored in one registry key, or segment those executable files and have them “placed in several dispersed keys” (Wong n. pag.) further promoting obfuscation and increasing the difficulty of detecting malicious files. Within the registry construct, text-based information may be encoded into binary format using hexadecimal notation and storing the “binary form in registry values as a string using type REG_SZ” (Wong n. pag.) for the key value. Instead of using a binary format to represent characters, hexadecimal notation provides an alternative type to represent the same characters. The acceptable range for hexadecimal notation is 0-F in place of 0-1 for a binary equivalent. For example, the word “password” in its hexadecimal representation of 70 61 73 73 77 6F 72 64, would be similar to the binary representation of 01110000 01100001 01110011 01110011 01110111 01101111 01110010 01100100. This alternative method encodes the same data and hides text-based information from ready discovery. An implementation flaw with the Windows registry engine causes the registry itself to hide value names ranging from 256 to 259 characters from viewing and editing while also hiding any contained key values. This flaw can be exploited to hide malicious code into the AUTORUN registry location:

```
HKEY_LOCAL_MACHINE\Software\Microsoft\Windows\CurrentVersion\Run
```

This location in the registry is referenced by the operating system to determine the executable files which will run during system startup. If a specifically crafted registry key with a binary value were provided a string name between 256 and 259 characters and inserted into this registry location, the executable binary would run during system start up processes. It would, however, be a transparent execution to the user and hidden by the registry viewer module.

Slack space hiding is a technique used to disperse hidden data over multiple locations within the physical storage media, usually the system hard drive. A Windows system’s hard drive stores data in clusters; a cluster is the smallest unit of digital storage space available in a New Technology File System (NTFS) volume. With a physical volume of 2GB or larger, the data on the hard drive are stored in 4KB clusters. When data are stored onto the hard drive, they do not occupy an equal number of clusters, and therefore can provide extra storage space on the hard drive, though that space is typically not made readily available to the user. Figures 1 through 4 illustrate this concept.

**CYBER FORENSICS**

Although a multitude of steganography, data obfuscation, and data transformation techniques are available to cyber criminals, equally robust and capable mechanisms exist to assist in the discovery of hidden data. Cyber forensics is the discipline used by highly trained examiners to discover, detect, utilize, and in some cases, sterilize infected systems through the removal of hidden data artifacts. In order to accomplish the aforementioned goals, an objectives-based framework for system investigation should be employed. The following approaches and methodologies foster a more comprehensive and thorough examination process, which afford the best possible investigation results when hidden data are suspected.
The crucial requirements for a successful steganographic system are "perceptual and algorithmic undetectability" (Wang 78). Furthermore, these systems must be comprised of an ability to meet three primary goals, "security of the hidden communication; size of the payload; and robustness against malicious and unintentional attacks" (Wang 79). These attacks refer to the techniques used by digital forensic examiners to detect the presence of obfuscated or hidden data streams in any file, directory, or system volume. Steganalysis is the methodology used by forensic investigators to make these discoveries on a given system. According to Wang, steganalysis involves two primary steps, "visual analysis" (Wang, 80) and "statistical analysis" (Wang, 81). Visual analysis uses the human eye or a computer-based inspection to discover the hidden data, while statistical analysis is used to reveal the alterations in a given file's behavior, such as file size, that results from embedding additional data into the host file.

Digital forensic examiners must use an objectives-based approach to discover hidden data due to the characteristics of obfuscation techniques. The following sections will discuss the approach offered and how each phase of that methodology can serve the examiner in a more constructive manner.

PHASES OF APPROACH

According to Beebe and Clark, the five basic phases of any digital investigation are preparation, incident response, data collection, data analysis, and incident closure (150). Preparations for initial incident response are performed by victim organizations and are not with the scope of this paper. Data collection and analysis are performed by forensic examiners. Incident closure represents a combined effort by the victim organization and the forensic examiner.

INCIDENT RESPONSE

The incident response phase includes seven components that foster the "initial pre-investigation response to a suspected computer crime related incident" (Beebe 150). These activities are initial detection of unauthorized activity, activity reporting, incident validation, damage assessment, incident containment, coordination with stakeholders, and investigation plan formulation.

DATA COLLECTION

The data collection phase serves as the primary point of assembling digital evidence to be used by the forensic examiner and victim organization in support of the investigation plan. This phase consists of live response data collection, network security queries, host-based and removable media evidence collection, data integrity verification, and data control, i.e. data catalogued, stored, and transported, commensurate with chain of custody protocols.

DATA ANALYSIS

During the data analysis phase, the examiner will conduct an initial survey in order to identify obvious artifacts of digital tampering and determine the skill level of the attacker or suspect. Various techniques are employed, such as keyword searches, extraction of unallocated slack space, file mapping and hidden data discovery in order to obtain pertinent evidence for follow-on examination, analysis, and event reconstruction. The data analysis phase is the critical component of the examination process. It is further subdivided as "survey, extract, and analyze" (Beebe 156). In the survey sub-phase, mapping activities are performed in order to describe and provide detailed information regarding various digital components. Survey actions include file system mapping, enumerating logical partitioning structures, determining disk layout, and discovering locations and irregularities associated with found artifacts. This sub-phase familiarizes the examiner with the analyzed object, the suspect or criminal's skill level, and the location of obvious and potential digital evidence.

In the extraction sub-phase, the examiner performs keyword searches, deconstructs proprietary formats (such as the metadata in a .doc file), conducts hidden data mining, filters, matches patterns, and analyzes file signatures or headers. Data extraction enables forensic investigators to avoid corrupting source files and volumes while simultaneously archiving the extracted items for use in the final phase. The examination sub-phase allows examiners to reconstruct events based upon the extracted data, i.e. confirm the presence or absence of proposed evidence. Additionally, it addresses the questions "who, what, when, where, why, and how (event reconstruction)" (Beebe 156). Examination is performed through log reviews, image and text viewing, chronology of file modification, correlation to actual user activity, and reviewing decrypted files if available. For example, in a scenario regarding the presence of child pornography on a computer system, the data analysis phase provides the mechanisms to recover images, correlate possession of images to the suspect, demonstrate suspect knowledge of possession and/or distribution of images, reconstruct the events surrounding image procurement (time and method), apply anti-obfuscation techniques, and confirm and/or refute possible defenses by the suspect. The data analysis phase leverages the examination procedures and framework for a more thorough investigation process.

The fourth phase is the presentation of findings and is composed of the activities surrounding the conveyance of discovered evidence. Collection techniques used by the forensic examiner are discussed in addition to how those techniques were deployed. Furthermore, event reconstruction provides the victim organization with the information necessary to support the final phase: incident closure.
INFORMATION CLOSURE

Incident closure is focused on investigation termination, identification, and presentation of lessons learned during the examination process. Critical reviews are conducted which provide the identification of vulnerabilities and application of countermeasures during the examination process. Best practices are identified during the presentation findings so they might be incorporated into future processes and procedures, e.g., developing an acceptable use policy or security policy. During this phase, evidence disposal might also be recommended if it is required to justify prosecution of a suspected criminal. All collected evidence pertaining to the incident is then catalogued, documented, and preserved.

The proposed framework is incomplete without knowledge of the methods and tasks available for examiners to leverage. Steganalysis is one of the primary methods used to accomplish investigation goals. Since steganalysis is a complex discipline, only a brief overview of the more prevalent and common methodologies employed will be addressed.

STEGANALYSIS

Steganalysis is the searching for and discovery of artifacts related to the installation and/or removal of steganography tools on a system. Steganography tools are used to perform data hiding or obfuscation. These tools tend to leave a digital footprint on a computer system, regardless of whether or not the tool has been removed by the user. Forensic examiners perform detection activities within the system to determine which tools might have been, or remain resident. The two primary detection types are signature based, i.e. “searches files for known byte patterns left by steganography programs” (Zax 28) and blind detection where examination is performed on “statistical properties of files exposed to steganographic algorithms” (Zax 28) as an indicator that something is hidden on the system.

Often, steganography tools leave artifacts that can be detected and forensically discovered in multiple ways. The most notable artifacts found are residual hash values or file/directory names, name and value combinations of registry keys, evidence in most recently used (MRU) lists, or evidence in temporary caches on the system. In addition to the artifacts that would lead to the discovery of installed and/or uninstalled steganography tools, are the detection systems used. Most forensic tools, such as EnCase®, automate the search for indicators by analyzing multiple system locations and components such as hard drive data, allocated and unallocated files in a cluster, deleted files, file or volume slack, open files with associated temporary directories, and hidden processes (Frith 6).

Furthermore, the automated components of forensic tool kits are used to analyze both volatile (data stored in a temporary location such as RAM memory) and non-volatile (data stored in a permanent location such as a hard drive) data as well as perform hash value verification. A hash is a string of characters created by implementing a mathematical function onto an input of data resulting in an arbitrary representation of the data’s digital fingerprint. A hash has three distinct strengths that make it crucial to any examination. First, it offers a one-way algorithm, such that “it is impossible to regenerate input data from the hash value” (Forte 14). Second, it is unique in that the same hash value will never be generated from two different inputs when applied to the same algorithm. Finally, hash functions offer repeatability because any given piece of data will always generate the same hash value when applied to the same hash algorithm.

TOOL KIT VULNERABILITIES

Many forensic tool kits remain susceptible to vulnerabilities that can be leveraged by cyber criminals to thwart and hamper the discovery processes. Anti-forensics attack the forensic effort by “negatively affecting the integrity of the digital evidence comprising the crime scene” and “disrupting the digital evidence available to forensic examiners in a given investigation” (Sartin 4). In the scope of anti-forensics, two overarching concepts comprise the primary methods of defeating the forensic effort. The first, data obfuscation, covers the tracks of cyber criminals or hackers through the destruction of digital evidence that might lead to the discovery of various artifacts. This is achieved by file system modifications in order to mislead the examiner, or backdoor program removal. However, the potential digital fingerprint left behind remains a problem for the cyber criminal. The second concept is that of data hiding which “masks evidence rather than destroying it” (Sartin 5). Three methods of hiding data are data encryption, file packing, and exploiting hidden disk areas.

Data encryption applied to data at-rest hides the nature and the extent of the system intrusion but only applies to persistent data types such as files, directories, registry keys, etc. Encryption may be applied to data in transit such as SSH, SFTP, and SSL, rather than to the data itself. File packing “combines two files to form a single file” (Sartin 6). This method is especially useful to hackers and cyber criminals because signature-based detection engines only look for the malicious file as a whole, and not for two separate components working in tandem. For example, a hacker could pack a backdoor program with a legitimate operating system service to mask malicious evidence and to hide indication of unwanted execution. Hiding data in hidden disk areas, such as directories not shown by default, delays initial discovery; however, it is easily detectable.

Digital forensic tools exhibit vulnerabilities. Tim Newsham indicates one forensic software vulnerability stems from code execution wherein arbitrary code on a given forensic station can be executed to corrupt the collected image, hide, or even destroy collected data, effectively rendering any possible evidence as worthless (3). An additional vulnerability lies in the susceptibility to Denial of Service (DoS) attacks in which a cyber criminal might use a specially crafted file to “cause the program to crash or hang” (Newsham 3). Although EnCase® is the industry standard, it cannot acquire a disk image which contains a corrupted Master Boot Record (the record responsible for telling the system where to look for the operating system upon initial boot up sequences). Nor can EnCase®
access a corrupted NTFS based volume, an indicator of unauthorized activity on the host system. EnCase® is susceptible to crashing when it encounters these types of anomalies.

These vulnerabilities reinforce the challenges faced by forensic examiners. Although forensic examiners are able to discover cyber criminal activity, cyber criminals will continue to devise methods to thwart the detection of malicious or unauthorized activity on a target system.

**CONCLUSION**

In conclusion, the opposing doctrines of cyber security and cyber crime are constantly evolving. Emerging threats, technologies, and the development of more advanced intrusion techniques further exacerbate the challenge associated with the digital forensic premise and desired goals. Deploying an in-depth, layered approach through use of the proposed objectives based framework combined with robust forensic tool kits, and highly capable forensic experts will gain an advantage over the cyber criminal community and ultimately hamper malicious activities.

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**ABOUT THE AUTHOR**

Tobias Voegele began his network career in 2003 after training as a Network Operations Technician in the US Navy. After a promotion to First Class Petty Officer in 2007, Tobias Voegele took on the role as an Assistant Division Manager and managed a large scale development project comprised of developing virtual network testing infrastructures, network vulnerability assessments, and reverse engineering. Upon his departure from the US Navy in 2009, Tobias began, and is still currently working for Booz Allen Hamilton as a network intelligence analyst, intrusion analyst, and intrusion detection instructor.
The Impact of “The CSI Effect” on Forensic Science Investigations and Trials

Rachael Strauss

The increasing focus on forensic science in television shows has caught the television viewing public's attention, even spurring renewed interest in science careers among high school and college students. At the same time, the contribution of forensic science in solving real crimes has become increasingly important.

The term, “forensic science” refers to the application of numerous scientific disciplines, to include chemistry, biology, and computer technology, to criminal and civil laws. Forensic Scientists are “skilled in applying principles and techniques of physical and natural sciences to the analysis of many types of evidence” to help solve crimes (Saferstein 16). Forensic tests provide the scientific basis for courtroom testimony to help prove or disprove events related to the crime. Crime Scene Investigation is the collection of physical evidence at a crime scene. Forensic science is the analysis of this evidence in a laboratory. Often both activities are indiscriminately merged under the term “Crime Scene Investigation” or “CSI.”

Some attorneys, forensic scientists and investigators believe television crime shows have changed how jurors evaluate evidence in the court room. One of the most popular television shows is CSI, leading to this phenomenon's being labeled the “CSI Effect.” Researcher Evan Durnal defined the CSI Effect as a phenomenon stemming from “the impact that CSI and related shows have on the ability of trial juries to objectively hear testimony and make decisions without biasing those decisions on information obtained outside the courtroom proceedings” (Durnal 2).

Some researchers have suggested CSI-type shows have changed the behavior of juries and criminals. Many have concluded juries are less inclined to convict a defendant unless the quantity and quality of forensic evidence is comparable to that depicted on television; however, this view is not universal because other researchers concluded these shows make juries smarter and more capable of evaluating forensic evidence. This paper examines the CSI Effect, including actions to mitigate negative impacts.

The jury evaluates all direct and circumstantial evidence presented in court. “Direct evidence relates immediately to the allegation being tested” (www.criminal-law-lawyer-source.com), i.e., direct evidence proves a specific assertion is factual without requiring any assumptions or inferences. Circumstantial evidence is “indirect evidence inferred from circumstances which afford a certain presumption, or appear explainable only on one hypothesis” (Oxford English Dictionary). It is typically characterized by a certain set of events or circumstances, which leads the juror to a conclusion of what happened based on reasonable inferences.

The jury may discount evidence it concludes is unreliable or does not prove the related assertion. Direct evidence, such as eyewitness testimony or scientific test results, may be discredited by challenging its accuracy. Circumstantial evidence may be challenged by offering the jury a reasonable alternate explanation for the observed events and facts. Because the jury may not see or understand the results of scientific tests, the credibility of the laboratory technician's testimony is crucial if the jury is to accept the testimony and properly weigh its significance. The laboratory technician must earn the jury's confidence through submission of professional education, experience, and qualifications as well as scientific methodology and tests performed. Sloppy test methods or incoherent testimony can undermine the jury's confidence in the technician, and by association, evidence. Forensic evidence may be discredited by challenging the validity of the science, the accuracy of the results, or the qualification of the laboratory technician. Even a misperception about the reliability of the scientific evidence or testimony can impact the jury's opinion.

Television crime shows depicting forensic science are comprised of two general groups. Cold Case Files, The FBI Files, and The New Detectives are fact-based docudramas. Bones, Castle, Cold Case, Law and Order, and CSI are fictional dramas, but often draw their storylines from real life events. Combined, these shows are watched on a regular basis by several million Americans. Donald Shelton, a researcher and trial judge reported at least “70 million people watched one of the three CSI shows according to a 2006 weekly Nielsen rating” (Shelton 34).

Crime dramas usually do not accurately portray forensic investigations or scientific testimony. As a result, these inaccuracies can bias jurors’ perception of forensic science during actual courtroom trials. While crime dramas seek to entertain, reality-based crime docudramas seek to entertain and educate. They portray all aspects of an investigation, including forensic science, as realistically as possible. The confusion arises when shows such as Law and Order advertise their storylines as based on real-life cases which may create the false impression that the shows are verbatim accounts.

Crime dramas imply the best technology and equipment are always available, and most crimes are solved quickly. The job of forensic scientists, crime scene investigators, detectives, or prosecutors is often not accurately portrayed in crime dramas either. For example, scientists are portrayed as experts in multiple scientific disciplines and the varied skills and teamwork needed to conclude a real criminal investigation is often minimized. (“TV crime fighting and crime solving dramas might show all of these occupations, but they might be all rolled into one worker” (Jones 7).) Crime dramas also portray them as people who rarely make mistakes, who act on impulse or in an unprofessional manner. However, these professions actually "require attention to detail; strong mathematics, scientific, analytical, and communication skills; and an inquisitive mind. Creativity also may be useful because, unlike their TV counterparts, most Crime-Scene Investigation departments do not have an unlimited budget for equipment” (Jones 9).

In contrast, crime docudramas acknowledge the fact that solving a crime may take a long time because evidence is insufficient, records misplaced, or the technology needed to analyze the evidence may not be available or even exist. These shows illustrate that successful investigations depend
on a team of trained investigators and scientists with many different skills who are professionals working in accordance with established procedures and recognized standards. These differences may explain why researchers have reached different conclusions when studying the CSI Effect.

Viewers of crime dramas may or may not realize how much poetic license these shows take, leading the viewer to very different opinions about the role forensic science plays in criminal investigations, including how much evidence can physically be collected from a crime scene, what tests should be conducted, and how the findings should be presented in the courtroom. These viewer-turned-juror opinions may be a positive influence, i.e., help them evaluate evidence more critically, or a negative influence, i.e., lead them to doubt established science and qualified witnesses.

The article entitled “The CSI Effect” discussed Dr. Robberts’ 2008 study which revealed “62% of defense lawyers and 69% of judges agreed that jurors had unrealistic expectations of forensic evidence” as a result of television crime dramas (“The CSI Effect”). Maggie Koerth-Baker quoted the Economist newspaper, which described the CSI Effect as “that unfortunate legal train wreck that is the result of jury pools being simultaneously over-informed, under-informed and misinformed about forensic investigation science by prime-time cop shows” (Koerth-Baker).

Unrealistic jury expectations can undermine the credibility of everyone associated with a case, including the forensic scientist, investigator, prosecutor, and defense attorney. A juror who believes solving real crimes is as simple and straightforward as it appears in crime dramas may end up questioning the competence of the forensic scientist and investigator because they think solving the case took too long, more evidence should have been found, more tests should have been performed, and test results should be more definitive. A forensic scientist’s credibility when testifying about laboratory procedures and test results can be undermined by a juror who does not believe these professionals are doing their job correctly based on what the juror saw in a crime drama. Similar concerns can affect prosecutors and defense attorneys, resulting in changes as to how they present or refute the evidence. Crime laboratories and other agencies have also “increased their efforts,” as well as “spent money to acquire modern technology and training that produces reliable results” (Dutelle 114). These types of actions have been taken because crime laboratories “feel the need to improve their forensic capabilities” despite the reality that the areas in which they are making the improvements are used infrequently (Dutelle 114).

Crime dramas imply collecting and testing physical evidence is much faster and simpler than the reality. Jurors may not realize there are legitimate reasons why a case may take years to solve or bring to trial. Trials may be delayed by legal motions or because technology needed to test evidence was not available at the time of the crime. In reality, these tests can take a long time due to their complexity. Analyzing forensic evidence takes time to ensure accurate results. If the process is rushed, important evidence could be analyzed incorrectly or misinterpreted. Researcher Jeffrey Heinrick discussed the case of Richard Ramirez, also known as the Night Stalker, in which “forensic scientists spent two years carefully analyzing and interpreting the evidence” (Heinrick 60).

Crime dramas also portray inaccurately how instruments and technology are used in real forensic laboratories. Dean Gialamas, Director of a California crime laboratory, stated that “the gadgetry in crime dramas is very close to what they have in an actual crime laboratory, but the major difference is the application of how some of the technology is used” (Lovgren 2). For example, DNA and fingerprint evidence cannot be processed as rapidly as depicted on television.

A delay may also occur because crime laboratories handle numerous cases simultaneously. Stefan Lovgren explained the “workload is so severe that forensic scientists may work two dozen cases at the same time” (Lovgren 2); whereas investigators in crime dramas are only assigned one or two cases. Researcher Jeffrey Heinrick also stated “crime labs are already backed up to full capacity, often waiting months, or even years to provide tangible evidence” (Heinrick 60).

Jurors may also believe more physical evidence should have been collected, tested, and presented. Jurors often expect to see more forensic evidence (such as DNA, fingerprints, and blood spatter) than was available or the prosecutor deemed necessary. According to Evan Durnal, “shows such as CSI put forth a perception that there is an ample amount of evidence left behind at every crime scene, as well as it being simple for the scientist to find” (Durnal 5). An actual crime scene often “does not have physical evidence” or as much evidence present at the scene as portrayed on television (Dutelle 113). “Jurors now demand expensive and often unnecessary DNA tests, handwriting analyses, gunshot residue testing, and other procedures that are not pertinent to the case” (Heinrick 59). “Prosecutors in the United States are now spending much more time explaining to juries why certain kinds of evidence are not relevant” (“The CSI Effect”).

Lack of physical evidence has resulted in acquittals despite other strong evidence. In the Robert Blake murder trial, Heinrick observed that, “physical evidence was lacking, but the witness testimony and the odd behavior of Mr. Blake himself was damning...[D]ue to a lack of gunshot residue and blood on his clothes, the jury voted to acquit Robert Blake” (Heinrick 59).

Prosecutors and defense attorneys find it hard to explain to juries the differences between crime investigations on TV and in real life and “…find themselves at pains to explain that one of television’s fictional devices—an unequivocal match between a trace of a substance found at a crime scene...whether it be fingerprints, DNA or some other kind of evidence—is indeed generally just fiction” (“The CSI Effect”). In a crime drama, the forensic evidence is “always nearly correct and the detective is never wrong” (Dutelle 113). In crime dramas, there is a surfeit of circumstantial and direct evidence that neatly fits together to tell a perfect story of the crime, which does not always happen in real investigations. When
Evidence does not perfectly mesh, jurors can be inclined to question the training, qualification, and job performance of a forensic scientist, investigator, or prosecutor.

To combat these misperceptions which impact credibility, many agencies react by changing procedures related to how evidence is collected, how much evidence is collected, and what tests are performed in the laboratory. “Investigators, crime scene technicians, and officers are finding themselves collecting and booking more evidence than they did in the past. This is happening because they have found that failing to do so is pointed to as incompetence or inefficiency” (Dutelle 114). Time, money, and resources are being wasted to ensure that investigators do not appear incompetent.

However, some researchers believe forensic science in television shows improves jurors’ ability to critically evaluate forensic evidence in court. Researchers Baskin and Sommers stated “some studies suggest that jurors do not have unrealistic expectations regarding the presentation of forensic evidence” (Baskin and Sommers 98). For example, Shelton surveyed study participants to determine “what potential jurors expected to see in terms of evidence” (Shelton 35). He found “those who watch CSI generally had higher expectations than non-CSi viewers” (Shelton 36), with respect to the availability, processing, and use of forensic evidence, but concluded that maybe CSI made them “better informed jurors” (Shelton 36). Researcher Nicholas Schweitzer also studied differences in how potential jurors who watched CSI and those who did not evaluated forensic evidence using a mock trial format with 48 university students acting as mock jurors. Study participants completed questionnaires to determine their views of the mock trial transcript and forensic evidence and were interviewed to determine their television crime drama watching habits. “Working with Michael Sales, an [Arizona State University] professor of law and psychology, Schweitzer found that respondents who watched CSI-type shows were more skeptical of the forensic hair analysis in the mock transcript than those who didn’t. They also claimed a greater understanding of forensic science and greater confidence in their verdicts.” (Boudreau. cf. Schweitzer (Jurimetrics http://www.public.asu.edu/~nachwei/archive/csieffect.pdf), 1).

David Michael Miranda, a forensic specialist for the Pasadena Police Department, believes “the plethora of forensic shows particularly CSI is positive for a lot of different reasons and there is a genuine need to understand what those reasons are and once we do that, it can be a positive force both inside and outside the profession” (“CSI”). Ideally, these shows help develop a balance to help future jurors learn to critically evaluate forensic evidence without applying unrealistically high expectations based on what they saw on television.

Adding to the problems associated with jurors’ biases created by crime dramas, some individuals believe shows like CSI help criminals learn to successfully commit crimes and elude conviction by leaving less evidence. Although these shows are not 100 percent accurate, they do show many aspects of forensic science, such as the types of evidence collected at a crime scene, thereby helping criminals understand how to sanitize a crime scene and destroy evidence. Ray Peav, a Los Angeles County Sheriff’s Department employee in the homicide unit stated, “Things like cigarette butts, coke cans, beer cans, a sweaty hat band or blood or semen, hairs, all those things that used to be left are no longer being left at crime scenes” (Rowlands 1). After visiting the Forensic Science Training Center at the University of Glamorgan in South Wales for an article about the CSI Effect, Maggie Koerth-Baker agreed with The Economist:

Criminals watch television too and there is evidence they are also changing their behavior. Most of the techniques used in crime shows are, after all, at least grounded in truth. Bleach, which destroys DNA, is now more likely to be used by murderers to cover their tracks. The wearing of gloves is more common, as is the tape – rather than the DNA-laden licking – of envelopes. Investigators comb crime scenes ever more finely for new kinds of evidence, which is creating problems with the tracking and storage of evidence, so that even as the criminals leave fewer traces of themselves behind, a backlog of cold-case evidence is building up (Koerth-Baker).

Actions like these reduce the evidence available at a crime scene that can be collected, analyzed, and presented to the jurors.

**Actions to Mitigate Negative Aspects of the CSI Effect**

Regardless of any potential negative impacts in the criminal justice system, crime dramas and docudramas are protected by freedom of speech. It is unlikely crime dramas will become more realistic. Therefore, all members of the criminal justice system must work to mitigate the negative aspects and reinforce the positive aspects of the CSI Effect.

Aric Dutelle, a professor of forensic investigation, suggested jurisdictions educate citizens by incorporating “the area of forensic investigation into their Citizen Police Academies to inform and educate the public as to the realities of forensic science” (Dutelle 114). Dutelle also recommended hiring “educated and trained personnel with backgrounds in forensic investigation” (Dutelle 114) and “conducting frequent refresher training and taking a look at current case loads and determine the most appropriate training and technology necessary to efficiently and effectively work the cases” (Dutelle 114).

Jury selection begins with voir dire, the process by which prospective jurors are questioned about their backgrounds and potential biases before being chosen to serve on a jury. Prospective jurors are routinely questioned regarding all possible biases, such as whether they would give more
weight to a law enforcement officer’s testimony compared to other witnesses. A potential juror who shows a bias for or against law enforcement officers may be dismissed. Potential jurors may also be dismissed if they show other biases based on their work, legal, or general life experiences, including those of family and close friends. It is common for judges to ask prospective jurors if these experiences created biases they could not put aside. The judge, prosecutor, and defense attorney should use the voir dire process as an opportunity to explore any biases, positive or negative, a potential juror may have acquired viewing crime dramas or docudramas on television, although merely being a regular viewer should not exclude someone from jury service.

Judges routinely remind jurors, before and during a trial, to consider only evidence presented in the courtroom. Before jury deliberations start, judges also provide detailed instructions to the jury regarding the applicable laws in the case. In cases involving forensic evidence, judges should explain that television crime shows are not a reliable standard by which to judge evidence or witnesses and direct jurors not to compare evidence or proceedings to what they have seen in these shows.

The actions below have the potential to mitigate the negative aspects of the CSI Effect by:

- Ensuring forensic scientists and investigators are properly trained, and that they understand and adhere to standards of scientific and investigatory procedures to reduce the chance of error.
- Ensuring lawyers understand the strengths and limitations of forensic evidence to enable accurate explanations to the jury.
- Improving the knowledge and understanding of the strengths and limitations of forensic evidence in the general public.
- Screening potential jurors to exclude those with biases from jury service and reminding jurors of their responsibility not to let outside influences impact their deliberations.

Typically, the concern over the CSI Effect is in the context of preventing the acquittal of a guilty defendant. However, the risk of a jury incorrectly acquitting a guilty defendant thus releasing a criminal back into society is not the only potential negative impact of the CSI Effect. The risk of a wrongful conviction is just as significant because it takes away the freedom of an innocent individual and undermines the credibility of the criminal justice system. In recent years, many wrongful convictions have been overturned based on DNA exonerations. According to The Innocence Project, invalid and improper forensics played a role in 52% of the overturned convictions, making it the second leading cause of wrongful convictions in the 225 cases in which The Innocence Project has been involved (“UnValidated”).

Therefore, there is a clear benefit to having better informed jurors to prevent incorrect acquittals and wrongful convictions. In one case, the forensic investigator testified the defendant’s blood type matched blood at the crime scene, but failed to testify the blood also would match approximately two/thirds of all men in the general population (“UnValidated”). Knowing how common the blood type was might have given the jury a different perspective regarding the significance of the blood type match for the defendant. This is one example where scientific evidence needed the proper context with accurate circumstantial evidence. If just one juror had the background to question the context in which the scientific evidence was presented, a wrongful conviction may have been prevented.

CONCLUSION

Overall, the impact of the CSI Effect on forensic science, and how jurors view forensic science, has been a mix of positive and negative. Fact-based crime docudramas, such as Cold Case Files, The FBI Files, and The New Detectives, realistically portray the strengths and limitations of forensic science and how investigations are actually conducted, which helps educate viewers. Fictional crime dramas, such as Bones, Castle, Cold Case, Law and Order and CSI, have mixed results, but the negative impacts generally outweigh the positive impacts. The negative is that crime dramas can create unrealistic expectations for jurors that prejudice their ability to correctly evaluate evidence and witnesses, but the positive is that these shows may educate jurors to be better able to evaluate evidence.

When a jury is either less inclined, or more inclined, to convict a defendant because they are comparing court room evidence and proceedings to a crime drama, the integrity of the criminal justice system is undermined. Neither a conviction nor acquittal is inherently positive or negative. What is negative is when the CSI Effect influences a jury to render a poorly reasoned, incorrect verdict; what is positive is when it helps the jury render a well reasoned and correct verdict. Understanding and mitigating the CSI Effect in the court room protects the credibility of our criminal justice system and improves public safety.
REFERENCES


ABOUT THE AUTHOR

Rachael Strauss graduated in December 2008 with a Bachelor of Science in Forensic Chemistry and a minor in Mathematics from York College of Pennsylvania (YCP). While at YCP, she was an active student-leader in the Chemistry Department, having served as a Chemistry Laboratory Assistant and President of the YCP Chemistry Society. Rachael is currently pursuing a master’s degree in Forensic Studies-Criminalistics from Stevenson University and expects to graduate in January 2012. While pursuing her master’s degree, Rachael has been working in retail as a copy and print center technician and an instructor for Mad Science. Following graduation, Rachael plans to pursue a career as a forensic investigator either in law enforcement or in anti-terrorism.
The Evaluation of Upconversion Powders Using an Infrared Laser for Latent Fingerprint Visualization In Comparison to Conventionally Utilized Fingerprint Powders

Marisa Bender

INTRODUCTION

The ultimate goals for the fingerprint examiner are to successfully develop or enhance prints that are not normally visible (latent) and to identify or eliminate questioned exemplars based upon the original fingerprint. Because the latent fingerprint is invisible to the naked eye, it becomes necessary to find the means to differentiate it from the surface on which the fingerprint is found. Examiners must develop the fingerprint, thus turning it into a colored product that can stand out for detection. The utilization of optical, physical, physio-chemical, and chemical methods can help achieve this goal [1].

The use of fingerprint powders in casework and at crime scenes is one of the most effective and convenient methods of detection. There are many types of fingerprint powders that can be used based upon their ability to provide contrast for the substrate on which the fingerprint was found [2, 3]. The most commonly utilized powders include regular flake metal powder, magnetic powder, and fluorescent powder. The flake metal powder is considered to be the most sensitive on smooth nonporous surfaces. The stearic acid component in the powder helps it adhere to the ridges of the deposited fingerprint [1, 4]. Magnetic powders have coarse flakes that only adhere to the fingerprint residue and work best on rough surfaces [5]. When the substrate is reflective or multicolored, a fluorescent powder is helpful to examine the fingerprint using UV light sources [1, 2]. However, these methods become less effective with substrates possessing strongly fluorescent backgrounds, thus creating the need for a better detection method [8].

Since 1977, researchers have explored the fluorescent properties of the natural components found in fingerprint depositions and exploited that luminescence with laser light sources. A chemical pre-treatment to improve the development of the fingerprint under the laser is another viable technique that can be employed in place of the commonly used fingerprint powders [7, 8]. Currently, minimal research has been done with the use of lasers emitting in the infrared region in fingerprint identification.

Recent research has been conducted in the use of lanthanide metals for fingerprint powders. These metals exhibit strong luminescence and have shown potential in reducing background luminescence on difficult substrates [9, 10]. Species that fluoresce will exhibit Stokes shifts, or radiation that is longer in wavelength than the original excitation wavelength. Lanthanide ions exhibit large Stokes shifts but will also display an Anti-Stokes shift or upconversion. Basically, the species will absorb at a lower energy, or a longer wavelength, than what is emitted [11]. The small energy levels of lanthanides allow for multiphoton absorption. The University of Technology Sydney has conducted research into the production and use of lanthanides for new upconversion powders in the detection of fingerprints [12, 13]. This study was conducted to determine if these new upconversion powders offer better visualization of fingerprints over the currently available and utilized fingerprint powders on some inherently luminescent substrates.

MATERIALS AND METHODS

Materials

The superglue INSTAbond S-100 (lot #GG-074) used in the superglue chamber was obtained from ACCRAbond Inc. The black fingerprint powder (Carbon black, CAS#1333-86-4) and white fingerprint powder (Titanium dioxide CAS#13463-67-7, zinc stearate CAS#557-05-1) were obtained from Lightning Powder Co., Inc. and applied with a fiber glass “zephyr” style brush. The magnetic black powder used was also from Lightning Powder Co., Inc. and applied with a magnetic brush (Sirchie Fingerprint Laboratories, Inc.). White magnetic powder (iron powder CAS#7439-89-6, titanium dioxide CAS#13463-67-7) from Lightning Powder Co., Inc. was used for added contrast on specific substrates. The green fluorescent powder (Greenwop) was obtained from Lightning Powder Co., Inc. and applied with a “zephyr” style brush. The upconversion fingerprint powder under the trade name “VISAS Green” was supplied by BVDA International. A squirrel hair brush was utilized to apply this powder.

Latent Fingerprints

Fingerprints were collected from twelve donors, four males and eight females, with ages ranging from 21 to 25 years on eleven different substrates (depending on availability). All substrates were non-porous or semi-porous in nature. These substrates included a polypropylene (PP) sheet protector, a polyvinyl chloride (PVC) sheet protector, red bubble wrap, a fold top sandwich bag, a zippered sandwich bag, black trash bag, a small evidence bag, a black birthday gift bag with multicolored characters, a white and a black pebbled surface, and a red Coke can. The substrates were cut into manageable strips so that fingerprints could be deposited onto each substrate using the index, middle, ring, and pinky finger in the fashion of a depletion series containing eight prints for each substrate. The donors were asked to charge their fingers before successively depositing their fingerprint down the substrate, and then recharge the finger for the next substrate. The first few latent prints should be very heavy and will continue to get sequentially lighter than the previous ones. Both eccrine and sebaceous fingerprints were obtained. The age of the depletion series varied between 7 and 30 days before treatment with cyanoacrylate fuming (Foster & Freeman MVC 3000 superglue fuming chamber, serial #3142) and the various powders to determine if the age of the fingerprint plays a factor in the effectiveness of the upconversion powder.
FIGURE 1: These were the steps taken to powder the two halves of the substrate and perform a side-by-side comparison for a depletion series. The green [right] side represents the upconversion powder and the purple [left] side is the fingerprint powder being compared to the upconversion powder.

After the deposition of the fingerprints, the substrate was cut in half or through the center of the prints in order to obtain a side-by-side comparison between the two treatments used. This can be a disadvantage since there is less of the fingerprint to evaluate, but it aids the researcher by allowing her to assess the effectiveness of the two techniques under comparison. One half of the substrate was processed with the upconversion powder and the other half with magnetic, non-magnetic, or fluorescent powder. Then the two halves were recombined to enable a direct comparison as to the quality of the fingerprint developed.

Visualization

Enhanced depletion series were viewed and evaluated using a variety of light sources. The commonly utilized fingerprint powders (non-magnetic, magnetic, and fluorescent) were viewed using a combination of the SUPERLITE 400 multiband light source from Lumatec (serial #090116), the CRIMESCOPE CS-16-400 alternate light source, and the Coherent Tracer Laser set at 532 nm. Samples powdered with the BVDA “VISAS green” upconversion powder were visualized using the Crimelite ASL infrared laser obtained from Foster & Freeman. This is a high intensity, narrow bandwidth battery-powered 6 Watt laser emitting in the infrared region at 976 nm.

Comparison

All substrates were photographed using the Foster & Freeman Digital Capture System 4 with a Fuji Finepix S2 Pro digital SLR camera (#43A03022) with a Nikon F-mount lens. The non-upconversion processed substrates (fluorescent) required a Schott OG550 529 nm orange filter with blue/green light (460-510 nm). The substrates processed with non-magnetic powder and magnetic powders were captured with white or natural light. The upconversion processed substrates were captured with a Schott GG495 476 nm yellow filter and the infrared laser as well as additional white light. All substrates were placed on top of a black semi-glossy backing paper to minimize any additional background fluorescence. When a fingerprint was captured on one half of the substrate, the same fingerprint on the other half of the substrate was also photographed. The two were visually compared and aligned side-by-side using a photo editing program at a later time.

Scanning Electron Microscope (SEM)

The Scanning Electron Microscope (SEM) was utilized to examine the entire spectrum of fingerprint powders used in this research. The instrument was a Hitachi Science Systems, Ltd. Scanning Electron Microscope S-3500N (mfg #1226-07) with an EDAX detecting unit model 3500N with an active area of 10mm2 (serial #8273-46210). Each powder (non-magnetic, magnetic, fluorescent, and upconversion) was obtained for adhesion to aluminum mounting stubs (cat #75220) with carbon adhesive tabs (cat #77825-12) acquired from Electron Microscopy Sciences. The Hitachi PC SEM program was opened on the computer and the vacuum system was turned off before inserting a sample. Once the vacuum was completely evacuated, the stub holding the powder was placed onto the stub holder and screwed tightly in place. The chamber under the vacuum was sealed again and the high voltage was initiated. The sample was scanned in TV mode so that the image is produced instantaneously in order to begin to focus the image. Images were captured in High Resolution mode to be saved to the computer. The images produced were later used to determine particle size and shape. Particle size was measured with the Quartz PCI-Image Management system and calibrated according to magnification using the micron marker.

RESULTS

The development of the latent fingerprints deposited in the fashion of a depletion series using various types of powders provided some insight into the effectiveness of each of the powders and how the powders compared to the upconversion powder. The prints tested were aged to various lengths of time (1-4 weeks) before development with the desired fingerprint powder. In most cases, the upconversion powder was determined to be just as effective in developing fingerprints as the conventionally utilized fingerprint powders in terms of the number of overall prints developed in the depletion series on each substrate. However, in terms of the clarity and level of detail exhibited in the fingerprints, the upconversion powder was assessed as not being a better method for developing aged fingerprints for both luminescent and nonluminescent exhibiting background substrates.
Upconversion versus non-magnetic powder

All of the substrates were allowed to age for a varying amount of time before utilizing a non-magnetic powder (either black carbon or white powder) for its comparison to upconversion powder. Four trials with varying ages of fingerprints were conducted to compare the non-magnetic powder to the upconversion powder. The best quality print, based on an initial visual examination, was chosen on each substrate and captured with the DCS-4. In the two week old depletion series examined, fingerprints were captured on a black trash bag, an evidence bag, a zippered sandwich bag, a PP sheet protector, a fold top sandwich bag, and a black pebbled surface. The images of the non-magnetic powdered side and the upconversion powdered side were compared side-by-side. Of the substrates mentioned, none of the upconversion powdered fingerprints were of the same quality as the non-magnetic powdered side of the fingerprint captured. Figure 2 displays the side-by-side comparison of a two week old eccrine fingerprint developed on an evidence bag. The left side developed with the black powder exhibits better clarity as well as Level III detail. Level II detail was only seen on the upconversion developed half.

Figure 2: Print #1 of a two week old eccrine depletion series developed on an evidence bag. The left side is developed with black carbon powder and the right side is developed with the upconversion powder.

Fingerprints were captured on the white pebbled substrate for the three week old depletion series; however, only the black carbon powdered side of this substrate was photographed due to the poor quality of the upconversion powdered half. From the four week old depletion series tested, only the black birthday bag had fingerprints developed with enough quality to photograph. Similar results were seen with this age of fingerprints as was shown with the two week old depletion series: the non-magnetic powdered substrates afforded better ridge detail and clarity of the fingerprints developed than with the upconversion powdered substrates.

Upconversion versus magnetic powder

All of the substrates were allowed to age for varying periods of time before cyanoacrylate fuming and the utilization of magnetic powder (either black or white magnetic) for its comparison to upconversion powder. Four trials with varying ages of fingerprints were conducted to compare magnetic powder to the upconversion powder. The 1½ week old fingerprints were photographed and documented on a polypropylene sheet protector, an evidence bag, and a red Coke can. The background of the Coke can could not be suppressed enough to obtain a clear image of the upconversion powdered side, leaving only the magnetic half to be photographed.

Testing the two week old depletion series proved to be more successful in that over half of the substrates tested displayed excellent ridge detail on both the magnetic and upconversion powdered halves. Fingerprint images were captured on a zippered “Stor-it” bag, an evidence bag, a fold top sandwich bag, a PP sheet protector, a black pebbled surface, a black trash bag, and a PVC sheet protector. When the two halves were combined for side-by-side comparison, magnetic powder developed a clearer and more detailed fingerprint than the upconversion powder. Figure 3 shows that the fingerprint developed with the white magnetic powder on the trash bag afforded better clarity and detail in the ridges than the side developed with upconversion powder. The upconversion treated half appears overdeveloped with the powder unevenly distributed over the ridges of the print. For the other ages of fingerprints the upconversion powder overdeveloped the prints, rendering it difficult to capture the ridge details. Only the side treated with magnetic powder was captured.

Figure 3: Print #2 of a two week old sebaceous depletion series developed on a black trash bag. The left side of the print was developed with white magnetic while the right side was developed with the upconversion powder.
Upconversion versus green fluorescent powder

The substrates used in this research were allowed to age for varying periods of time before cyanoacrylate fuming and powdering with Greenwop (green fluorescent powder) for its comparison to the upconversion powder. Four trials of the varying ages of prints were performed to compare the upconversion powder to the green fluorescent powder. In the 1 ½ week old depletion series, fingerprints were developed and seen with enough detail to photograph on the PP sheet protector, the red Coke can, the bubble wrap, the black trash bag, and a multicolored birthday bag substrate. Figure 4 shows a print developed on a multicolored birthday bag where the left side was developed with Greenwop and the right side developed with the upconversion powder. The upconversion side appears overdeveloped with parts of the print obstructed by the excessive amount of powder and uneven distribution over the ridges.

FIGURE 4: Print #6 of a 1 ½ week old sebaceous depletion series developed on a multicolored birthday bag. The left side is developed with Greenwop powder and the right side is developed with the upconversion powder.

In testing the two week old depletion series, sufficient ridge detail was visualized on the substrates under the appropriate light source on the evidence bag, the red bubble wrap, the red Coke can, the multicolored birthday bag, and the black trash bag. Figure 5 shows a fingerprint developed on the red Coke can. The left side of the image was developed with Greenwop and the right side with upconversion powder. The Greenwop developed a much clearer, detailed print, but the busy background overpowered the print. The background is more suppressed on the upconversion half, but the print is barely visible.

The three week old depletion series developed fingerprints with sufficient ridge detail for photographing on the zippered “Stor-it” bag, PP sheet protector, PVC sheet protector, evidence bag, black trash bag, black pebbled surface, multicolored birthday bag, and fold top sandwich bag. The fingerprints in the 4 ½ week old depletion series were fairly degraded and had evaporated to a certain degree. Prints were developed on the Coke can and the birthday bag, but much of the ridge detail had deteriorated or was destroyed during the development process. Due to the heavy nature of both the Greenwop and the upconversion powder, there were many instances when one half of the fingerprint was developed, but the other half of the fingerprint was not developed.

Scanning Electron Microscope (SEM)

The commercial powders (non-magnetic, magnetic, and fluorescent) as well as the upconversion powder were analyzed using a Scanning Electron Microscope in order to determine the overall morphology for a better understanding of what makes the powders different from one another. Black carbon powder (non-magnetic) had thick rounded flakes with a particle size ranging from 20-33 µm. Figure 6 shows the particles of the black carbon powder as being flaky with no sharp edges. The white powder (non-magnetic) appeared as light, grainy particles with a particle size ranging from 0.55 – 0.85 µm, which is a very small size in comparison to the other fingerprint powders. The black magnetic powder had a similar appearance in particle shape to the black carbon powder, but the black magnetic flakes have sharper edges. This magnetic powder had a particle size ranging from 11-18 µm. The particles of the white magnetic powder are thick and clumpy, appearing “heavy” in nature. The size of the particles ranges from 100-160 µm. White magnetic powder contained the largest particles compared to the other five fingerprint powders, yet remains a very effective development tool. The green fluorescent powder (Greenwop) particles appeared as perfect spheres with geometrical indentations spaced around the outside similar to a soccer ball. These particles ranged in size from 1-2.5 µm. The upconversion powder had varying sizes of particles that clumped together. These particles ranged in size from 30 µm to 35 µm. Figure 7 shows the particles of the upconversion powder as being very clumpy and heavy.
FIGURE 6: Black carbon fingerprint powder at 1,000x magnification with a particle size of 20-33 µm.

FIGURE 7: The upconversion fingerprint powder at 5,000x magnification with a particle size of 30-35µm.

DISCUSSION

Overall, the upconversion (Anti-Stokes) powder was not determined to be superior to those fingerprint powders currently in use. In all three instances when the upconversion powder was tested against the other fingerprint powders, the upconversion powder developed almost as many prints in the depletion series as the other fingerprint powders. However, when illuminated with the infrared laser and photographed using the DCS-4 imaging system, the upconversion side did not provide the same level of quality as the side developed with one of the three fingerprint powders.

The Scanning Electron Microscope (SEM) pictures clearly illustrated the way the powders adhered to the fingerprints as well as their effectiveness as a method of developing latent prints. The black carbon fingerprint powder has somewhat large uniform flakes, ranging in size from 20-33 µm, and the white powder contains very fine flake-like particles, with a size of 0.55-0.85 µm. Black carbon powder was very effective for developing fingerprints on the clear plastic substrates. The white powder was very effective when used on the black substrates (e.g., the black trash bag and the black background portions of the birthday bag) as it provided excellent contrast on the dark background and adhered well to the fingerprint ridges. The black magnetic powder exhibited finer flake-like particles that were similar in their size and shape when compared to the black carbon powder. Yet, the particles exhibited irregularly-shaped flakes with rough, jagged outlines. The white magnetic powder had the biggest particles, 100-160 µm, which also appeared heavy in nature. This “heaviness” did not have any adverse effects as fingerprints were well developed with excellent contrast. The magnetic powders developed prints on a number of the substrates, including the strongly luminescent background of the red Coke can. The magnetic powder brought out the fingerprint image by sufficiently suppressing the background; the writing and areas of color were reduced so that the fingerprint image stood out. The Greenwop, or green fluorescent powder, resembled perfect spherical particles that were fairly large in size. This powder tended to lie heavily on and around the developed fingerprints. However, the green fluorescent powder adhered well to the fingerprint and developed a greater number of prints on more substrates than the other two conventional powders. The upconversion powder SEM image displays particles that are irregularly shaped with a good degree of clumping. The SEM image showed that the particles were fairly small in size, 1-2.5 µm, but this measurement was difficult to accurately obtain because of the clumps of particles seen in the SEM image. The powder could not distribute across the fingerprint ridges as effectively because it would clump together in certain areas and not dispense evenly over the area.

The laser used in this research was a Foster & Freeman Crimelite ASL light source that emitted in the infrared region at 976nm. This infrared laser contained a 6 Watt diode, i.e., a very intense and powerful laser. It would be inferred then that this laser would illuminate the powder very strongly and brightly. During the course of the research, it was determined that the laser was not as intense as anticipated. The laser illuminated the upconversion powdered fingerprints well, to a certain degree, but the fingerprints could have been brighter. Well-developed prints were viable in many instances, yet when photographing the fingerprints, the same image was not captured. The camera could not pick up the illumination from the laser and produce an image that depicted the same observed image. Upconversion images always displayed a more blurred or “fuzzy” fingerprint than the other conventional fingerprint powders. Overall, the reduction in detail or the observed “fuzziness” could be attributed to the laser, the upconversion powder, or a combination of both.
CONCLUSION

The conventional fingerprint powders (non-magnetic, magnetic, and green fluorescent) utilized in this research were very effective in developing prints on the non-porous substrates chosen for study. The upconversion powder sufficiently suppressed the background luminescence and the infrared laser demonstrated strong illumination. However, when the developed conventional powdered fingerprints were compared to the same print developed with upconversion powder, the same level of detail and clarity was not apparent. For this research, the conventional fingerprint powders proved to be the superior development methods for aged latent fingerprints. The upconversion powders have the potential to be a good method of development, especially on luminescent and multicolored substrates, but additional research and modifications would be necessary to improve upon this method. It can be concluded that the conventional powders were more effective in developing and highlighting the prints.

REFERENCES


ABOUT THE AUTHOR

Marisa Bender is a recent graduate of Stevenson University, where she received her Bachelor's of Science degree in Chemistry. Marisa's accomplishments include participating on the volleyball team for four years; serving as captain her senior year, initiating a chapter of the American Chemical Society and serving as Co-President, and her inductions into Kappa Mu Epsilon (math honor society), Sigma Alpha Pi (leadership society) and Gamma Sigma Epsilon (chemistry honor society). She is currently working on a Master's of Science degree in Forensic Science, with a focus in Chemistry at Stevenson University. Currently, Marisa is interning with the United States Secret Service in the Identification Branch of the Forensic Science Division working on various research projects with fingerprinting methods and instrumentation.
Invitation to Contribute Articles to the Stevenson University Forensics Review Journal

The Stevenson University Forensics Review Journal is seeking articles from scholars in the fields of forensic studies and science.

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