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The Analytical, Technical Processes behind the Evaluation of Forensic Evidence through Questioned Document Examination

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Abstract

A will is found next to a dead body. A suicide letter is left at a crime scene. A ransom note is near a kidnapped individual. Questioned document examiners are of utmost importance within the forensic science community to identify perpetrators and provide closure for cases. Handwriting, paper and ink analysis embody areas studied by forensic scientists to determine authorship, reliability and authenticity. Each person is unique and specific features are showcased within an individual's writing.

Since the emergence of letters, people have created, developed and immersed themselves into the community process of writing. Features have advanced from childhood learning styles to adult routines. Minute characteristics are located by questioned document scientists through various techniques, methods and instrumental analysis. Handwriting features, paper inspection and ink examination result in unique quality identification. The Electrostatic Detection Apparatus and Video Spectral Comparator are two of the most widely used machines by questioned document scientists for validity purposes. After conducting tests, examiners are called to court as expert witnesses to testify regarding evidence. Preparatory procedures are followed in addition to both verbal and visual demonstrations of samples. From the crime scene to transportation to the crime laboratory to the courtroom, evidence is distributed with care and standard operating procedures are enacted. Appropriate handling of samples is always required to ensure precision, accuracy and protection of evidence. The most proper collection, analysis and demonstration of samples is essential in assisting the trier of fact, judge and jury, with reaching an ultimate decision.

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Introduction

Lawbreakers who commit forgeries, falsifications and fraud act to advance themselves within society. Deceit, manipulation and deception are used to cause harm towards others and overcome rules enforced by the criminal justice system. As a result, questioned document examiners, known as forensic scientists, work safely, tirelessly and productively to identify perpetrators, accuse criminals and convict suspects. The law involves checks and balances to control the crime rate and causes people to think twice before acting irrationally. Every day, situations are encountered with life or death outcomes. Groundbreaking, negative consequences derive from crimes being committed. However, making the right choices may leave personal freedoms intact. Each person has the choice to go down the path of guilt or innocence, but it is up to that individual to make the honorable decision.

Chapter 1: Questioned Document Examination

1.1 Forensic Science

Known and unknown samples are obtained from crime scene units, brought to crime laboratories and analyzed by forensic scientists. There is a link between science and law, in both civil and criminal cases, which is used to identify and convict perpetrators of offenses (Agius et al., 2017; Beck, 2009; *Evidence Submission*, 2019; Muth, 1999). Examiners pose the basic who, what, where, when, why and how questions when piecing together information from evidence (Beck, 2009). Clear and concise conclusions arise, leading to justice being served against the guilty and closure made for the innocent.

1.2 Questioned Document Examination

Questioned document examination is a specialization for forensic scientists. Unidentified handwritten or printed materials are compared with authentic papers, known as exemplars, to determine authorship (Agius et al., 2017; Muth, 1999; Slyter, 1995). Analysis is conducted on additions, substitutions, adjustments and indentations found within handwriting, paper, ink, print and electronic media (Agius et al., 2017; Beck, 2009; *Guide for the Development*, 2010; Muth, 1999). Documents examined may consist of checks, wills, suicide notes, insurance policies, deeds, ransom notes or business papers (Beck, 2009; Muth, 1999). Forensic document examiners combine handwriting, paper and ink analysis to convict suspects.

1.3 Questioned Document Examination versus Graphology

Questioned document examination and graphology are two diverse forms of handwriting analysis, which result in conclusions about a person. Both concepts cannot identify an individual's dominant hand, age or gender, but can instead determine unique handwriting features (Muth, 1999; Nickell, 1996). Graphology detects personality traits, while questioned document examination determines authorship (Muth, 1999; Nickell, 1996). Graphology is a pseudoscience which does not delve into the scientific method, while questioned document examination is a logical science that targets the reliability of a sample (Nickell, 1996). Forensic science laboratories utilize questioned document examination to analyze handwriting, paper and ink materials rather than the graphology technique.

1.4 Class Characteristics versus Individual Characteristics

Questioned document scientists interpret evidence as either class or individual. Class characteristics are generalized -- seen throughout a population-- while individual characteristics are specific to one person, instrument or method (Agius et al., 2017; Muth, 1999). When a shift is made from class features to individual qualities, the probability for determining the creator of a document escalates. Class characteristics are not precise, but rather common throughout the world, which can lead to incorrect accusations being formed. Individual characteristics must be identified to convict the correct person (Agius et al., 2017). These unique attributions include handwriting routines, paper modifications and ink aging, solidifying the accuracies of an arrest (Agius et al., 2017; Muth, 1999). Examination of documents requires patience, diligence and

efficiency, to locate personalized characteristics, in order to verify the information obtained is in fact valid.

1.5 General Laboratory Analysis

Questioned document experts ponder a series of thoughts prior to unknown analysis for furthering examination processes and arriving at supported results. Scientists work to determine the author of a document, time frame the paper and ink were produced, if any alterations were made to the note and consistency between the unidentified handwriting to known samples (Beck, 2009; *Guide for the Development*, 2010). Complete analysis occurs in laboratories, away from the crime scene, except for ransom and bank robbery notes (Beck, 2009). Immigration and border control also require immediate investigation of paper authenticity and security, by placing laboratories directly at the site of question (*Guide for the Development*, 2010). If there is a possibility for innocent lives and property to be at risk, the crime scene unit must decide which documents to prioritize and which evidence to save for future analysis.

Chapter 2: History and Development

2.1 Pre-Alphabet Writing, Paper and Ink Origin

Handwriting, paper and ink originated to preserve time and in doing so, became historical developments. The first visual form of communication was a pre-alphabetic style used in Mesopotamia and Egypt (Agius et al., 2017; Nickell, 1996). Around 3500 B.C, the ancient Sumerians formed drawings on rocks known as the pictographic system (Nickell, 1996). This technique expanded into cuneiform, the imprinting and heating of symbols (Nickell, 1996).

A writing tool was made from a reed and a sheet of paper was used from a clay mold, for recordkeeping purposes (Nickell, 1996). Around 3000 B.C, the Egyptians used a method similar to the Sumerians, with reed plants and stones, called hieroglyphics (Nickell, 1996). Sumerian and Egyptian approaches converted "...phonetic writing (wherein symbols represented sounds)... into syllabic writing (in which syllables were combined to make new words)" (Nickell, 1996, p. 8). Permanent story and law records developed within ancient societies, prior to a written alphabet, and set precedents for the current writing system.

2.2 Alphabet Writing, Paper and Ink Evolution

Letters evolved from symbolic systems and prospered into sophisticated communication forms, presently used worldwide. Around 1600 BCE, Mesopotamia and Egypt announced the creation of an alphabet (Agius et al., 2017; Nickell, 1996). The new advancement was spread by word of mouth, from the Phoeneicans to the Greeks (Nickell, 1996). Inhabitants of Rome used

this knowledge to construct the present twenty-six-letter alphabet, around 700 B.C (Agius et al., 2017; Nickell, 1996). An integration existed between a stylus and a wax tablet for the production of only square capitals, to the advancement of curved capital letters to the production of lowercase letters (Nickell, 1996). This can be seen in Figure 1, to the right, with the Roman alphabet being converted into Gothic writing and changing into present-day penmanship, created on paper with pen ink (Nickell, 1996, p. 9). The development of the intricate writing system has both figuratively and literally resulted in the recording of history.

Figure 1- Development of Alphabetic Handwriting

(Nickell, J. (1996). *Detecting forgery : Forensic investigation of documents*. The University Press of Kentucky. p. 9)

2.3 Modern Writing, Paper and Ink Development

Writing was further altered by each nation into individual, modern systems. Aspects from Roman styles were utilized as originally seen, manipulated into diverse writing

IMPORTANT DATES FOR DATING INKS

Event	*Date*
India/Carbon Inks	618-906 AD
Iron Gallotannate Inks	about 600 AD
Fountain Pen Inks:	
• Gallotannate	1880s
• Blue Black	1880s
• Modern Washable	1940s
Ballpoint Inks	1939 (in Europe)
• Oil Base	1945 (in the U.S.)
• Glycol Base	1951
• Erasable	1963
• Pressurized	1968
Copper Phthalocyanine Dye	1954
Fiber/ Porous Tip Pen Inks	1962 (in Japan) 1965 (in the U.S.)
Rolling Ball Marker Inks	1968
Gel-Pen Inks	Mid-1980s (in Japan) About 1990 (in the U.S.)

Figure 2- Evolution of Ink

(Brunelle, R. L., & Crawford, K. R. (2003). *Advances in the forensic analysis and dating of writing ink*. Charles C Thomas. p. 7)

combinations or completely forgotten, creating individualized dialects throughout the world (Agius et al., 2017; Nickell, 1996). Around 600 A.D., word spacing and punctuation methods were introduced (Nickell, 1996). Other developments including "...today's letters-J, U and W-were not used by the ancients at all..." (Nickell, 1996, p. 8).

The production of the first ballpoint pen took place in 1939 with mass-distributions in 1945 (Brunelle & Crawford, 2003). Ink in the United States changed from oil-base to fiber tip to

gel-pen, shown in Figure 2 above, displaying unique features within the handwriting style, paper impressions and ink appearance (Brunelle & Crawford, 2003, p. 7). The advancements of ink production, found in other areas around the world, can also be seen in Figure 2 (Brunelle & Crawford, 2003, p. 7).

In Japan, a rolling ball marker was produced, which lacked striations on paper (Brunelle & Crawford, 2003). These marks are necessary to locate individual features and without this important quality, a suspect may have the opportunity to walk away from an offense without being detected (Brunelle & Crawford, 2003). As a result, inspection of specific formations and placements of words is necessary in order to establish justification against a perpetrator and convict that suspect of a crime. There have been progressions from a sole verbal style to worldwide handwriting systems, which continues to evolve over time (Leaver, 2006). Handwriting, paper and ink developments are accredited back to years of meticulous work and have become known as today's present-day writing system.

Chapter 3: Evidence Preservation

3.1 General Procedures

From the crime scene to transportation to the crime laboratory, each unit enforces safe collection, movement and analysis of evidence. Trained individuals are educated on methods for proper preservation of documents (Dunlap, 2003; Muth, 1999). Papers must always be put in "...archivally safe covers away from strong light and moisture" (Muth, 1999, p. 254). All evidence should be stored in "...the same condition as when discovered, unless the condition itself is not static and will subject the document to further harm" (*Evidence Submission*, 2019, p. 1). Introductions of outside factors to documents must be avoided. It is necessary "...to refrain from placing any objects on top of the questioned documents that could diminish possible evidence" (Dunlap, 2003, p. 2). There should be no "...staples, paper-clip marks, tears, cuts, folds, and extraneous notations..." (Dunlap, 2003; *Evidence Submission*, 2019, p. 1; Muth, 1999).

However, any unavoidable modifications must result in recordkeeping on a separate form (Muth, 1999). This would include the name of the person who produced the error, date of occurence, time of contact, location of change and anything else of value (*Evidence Submission*, 2019). Proper gathering, transferring, examination and storage of documents is required to present authentic information in court.

3.2 Chain of Custody

Routines are put in place throughout criminal investigations to contain best possible manners for the securing and tracking of evidence. In each department there are directors who "...require that standard operating procedures for examinations and maintenance of the chain of custody be written down" (*Guide for the Development*, 2010, p. 24). The chain of custody is a log which records the location of all pieces of evidence at specific intervals. The name of the person, date, time and location are written down on this paper (*Evidence Submission*, 2019).

Organization and logic is to be adopted by every person in the field in order to avoid self-inflicting and incorrectly processed evidence. For instance, "Mechanisms should be in place to ensure that these practices and procedures are being followed. Also, strategies should be in place for addressing and correcting any detected issues..." (*Guide for the Development*, 2010, p. 24). Accordingly, forensic units are constantly enforcing and maintaining advanced guidelines. Chain of custody standards showcase the receival, transfer and use of materials, to assist with document knowledge for verification of credibility.

3.3 Crime Scene

Crime scenes prioritize preservation of human life, property and evidence to protect victims and sentence unlawful citizens. Photographs are taken by specialized forensic technicians and, in certain instances, by a questioned document examiner, preceding evidence collection (*Evidence Submission*, 2019). In prior cases, a "...35mm or larger format, black and white film..." was utilized, but currently there are high resolution digital cameras in the field (*Evidence Submission*, 2019, p. 3). Document size is determined and visualized through a scale, typically seen as a ruler or standardized item (*Evidence Submission*, 2019).

Crime scene units focus on document security. After the completion of photograph documentation, trained professionals properly handle and encase papers to avoid loss, adjustments or additions (Dunlap, 2003; *Evidence Submission*, 2019; Muth, 1999). Therefore, documents are placed in manila envelopes, transparent plastic sleeves or protective wraps (Dunlap, 2003; *Evidence Submission*, 2019). Prior to evidential insertion, investigator's initials, case number, date and other identifying crime scene information are written on envelopes to avoid disturbances to documents (*Evidence Submission*, 2019). If there is any uncertainty with evidence collection, the crime scene unit must immediately contact a questioned document expert for clarification on how to move forward with the process (*Evidence Submission*, 2019). Systems are used in all crime scenes to conserve evidence.

3.4 Transportation

When materials are transported from crime scenes to crime laboratories, conservation must be enforced. Individuals are trained in safeguarding evidence. From this knowledge, items are placed in protective wrap and document boxes to escalate preservation of information found within (Dunlap, 2003). If there is any evidential interference introduced, incorrect results will be recorded and this may change the outlook of an offense (*Evidence Submission*, 2019). For instance, the constant starting and stopping of a vehicle during transportation may result in a document being altered. In order to avoid this phenomenon from occurring, specialists are trained on adhering to proper care and handling of evidence standards (Dunlap, 2003; *Evidence Submission*, 2019). This includes placing documents into uncontaminated packages and deducting the introductions of outside factors (Dunlap, 2003). Due to the enforcement of

principles on the preservation of materials, the movement of evidence from a crime scene to a crime laboratory is stable, accurate and efficient.

3.5 Crime Laboratory

Documents arrive at crime laboratories, where they are additionally processed to detect authorship of samples and provide closure for cases. Protocols followed by all crime laboratories to avoid contamination and ensure acceptable analysis of evidence include quality assurance, quality control and proficiency testing (*Guide for the Development*, 2010; Sun et al., 2016). As a result, professionalism is maintained by setting mandates specific to policies and procedures (*Guide for the Development*, 2010).

Crime laboratories utilize reference collections and databases for comparing unknowns to authentic, known samples (*Guide for the Development*, 2010; Muth, 1999). The process involves the analysis of repetitive letters, numbers, words and phrases from a questioned document, against identified paperwork (*Guide for the Development*, 2010; Muth, 1999). A crime laboratory must have "...flexibility to change along with the needs of its occupants, technology or scientific methodologies", which confirms the importance of applying rules (*Guide for the Development*, 2010, p. 22). Forensic laboratories undergo preparation, knowledge and adaptation requirements to sustain structure within the workplace and provide key information in court.

Chapter 4: Crime Laboratory Sections

4.1 General Order of Analysis

The order in which evidence is examined, is vital for proper analytical procedures. Pictures must be taken before any materials are investigated, for documentation purposes (*Evidence Submission*, 2019; Muth, 1999). If additional changes are made, they must be recorded and further processed through a compilation of photographs (Muth, 1999).

Questioned document examination is prioritized in relation to damaging evidentiary inspections including fingerprints, biological materials, drug evidence and shoe impressions (Dunlap, 2003 *Evidence Submission*, 2019; *Guide for the Development*, 2010). This is due to the fact that papers are extremely delicate and the introduction of small markings with excessive handling may result in evidential analysis complications (*Evidence Submission*, 2019). Unnecessary contact with documents can result in hindrance of writing, paper or ink investigation, resulting in a case remaining unsolved or incorrectly closed.

Once the examiner is satisfied with the assessment, there is a distribution of this evidence throughout the crime laboratory. A specialized system was created in Australia called the National Forensic Rapid Laboratory, which results in all sections of the crime laboratory investigating evidence at a recurring time (Agius et al., 2017). This process is used to solve current cases, cold cases and related cases. Courtroom knowledge is enhanced through expert witness accounts on the examination and comparison of evidence throughout the crime

laboratory (Agius et al., 2017). The succession of evidence collection, processing and filing are critical for maintaining proper preservation techniques.

4.2 Questioned Documents, Fingerprints and Biological Examination

4.2a Order of Analysis

Questioned documents may contain fingerprint markings and biological specimens, within the papers themselves. Patent prints may be present on suicide notes, checks, wills or any other form of paper (Muth, 1999). A substance, such as blood, will be visible within these prints.

In an instance involving patent prints, questioned documents would be analyzed first, followed by fingerprint examination and lastly evaluated through serological testing (Dunlap, 2003; *Evidence Submission*, 2019; *Guide for the Development*, 2010). This order of analysis supports proper forensic science laboratory mandates and recommendations from the United Nations Office on Drugs and Crime (UNODC) manual (*Guide for the Development*, 2010). Handwriting, paper, ink, fingerprints, blood and DNA are unique to individuals, resulting in a link between lawbreakers and victims. The correct investigative sequence is essential for cases, so all sections of the crime laboratory must be educated prior to analysis.

4.2b Case Analysis

Questioned documents, fingerprints and biological examinations are implemented prior to trials. In the murder of Karen Pannell, a DNA test was conducted to identify the suspect's skin cells beneath the victim's fingernails ("Medical Detectives", 2003). This particular piece of

evidence was not specifically related to paper analysis. However, other instances may involve a link between fingerprints, DNA and questioned documents. As a result, instruments including ESDA, VSC5000 and UV would be utilized (Parsons et al., 2015).

The study involving the transference of perspiration from fingertips to a handwritten paper, analyzed a series of individualized characteristics (Parsons et al., 2015). Both destructive and non-destructive techniques were applied, so the order of analysis was important to avoid loss of information (Parsons et al., 2015). Questioned documents must be investigated first, followed by fingerprints and then DNA (Dunlap, 2003; *Evidence Submission*, 2019; *Guide for the Development*, 2010). Seen in Figure 29 below, this study showed the failure of ESDA in

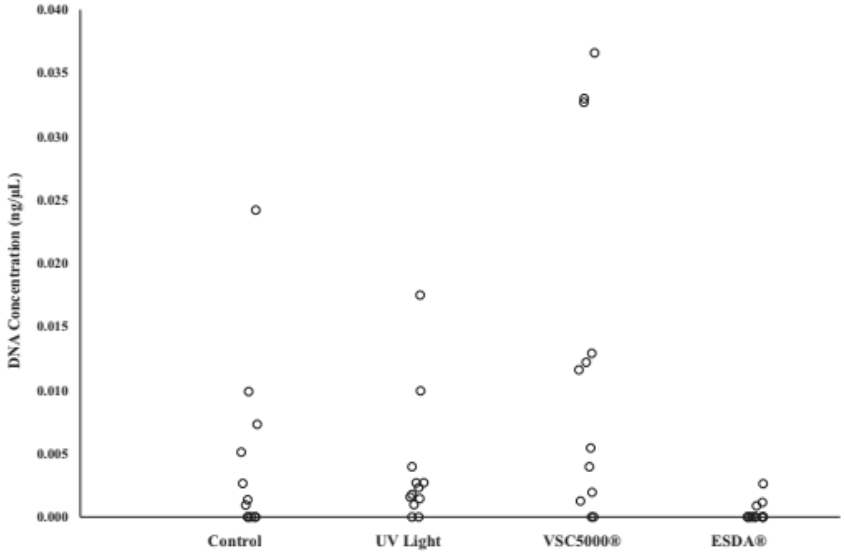


Figure 29- DNA Results

(Parsons, L., M.Sc., Sharfe, G., & Vintiner, S., B.Sc. (Hons). (2015). DNA analysis and document examination: The impact of each technique on respective analyses. *Journal of Forensic Sciences*, *61*(1), 26-34. http://doi.org/10.1111/1556-4029.12848. p. 33)

comparison to possible productions of DNA by VSC5000 and UV light analyses (Parsons et al., 2015, p. 33).

In terms of fingerprints, there may be additional tests performed (Parsons et al., 2015). Since the ink and paper were controlled, various handwriting styles of the questioned documents were primarily interpreted (Parsons et al., 2015). Crime laboratory educational procedures for the investigation of fingerprints and biological materials within documents, are necessary for validity purposes.

4.3 Questioned Document and Fingerprint Examination

4.3a Order of Analysis

Questioned documents may be analyzed for additional criteria, to include fingerprints. The two common prints are patent, seen from a physical dye, and latent, further processed for detection (*Evidence Submission*, 2019). Methods of examination vary depending on where the prints were found. When considering questioned documents, the order of analysis involves questioned document examination prior to fingerprints (Dunlap, 2003; *Evidence Submission*, 2019). The processes behind fingerprint detection are destructive in nature, and could eliminate incriminating information found within papers, so there is a necessity to follow standard operating procedures (Dunlap, 2003; *Evidence Submission*, 2019). Forensic scientists have knowledge within their own areas of expertise, but also incorporate routines within the entire crime laboratory, to ensure the safeguarding of evidence from unnecessary damage.

4.3b Case Analysis

Cases involving fingerprint techniques must consider the impact of technology and chemical use on documents. The compound ninhydrin is often utilized to assist with the emergence of latent fingerprints (*Evidence Submission*, 2019). However, the use of this chemical will damage indentations found on documents, destroying essential information (*Evidence Submission*, 2019).

In the case involving the murder of Karen Pannell, fingerpints were examined from a pizza box found at the victim's residence **(**"Medical Detectives", 2003). After using ninhydrin, forensic scientists found Timothy Permenter's fingerprints ("Medical Detectives", 2003). This placed Permenter at the crime scene, around the time of Pannell's murder, resulting in his alibi being questioned and ultimately murder charges beind brought against him ("Medical Detectives", 2003). Since the pizza box did not incorporate any written manners or ink features, this represented a sole instance where prints may be primarily analyzed **(**"Medical Detectives", 2003). The correct order of inspection must be determined for providing accuracy, efficiency and safety.

4.4 Questioned Document and Serological Examination

4.4a Order of Analysis

Blood is an additional examination section within questioned documents. A red substance on a paper may not always indicate the presence of blood. Assumptions should never be made, but rather specific tests must be performed. Similar to fingerprints, questioned document

examination takes precedence over serological analysis for the most efficient preservation of evidence (*Evidence Submission*, 2019).

It has been determined that “Blood is potentially more damaging as it will wet the paper causing the gluing action to begin, and it additionally contains starch, a very good glue in of itself. Further, blood can partially or totally obliterate writing found on the document” (*Evidence Submission*, 2019, p. 3). Proper methods for the collection and storage of papers is critical, to avoid contamination of materials. For instance, if the:

> “...document has been soaked by body fluids, it should not remain in an airtight environment for any extended period of time. Doing so will further damage the document, hinder any subsequent serological examination, and certainly provide an unpleasant atmosphere for the forensic scientist once the bag is opened” (*Evidence Submission*, 2019, p. 3).

It is necessary for all areas of the crime laboratory to communicate effectively with one another, in order to obtain the most beneficial results.

4.4b Case Analysis

Blood analysts incorporate their own techniques for determining the identity of a perpetrator. In the case of the muder of Sharri Dally, there were brownish stains in the rental car’s back seat ("Medical Detectives", 2004). These stains resembled potential blood, but further tests were conducted for confirmation and identification purposes ("Medical Detectives", 2004). The chemical reagent phenolphthalein will turn a pinkish color when reacting with hemoglobin in blood ("Medical Detectives", 2004). In this scenario, the phenolphthalein test indicated the

substance was serological ("Medical Detectives", 2004). Luminol testing was conducted and further supported the presence of blood, found throughout the vehicle ("Medical Detectives", 2004). Paternal testing revealed the connection between these samples and Sharri Dally ("Medical Detectives", 2004). Since the blood had no direct link to questioned document analysis, the order of interpretation granted serological testing priority.

However, the murder of Karen Pannell demonstrated a connection between serology and questioned documents. The surface next to Karen's body spelt "R", "O", "C", but the time frame between the dried up blood spatter and freshly produced writing was inconsistent ("Medical Detectives", 2003). This delayed response indicated that someone other than Pannell had produced the writing, which was later determined to be Permenter ("Medical Detectives", 2003). In blood spatter investigation, the medical examiner detected physical ailments in the victim's body and noticed the incorrect hand usage to produce the writing ("Medical Detectives", 2003). Blood tests, indirectly related to questioned documents, were conducted to further advance information within cases and assist the trier of fact with decision making.

Chapter 5: Handwriting, Paper and Ink Analysis

5.1 Handwriting Inspection

5.1a Class Characteristics to Individual Characteristics Development

The brain develops from an early age and continues to evolve throughout a person's life. Children go to school and become educated on the alphabet. Words are taught, practiced and used through writing. This advanced motor process is adopted around five or six years old, after a child has developed simpler skills including moving, smiling and talking (Muth, 1999).

In the beginning, writing is grasped through a duplication technique that is a class characteristic. Individuals start with "...a system, such as Palmer, ZanerBloser, or the newer

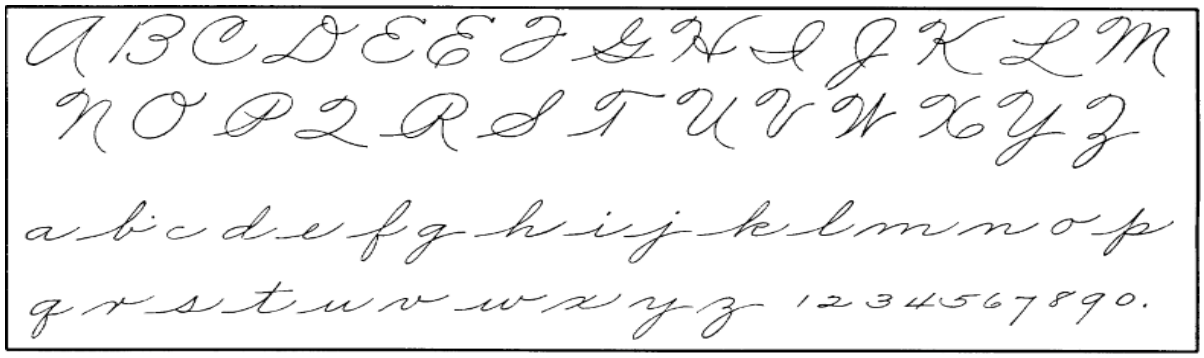


Figure 3- Palmer Copybook Style

(Nickell, J. (1996). *Detecting forgery : Forensic investigation of documents*. The University Press of Kentucky. p. 27)

D'Nealian style" as a print foundation and progress to cursive, seen in Figure 3 above (Leaver, 2006; Nickell, 1996, p. 27). Teachers focused solely on "...penmanship copy books or blackboard

illustrations of the different letters...” for students to shape words through a drawing technique (Nickell, 1996, p. 25).

Currently, a multitude of diverse techniques are practiced. Through repetition and age, direct example styles advance within an individual’s writing into unique habits of “...the subconscious mind... and the process... becomes more or less automatic” (Muth, 1999; Nickell, 1996, p. 25; Slyter, 1995). Handwriting qualities prosper during a person’s life, which are reflected through visual and physical appearances of class characteristics adjusting into individual characteristics.

5.1b Unique Features

Handwriting progresses for individuals over time. Constant practice and completing adolescence results in a person’s handwriting habit enhancing (Leaver, 2006). Formation of words are “...so ingrained and automatic that the writer is unaware of how uniquely individual the handwriting habit has become” (Leaver, 2006, p. 225). Analysts investigate personal preferences, natural skill set and repetition behind writing (Agius et al., 2017). They also consider “...the assumption that no two people write exactly the same and no one person writes the same word identically twice”, due to environmental and outside components (Agius et al., 2017, p. 395; Leaver, 2006; Muth, 1999). This explains the difficulty and lack of similarities behind attempting to manipulate another’s writing style (Lewis, 2005; Slyter, 1995).

In one case, Diana Haun was a main suspect for Sharri Dally’s murder ("Medical Detectives", 2004). On May 5th, 1996, the day before Dally went missing, Haun rented a car ("Medical Detectives", 2004). When questioned, Haun claimed the signature was forged and

denied involvement in the murder ("Medical Detectives", 2004). Jack Harris, the questioned document specialist, examined the rental car agreement, wig receipt and ax paper signatures to known samples from Haun ("Medical Detectives", 2004). It was determined Haun had tried to disguise her writing, but distinguishing features matched signatures she had produced ten years

Figure 4- Unique Handwriting Features

(*Medical detectives (forensic files) - season 8, ep 4: Sign here* [Video]. (2004). https://www.youtube.com/watch?v=EuNnxHZrhh8. 12:36-12:40, 12:42-12:47)

earlier, as seen in Figure 4 above ("Medical Detectives", 2004, 12:36-12:40, 12:42-12:47). This confirms the connection of motor functions with the brain to form habits specific to a sequence, time and force (Muth, 1999). Specialists are able to observe, detect and conclude the importance of distinctive writing details through case analysis.

5.1c General Questioned Document Analysis

Questioned document examiners view specific formations of writing to determine which individual created a sample. As seen in Figure 5 below, the letter movements, positioning of words, force on paper and writing style are primarily interpreted (Slyter, 1995, p. 11). These characteristics are further categorized as speed, proportion, pressure and design, becoming habits and individualized features of one person (Leaver, 2006; Slyter, 1995). Even writers' stances can change the structuring of their letters (Muth, 1999). Therefore, analysts must consider any type

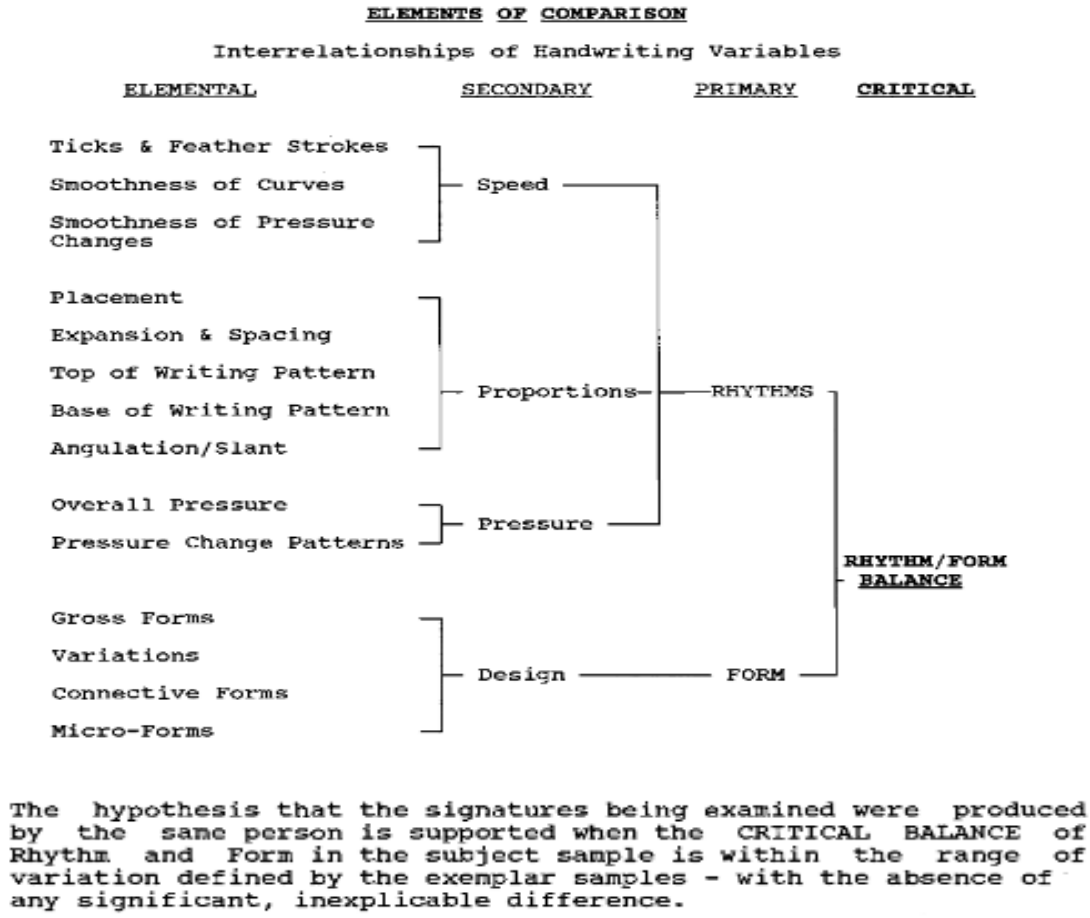


Figure 5- Questioned Document Examination Analysis

(Slyter, S. A. (1995). *Forensic signature examination*. Charles C Thomas. p. 11)

of scenario prior to forming conclusions. Comparisons of commonly used phrases, writing strokes, clean lines, pen lifts and spacing are valuable inquiries for these experts (Agius et al., 2017; Leaver, 2006; Muth, 1999).

If there is only a small section of a writing sample at a crime scene, the questioned document scientist must decide if there are enough determining factors to indicate authorship (Agius et al., 2017). There must be a significant combination of individualized characteristics to proceed with charging a person for a crime (Leaver, 2006). A strong base for studying

documents is necessary prior to additional in-depth inspection by forensic scientists.

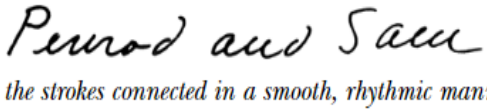
5.1d Specific Questioned Document Analysis

Distinctive qualities within writing are accumulated by analysts to provide attestation towards authenticity. Main areas considered are "...elements of style, elements of execution, consistency and lateral expansion and word proportions" (Agius et al., 2017, p. 396). In total, there are twelve categories questioned document scientists use to investigate forgeries associated with handwriting. They look at uniformity, irregularities, size and proportion, alignment, spacing and pen lifts, degree of slant, weight of strokes, t-bars and i-dots, the needle, the wedge, the round, the flat, loops, circle formations and initial and final strokes (Lewis, 2005). Other factors taken into consideration include writing surface, position of pen, stance of author, type of writing tool and temperatures associated with the samples (Leaver, 2006).

Experts must fully understand the evaluation of features through handwritten letters and signature comparisons (Slyter, 1995). These document formations follow central concepts, but individual qualities may be developed differently through each method (Slyter, 1995). Since class characteristics are widely used, individual characteristics are of utmost importance for assistance with inspection. General qualities are copied through a drawing technique, while specific traits are formed from a penmanship routine (Leaver, 2006; Muth, 1999; Nickell, 1996; Slyter, 1995). Scientists ask a series of questions in each section of analysis to detect unreplicable characteristics and confirm document authenticity.

5.1e Questioned Document Analysis Examples

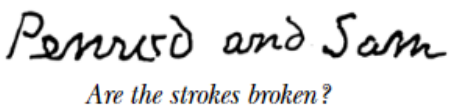
The same phrase was written differently and analyzed through twelve techniques. As seen in Figure 6 to the right below, the consistency in the writing demonstrates ease and comfort for an individual who actually produced the document (Lewis, 2005, p. 7). A person repeats the same letter formations for years, which is shown through clean lines. The second area of analysis is instinctiveness (Lewis, 2005). If the strokes are not consistent and look forced, viewed in Figure 7 to the left below, then that paper may have been forged (Lewis, 2005, p. 8). Another example of distinct writing includes the height of letters (Lewis, 2005; "Medical Detectives", 2004). As seen in Figure 8, to the right below, people create different dimensions as their own styles (Lewis, 2005, p. 9). Examiners also survey the placement of words in comparison with the baseline, shown in Figure 9 to the left below (Lewis, 2005, p. 10). Sometimes the words are placed next to one another, while other times they are inconsistent with each other. The space" found within letters, words and margins of



Are the strokes connected in a smooth, rhythmic manner?

Figure 6- Uniformity

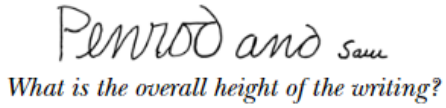
(Lewis, G. D. (2005). *Bates' I.S.Q.D. : Identification system for questioned documents* (Vols. 2nd ed.). Charles C Thomas. p. 7)



Are the strokes broken?

Figure 7- Irregularities

(Lewis, G. D. (2005). *Bates' I.S.Q.D. : Identification system for questioned documents* (Vols. 2nd ed.). Charles C Thomas. p. 8)



What is the overall height of the writing?

Figure 8- Size and Proportion

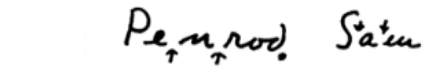
(Lewis, G. D. (2005). *Bates' I.S.Q.D. : Identification system for questioned documents* (Vols. 2nd ed.). Charles C Thomas. p. 9)

Do the letter strokes leave the baseline?

Figure 9- Alignment

(Lewis, G. D. (2005). *Bates' I.S.Q.D. : Identification system for questioned documents* (Vols. 2nd ed.). Charles C Thomas. p. 10)

unknown and reference samples are compared, demonstrated in Figure 10 to the right (Lewis, 2005, p. 12). In certain instances, the separation is wide. In other scenarios, the separation is narrow. This all depends on the person creating the document.



What is the proportion of space breaks between letters?

Figure 10- Spacing and Pen Lifts

(Lewis, G. D. (2005). *Bates' I.S.Q.D. : Identification system for questioned documents* (Vols. 2nd ed.). Charles C Thomas. p. 12)

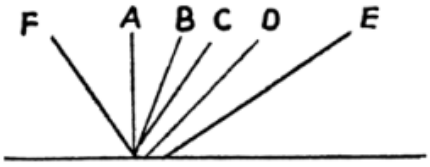


Figure 11- Slant Chart

(Lewis, G. D. (2005). *Bates' I.S.Q.D. : Identification system for questioned documents* (Vols. 2nd ed.). Charles C Thomas. p. 13)

Standards utilized by questioned document analysts include slant charts for detection of angle production, seen in Figure 11 to the left (Lewis, 2005, p. 13; "Medical Detectives", 2004). The seventh point of inspection indicates how each person presses down on paper differently, creating unique indentations viewed through personal examples (Lewis, 2005). Three of the most distinctive letters are “t, “i” and “j”, due to a multitude of cross

Does it have a terminal hook?

Is the staff uncrossed?

Is it tied?

Figure 12- Letter “T” Features

(Lewis, G. D. (2005). *Bates' I.S.Q.D. : Identification system for questioned documents* (Vols. 2nd ed.). Charles C Thomas. p. 16)

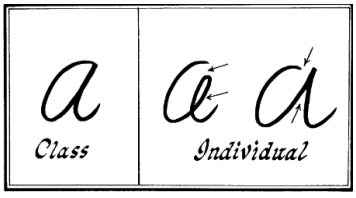


Figure 14- Letter “A” Features

(Nickell, J. (1996). *Detecting forgery : Forensic investigation of documents*. The University Press of Kentucky. p. 27)

Is it a small circle made counterclockwise?

Is it a jab?

Is the dot missing?

Figure 13- Letter “I” Features

(Lewis, G. D. (2005). *Bates' I.S.Q.D. : Identification system for questioned documents* (Vols. 2nd ed.). Charles C Thomas. p. 17)

and dot formations, found in Figures 12 and 13 above (Leaver, 2006; Lewis, 2005, pp. 16-17). Sometimes the features are lacking marks, while other times they are exaggerated. Figure 14, shown in the middle above, is an example of the letter "a" with class characteristics, one solid line, versus individual characteristics, many openings and overlaps (Nickell, 1996, p. 27). General features, in Figure 14, result when a person learns to write or attempts to replicate writing (Nickell, 1996, p. 27). Minute details, also shown in Figure 14, are from years of

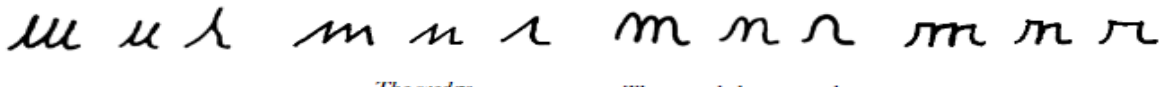


Figure 15- Needle, Wedge, Round and Flat

(Lewis, G. D. (2005). *Bates' I.S.Q.D. : Identification system for questioned documents* (Vols. 2nd ed.). Charles C Thomas. p. 18)

experience with creating the same letter patterns (Nickell, 1996, p. 27). Figure 15 above represents diverse formations and appearances of the same three letters, which depends on the individual who produced the writing (Lewis, 2005, p. 18). The tenth comparison, found in Figure 16 to the left, involves loops in letters to see if there is anything peculiar in a person's handwriting (Lewis, 2005, p. 21). The creation of letters with circle formations, including breaks in writing, is displayed in Figure 17 to the right (Lewis, 2005, p. 23). The final section of analysis involves unique

Figure 16- Loops

(Lewis, G. D. (2005). *Bates' I.S.Q.D. : Identification system for questioned documents* (Vols. 2nd ed.). Charles C Thomas. p. 21)

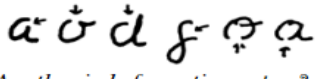
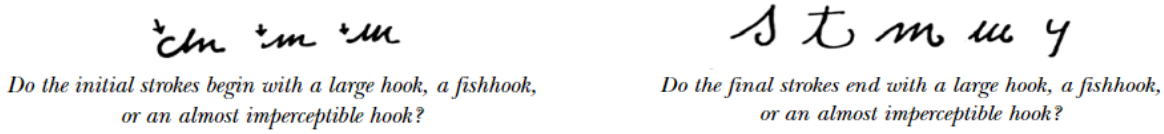


Figure 17- Circle Formations

(Lewis, G. D. (2005). *Bates' I.S.Q.D. : Identification system for questioned documents* (Vols. 2nd ed.). Charles C Thomas. p. 23)

characteristics shown at the beginning and ends of letters, found in Figure 18 below (Lewis,



Do the initial strokes begin with a large hook, a fishhook, or an almost imperceptible hook?

Do the final strokes end with a large hook, a fishhook, or an almost imperceptible hook?

Figure 18- Initial and Final Strokes

(Lewis, G. D. (2005). *Bates' I.S.Q.D. : Identification system for questioned documents* (Vols. 2nd ed.). Charles C Thomas. pp. 23, 25)

2005, pp. 23, 25). When questioned document experts interpret all of these sections, conclusions regarding authorship of documents are made and examination procedures are further supported.

5.2 Paper Examination

Writing on paper through print techniques and machine-based methods, result in distinct qualities. Included in this inspection are illegal documents, consisting of identity cards, passports and stolen blanks (Agius et al., 2017). The standard library, type of document and paper age are crucial for identification purposes, since diverse traits are integrated within materials (Muth, 1999). Whether a document is blank, lined, graph or legal, the handwriting outlook, display of ink and internal characteristics are unique (Muth, 1999). In reference to a typewriting machine, paper destruction may be observed and measured (Muth, 1999).

Forensic scientists focus on visuals including "UV features, watermarks and the machine-readable zone", which are compared to known and past case references found within the system (Agius et al., 2017, p. 395; *Guide for the Development*, 2010; Parsons et al., 2015). Watermarks are part of a manufacturer design, viewed when paper is held up to a light source (Beck, 2009). They are important pieces of information hidden within documents, shown in

Figure 19 to the right below, which assist with determining the location of paper origin and conclude authenticity through time frame detection (Beck, 2009, p. 26). In addition, the writing tool and production surface are essential to consider when analyzing questioned documents (Muth, 1999). Paper characteristics have distinguishing qualities that may be manipulated, but also assist with the examination of handwriting and ink credentials, to verify the creator of a document.

Figure 19- Watermarks

(Beck, E. (2009). *Cool written records: the proof is in the paper : the proof is in the paper*. Checkerboard Library. p. 26)

5.3 Ink Investigation

Forensic document scientists view evidence, such as ink, for suspect identification. The examiner decides if a pencil, ballpoint, felt tip, or fountain pen were utilized (Muth, 1999). The type of ink involved is a key variable to solving a case. As previously mentioned, Diana Haun was charged with the murder of Sharri Dally and this was partially accredited to ink deductions ("Medical Detectives", 2004). District Attorney Michael K. Frawley stated that Haun used a

Figure 20- Individualized Pen Ink

(*Medical detectives (forensic files) - season 8, ep 4: Sign here* [Video]. (2004). https://www.youtube.com/watch?v=EuNnxHZrhh8. 14:46-14:50, 18:31-18:33)

green pen for her checks, which he found peculiar since that color is rarely seen ("Medical Detectives", 2004). Mr. Frawley said “Not too many people carry a green-ink pen in their purse” and “When Diana Haun was arrested, she - she was found - in her purse - a green-ink pen” ("Medical Detectives", 2004, 13:40-13:51). This could have been a coincidence, even though it seemed unlikely, so confirmation of ink composition from known and unknown samples was necessary.

The pen and checks were collected, seen in Figure 20 above, and sent to the crime laboratory where Howard C. Rile, Jr. provided questioned document expertise ("Medical Detectives", 2004, 14:46-14:50, 18:31-18:33). This analyst was able to use a series of techniques and machines for comparison purposes and concluded that the ink matched, showing Diana Haun had signed the papers ("Medical Detectives", 2004). The color, manufacturer and type of ink are interpreted to ensure closure.

Chapter 6: Instruments, Chemicals and Tests

6.1 General Instruments

Tools are essential for assistance with evidence detection and making conclusions. Scientists use equipment to aid with inspection processes and support results. Destructive comparison and detection of ink in the crime laboratory may occur through silica gel line formation with thin layer chromatography (TLC), a National Institute of Standard Technology (NIST) search on peak strength and evaporative component detection from gas chromatography–mass spectrometry (GC/MS) or peak value criteria with dye identification by liquid chromatography–tandem mass spectrometry (LC-MS/MS) (Agius et al., 2017; Brunelle & Crawford, 2003; Parsons et al., 2015; Sun et al., 2016). Preservation methods to investigate ink shade and overall outlook involve the use of a stereomicroscope and an Axio Imager Z2 Vario Microscope with the Axiocam HRC CCD feature (*Guide for the Development*, 2010; Muth, 1999; Parsons et al., 2015; Sun et al., 2016). Instruments strengthen analytical methods by assisting examiners with identification of minute characteristics.

6.2 Specific Instruments

Questioned document examiners primarily focus on two instruments for analysis. The machines are nondestructive and known as the electrostatic detection apparatus (ESDA) and video spectral comparator (VSC) (Leaver, 2006; "Medical Detectives", 2004; Parsons et al., 2015). The ESDA uses electrostatic charges for indentation examination from handwriting, paper

and ink pressure (Leaver, 2006). The writing on multiple documents or attempts at replicating another's signature, leads to paper mark productions (Leaver, 2006). An example of this characteristic is displayed in Figure 21 to the right above (Leaver, 2006, p. 227).

Figure 21- ESDA Traced Signature Indentations

(Leaver, W. L., BS, D-ABFDE. (2006). Introduction to forensic document examination. In A. Mozayani & C. Noziglia (Eds.), *The forensic laboratory handbook procedures and practice* (pp. 223-248). Humana Press. http://eknygos.lsmuni.lt/springer/658/223-248.pdf. p. 227)

The VSC is used in the ultraviolet, invisible and infrared regions to locate ink formulations, security features and watermarks for differences, matches and alterations within paper samples (Leaver, 2006; "Medical Detectives", 2004; Parsons et al., 2015; Sun et al., 2016). In one particular study, eighteen ink samples were inspected and compared by VSC6000/HS through near infrared light of different wavelengths, found in Figure 22 below (Leaver, 2006; Sun et al., 2016, p. 1118). The colors were seen within a range from light to medium to

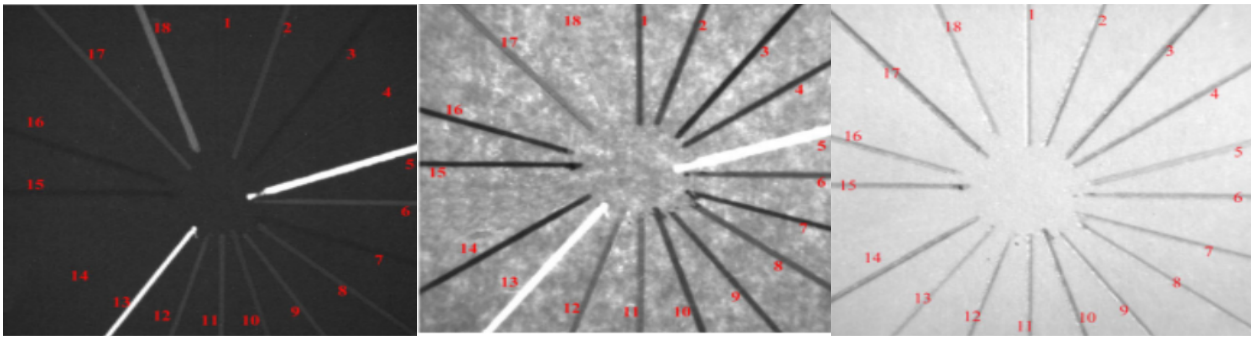


Figure 22- VSC Ink Differences

(Sun, Q., M.Sc., Luo, Y., M.Sc., Zhang, Q., Ph.D., Yang, X., B.Sc., & Xu, C., B.Sc. (2016). How much can a forensic laboratory do to discriminate questioned ink entries? *Journal of Forensic Sciences*, *61*(4), 1116-1121. http://doi.org/10.1111/1556-4029.13067. p. 1118)

medium-dark to fully dark, to demonstrate different drying times, and were then compared with one another for identification purposes (Leaver, 2006; Sun et al., 2016).

The murder of Sharri Dally was also solved by VSC analysis. Diana Haun, the main suspect, had a known pen which matched the ink used in purchases tied to the murder ("Medical Detectives", 2004). This information revealed Haun had in fact signed the documents and was then convicted of first-degree murder with a life sentence ("Medical Detectives", 2004). The Electrostatic Detection Apparatus and Video Spectral Comparator are invaluable in accommodating questioned document scientists with convictions and will continue to be crucial for years to come.

6.3 General Tests

Tests are conducted by forensic scientists to identify perpetrators. October 2003 involved the murder of Karen Pannell by her ex-boyfriend Timothy Permenter ("Medical Detectives", 2003). The chemical ninhydrin was utilized on a pizza box, which had come from the victim's apartment, to materialize fingerprints ("Medical Detectives", 2003). This substance reacts with amino acids found in fingertip sweat, to display a reddish-purple color on a porous cardboard surface ("Medical Detectives", 2003). In this particular instance, the prints were compared to known samples from the victim, suspects and other innocent individuals linked to the murder ("Medical Detectives", 2003). It was determined the fingerprints matched references from Timothy Permenter ("Medical Detectives", 2003). After a Y-STR test was conducted on male skin cells under Pannell's fingernails, it was determined Permenter's DNA was present ("Medical Detectives", 2003).

In the murder of Sharri Dally, blood tests involving phenolphthalein and luminol were administered ("Medical Detectives", 2004). Due to a color change and positive match identification, it was determined Sharri Dally's blood was consistent with the stains found at the crime scene ("Medical Detectives", 2004). These methods are damaging to evidence and will become secondary to questioned document analysis (*Evidence Submission*, 2019). However, the mentioned cases lacked writing and allowed for the primary enactment of these other evidential tests (*Evidence Submission*, 2019).

However, if there had been a possibility that unique handwriting, ink and paper characteristics were involved, then document tests would have been prioritized (*Evidence Submission*, 2019). This is based on the fact that papers are sensitive and fragile (*Evidence Submission*, 2019). Tests involving the use of chemicals will destroy individualized qualities within questioned documents and may result in a guilty person gaining freedom (Dunlap, 2003; *Evidence Submission*, 2019). Precautions must always be taken, when assessing evidence, to avoid contamination and possible destruction of analytical areas.

6.4 Specific Tests

Questioned document scientists perform specific, authorized experiments on known and unknown papers. Experts determine authenticity through the use of different lighting sources, photography and nondestructive chemicals, which have been validated as accurate identifiers (Muth, 1999). Scientists Witte, Hess, Mitchell, Hofmann and Brunelle created a foundation for determining the dating and identification of ink, through chemical techniques (Brunelle & Crawford, 2003). In the year 1988, Brunelle's research developed into an "...ink reference

collection...” which “...was transferred from ATF to the United States Secret Service Forensic Laboratory…” (Brunelle & Crawford, 2003, p. 4). This database “...is the largest in the world and now consists of over seven thousand different formulations of ink” (Brunelle & Crawford, 2003, p. 4).

These scientists also implemented the production of chromatography tests, but the destructive nature requires other methods to take priority (Beck, 2009; Brunelle & Crawford, 2003; Parsons et al., 2015; Sun et al., 2016). The R-ratio, percent extraction, dye ratio, accelerated aging and relative age comparison tests are current handwriting, paper and ink methods utilized by inspectors to determine the time frame of document production (Agius et al., 2017; Brunelle & Crawford, 2003). In one particular case, the R-ratio, percent extraction, and dye ratio procedures revealed the truth about document creation, as seen in Figure 23 to the left (Brunelle & Crawford, 2003, p. 184).

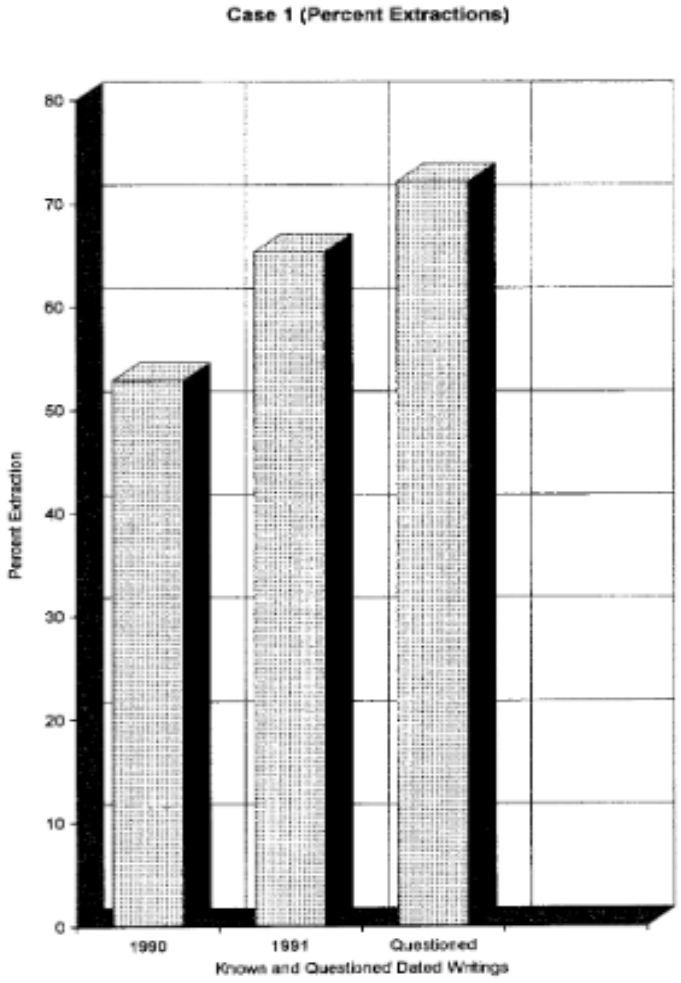


Figure 23- Percent Extraction Test

(Brunelle, R. L., & Crawford, K. R. (2003). *Advances in the forensic analysis and dating of writing ink*. Charles C Thomas. p. 184)

Forensic scientists observed much higher results on the questioned document for all three tests in comparison to known samples (Brunelle & Crawford, 2003). This revealed confirmation of deceit from the physician and further emphasized that the surgical drawing had indeed been created after the patient's operation (Brunelle & Crawford, 2003). The likelihood ratio approach is also important for the recognition, analysis and verification of handwriting, through statistical values (Agius et al., 2017). Tests, which specially detect authenticity of unknown handwriting, papers and ink, have progressed to precise and accurate extremities.

Chapter 7: Studies, Cases and Motives

7.1 Studies

Research studies were conducted by forensic scientists to detect differences and unique qualities associated with handwriting, paper and ink inspection. In one scenario, handwriting was investigated through height, width and spacing features of the letters “t” and “h” (Agius et al., 2017). Letters, words and spacing are all individualized, when creating samples, so tests similar to this one are imperative for distinction purposes.

A paper and ink study was performed for DNA testing (Parsons et al., 2015). Twenty people were to avoid washing their hands one hour prior to their involvement (Parsons et al., 2015). They used a specific pen, for a distinct message, creased the paper and put the note into

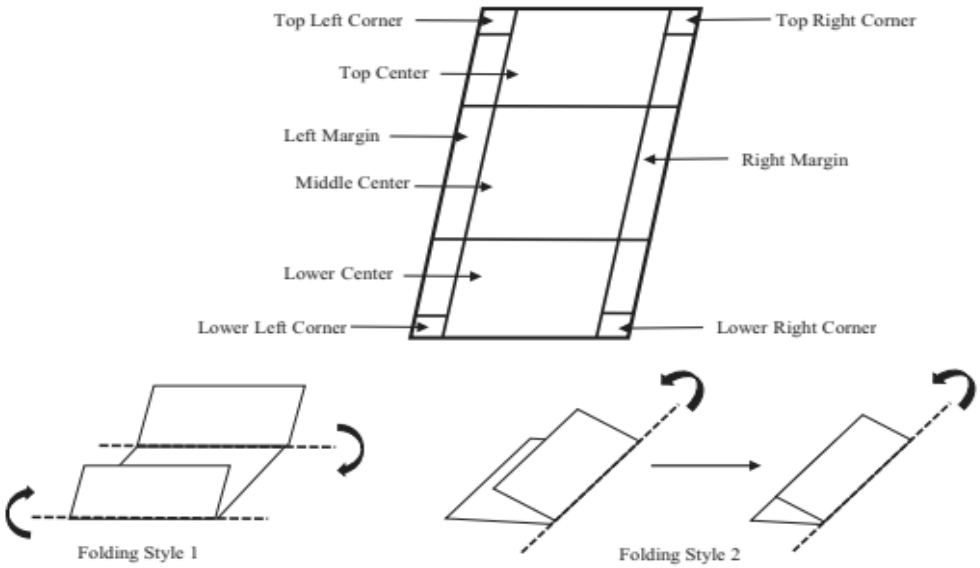


Figure 24- Folds and Points of Contact

(Parsons, L., M.Sc., Sharfe, G., & Vintiner, S., B.Sc. (Hons). (2015). DNA analysis and document examination: The impact of each technique on respective analyses. *Journal of Forensic Sciences*, *61*(1), 26-34. http://doi.org/10.1111/1556-4029.12848. p. 28)

an envelope (Parsons et al., 2015). The points where each person touched and folded the document were observed, recorded and studied, as seen in Figure 24 above (Parsons et al., 2015, p. 28).

Two men were asked to complete the same task with a few differences. The men did not wash their hands thirty minutes prior to the study, put their thumbs on their faces and placed those fingers on eight papers (Parsons et al., 2015). Controlled samples were also used for comparison purposes (Parsons et al., 2015). Same conditions were applied to all documents and evaluated by ESDA, VSC5000 and UV techniques to verify outcomes (Parsons et al., 2015).

Conclusions determined ESDA was unable to detect DNA, but VSC5000 and UV results were positive for DNA (Parsons et al., 2015). Ink was studied through eighteen different blue ballpoint pens, with protective and damaging techniques (Sun et al., 2016). The main areas of analysis focused on the visual perspective of the dyes, evaporative components within the samples and overall pigments (Sun et al., 2016). After the inks were analyzed with VSC5000, GC/MS, TLC and LC-MS/MS tests, results were compared and each pen was distinguished from one another (Sun et al., 2016). Since studies involve repetition and confirmation, results are recorded, validated and prioritzed.

7.2 Cases

7.2a Authenticity

Real-life cases were interpreted by questioned document experts, to determine the authenticity of samples. Handwriting, paper and ink were investigated through various conducted tests. In one specific case, a will was inspected to determine alteration possibilities through

handwriting and ink examination (Brunelle & Crawford, 2003). The will was signed and tested by percent extraction and accelerated aging methods, to demonstrate if any changes were made, seen through diverse ink productions (Brunelle & Crawford, 2003). Specifically acknowledging ink, a previously mentioned case focused on the truth materializing through R-ratio, percent extraction, and dye ratio tests (Brunelle & Crawford, 2003).

In a separate instance, during the year 1795, a fake presentation of a William Shakespeare play was solved through inconsistent watermarks found on the sample (Muth, 1999). Both paper and ink authenticity were analyzed in another case involving greed (Brunelle & Crawford, 2003). The relative age comparison tests and percent extraction were performed by forensic scientists to inspect the dryness of ink from multiple samples (Brunelle & Crawford, 2003). This information revealed the paperwork was produced in close proximity to one another, rather than the perceived to be ten-year time span (Brunelle & Crawford, 2003).

In the year 1992, all areas of questioned document examination were explored (Muth, 1999). Handwriting, paper and ink authenticity of a particular form of The Declaration of Independence was in question (Muth, 1999). It was determined by microscopic detection that the document was fraudulent (Muth, 1999). The words used, ink behind the signatures and paper time frame were inconsistent with what would have been displayed on an original sample (Muth, 1999). Questioned document inspectors must use their knowledge of diverse processes to proceed with evidential information, for the potential conviction of an offender.

7.2b Forensic Files

The televised program Forensic Files broadcasts cases solved primarily by forensic science is methods. One trial focused on the murder of thirty-nine year old Karen Pannell in 2003 inside her Tampa, Florida apartment ("Medical Detectives", 2003). The four main suspects were Karen's ex-husband Jeff Paine, ex-boyfriend Roc Herpich, most recent ex-boyfriend Timothy Permenter and a current British Airways pilot lover ("Medical Detectives", 2003). The letters "R", "O", "C" were found on the wall, but forensic experts determined Karen was not physically capable of producing them with her less-dominant hand ("Medical Detectives", 2003).

Figure 25- Time frame of Writing and Blood Spatter

(*Medical detectives (forensic files) - season 13, ep 36: Writing on the wall* [Video]. (2003). https://www.youtube.com/watch?v=uFEzYqMTzv4. 8:20-8:27)

Displayed in Figure 25 to the left, is the lack of consistency in time frame for the handwritten blood in comparison to the already dried blood spatter ("Medical Detectives", 2003, 8:02-8:27). Experts determined Roc Herpich had been framed and revealed the truth behind this case, condemning Timothy Permenter of first-degree murder ("Medical Detectives", 2003).

In 1996, thirty year-old Sharri Dally, from Ventura, California, went missing and her body was found twenty-five days later ("Medical Detectives", 2004). Both Mike Dally, Sharrie's husband, and his mistress, Diana Haun, were murder suspects. Evidence from pen ink was inspected through a video spectral comparator in the ultraviolet, invisible and infrared light ranges ("Medical Detectives", 2004). It was determined Diana Haun had made purchases to kill

Sharri Dally, and Mike Dally was her accomplice ("Medical Detectives", 2004). Information disclosed within Forensic Files is factual, investigative and informative for the public and scientific community.

7.3 Motives

Scientists, witnesses and lawyers provide essential information to assist with the identification of motives behind criminal actions. Studies are conducted to prove hypotheses and with enough substantial evidence, support theories. Knowns, unknowns and conditions are controlled by experts to answer specific questions and produce outcomes (Parsons et al., 2015). Questioned document analysts decipher cases to rationalize why a person would inflict harm on another human being. Greed, jealousy and revenge motivate individuals to commit misdemeanors and felonies (Brunelle & Crawford, 2003; "Medical Detectives", 2003; "Medical Detectives", 2004; Muth, 1999).

Some people have a mentality to excel before others, even if that means harming another in the process. They use their selfish desires to achieve power, while knowing they may cause destruction towards someone else's physical, mental and emotional needs. Through a combination of knowledge and skills, forensic scientists bring to light fraud, forgeries and fabrications committed by unlawful citizens.

Chapter 8: Pictures in Court

8.1 Court Demonstrations

Scientists present demonstrations in court to assist with favorable verdicts, based on factual statements. Verbal declarations are extremely important. However, a combination of spoken and visual displays are necessary to fully lure in the public. The jury must see the evidence in person, since "a picture is worth a thousand words", to provide a greater understanding and comprehension (Slyter, 1995, p. 5). These photographs truly support and promote statements. Experts have advanced from professional photography services to the integration of scanned images and digital photography (Lewis, 2005).

There are also enlargements of images, as displayed in Figure 26 to the right below, to represent original copies and blown up samples for analysis and explanatory purposes (Lewis, 2005, p. 82). When a signature or piece of handwriting is shown in two forms, the jury is able to perceive the original viewpoint of the letters and then individual features within a person's writing style. Jurors can place themselves at the scene and look at the papers through the eyes of the examiner. Additional materials are always beneficial, especially when pertaining to court cases.

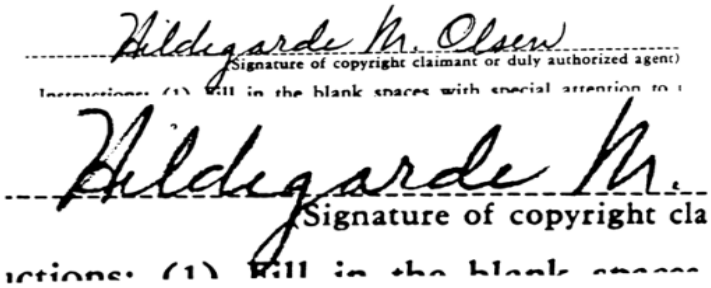


Figure 26- Picture Enlargements

(Lewis, G. D. (2005). *Bates' I.S.Q.D. : Identification system for questioned documents* (Vols. 2nd ed.). Charles C Thomas. p. 82)

8.2 Picture Examples

Questioned document examiners, in addition to other specialities, further their credibility through pictures brought to court. One example of a signature that may have the potential to be presented at trial, is found in Figure 27 below (Leaver, 2006, p. 229). The name William Smith was signed six different times and analyzed by a specialized expert (Leaver, 2006). When

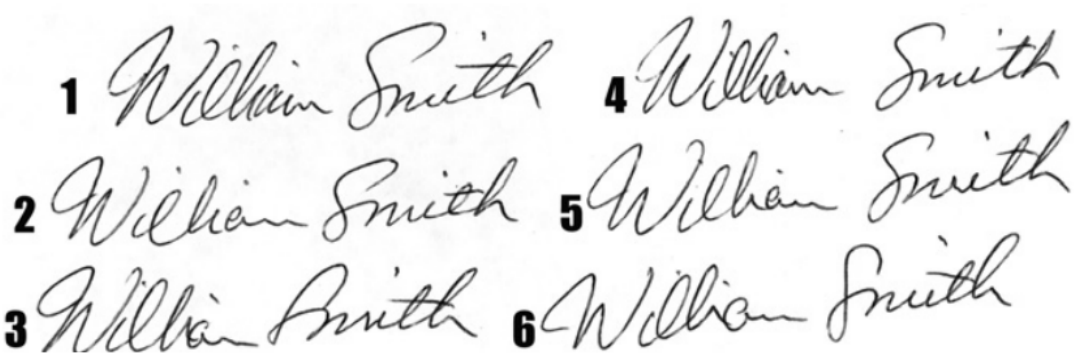


Figure 27- Signature Variations

(Leaver, W. L., BS, D-ABFDE. (2006). Introduction to forensic document examination. In A. Mozayani & C. Noziglia (Eds.), *The forensic laboratory handbook procedures and practice* (pp. 223-248). Humana Press. http://eknygos.lsmuni.lt/springer/658/223-248.pdf. p. 229)

samples similar to the one shown in this picture are displayed and explained in court, the jury is able to form clear and concise decisions regarding the suspect's integrity (Leaver, 2006). The questioned document analyzer who investigated Figure 27, compared a multitude of aspects within each signature to piece together similarities and differences (Leaver, 2006, p. 229). Although the six signatures seem to be slightly different from one another, it was determined they were produced by the same individual due to a blend of variations (Leaver, 2006). Formed are routine patterns rather than coincidences. Photographs shown to a jury can be the difference

between a unanimous verdict to convict a criminal or one person ruling in favor of the suspect and leading to freedom, so presentation is of utmost importance.

8.3 Picture Investigation

Samples must be taken and investigated by experts to determine authenticity. Knowns and unknowns are placed in side-by-side comparisons to detect similarities and differences. In Figure 28 below, there are a total of twelve signatures displayed (Slyter, 1995, p. 6). When looking at signatures cut from canceled checks, one can determine differences within an individual's own handwritten style in comparison to features from others (Slyter, 1995). Even though the twelve signatures seem to be produced by different people, they actually were created

Figure 28- Signature Comparisons

(Slyter, S. A. (1995). *Forensic signature examination*. Charles C Thomas. p. 6)

by the same person (Slyter, 1995). This showcases the importance of the questioned document expert in demonstrating and emphasizing educational information in court (Slyter, 1995).

Examples from an individual, family and friends are called study boards, which produce distinctive characteristics to tie a person to a crime (Slyter, 1995). Handwritten notes and signatures are specific to one individual, but areas within that person's style may vary from time to time. A questioned document scientist must provide expertise to further assist with jury knowledge.

Chapter 9: Court Examination

9.1 General Expert Witness

Courts require evidence to be presented by expert witnesses. An expert witness is a person who specializes in a specific area of knowledge, skill, experience, training, or education and provides the judge, jury, attorneys and public with critical details (Brunelle & Crawford, 2003; Slyter, 1995). These scientific and non-scientific individuals take an oath, testify and assist with comprehension of their specialized occupations (Brunelle & Crawford, 2003). An expert witness is used when "...(1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and method, and (3) the witness has applied the principles and methods reliably to the facts of the case" (Brunelle & Crawford, 2003, p. 210).

A cross-examination takes place to determine the acceptance of an individual by the court, to advance the education of others (Muth, 1999; Slyter, 1995). Once a person is admitted, evidence is presented to emphasize authenticity. There should be no questioning of standards by the specialist and confidence in evidential analysis must always be represented (Muth, 1999). It is necessary for the acceptance of an expert witness's information "...under Davis/Frye, a novel technique upon which an expert… opinion must have gained general scientific acceptance ...established by disinterested and impartial experts", to avert from bias (Brunelle & Crawford, 2003, p. 206).

Inadmissible information, collected or examined wrongfully, is prohibited from being presented to the judge or jury. The collection and analysis of evidence is demonstrated through a

presentation involving various styles of representation. Expert witnesses in court are necessary to tie a case together and provide additional evidence to solidify a verdict.

9.2 Questioned Document Expert Witness

Questioned document examiners present their investigations in the courtroom through expert testimony. Although not all forensic analysts are notified to appear in court, scientists must still gather unbiased information through trial preparation (Slyter, 1995). All evidence, techniques and procedures are demonstrated, even if improper analysis occurred. It is more beneficial to present evidence with mistakes, rather than covering up errors.

If an individual decides to leave out certain information, then that person's integrity may remain in question (Slyter, 1995). This will benefit attorneys, who are providing support for their clients, against a specialist's statements (Slyter, 1995). If an expert does not know the answer to a specific question, then that individual should truthfully state a lack of knowledge (Slyter, 1995).

Answers must be considered prior to courtroom statements, to convey information accurately (Slyter, 1995). This "...firsthand experience is worth a thousand pictures", through knowledge, understanding and presentation of evidence (Slyter, 1995, p. 5). Questioned document analysts provide expertise regarding the chain of custody, the receival and recording of evidence, in addition to methods, techniques and tests utilized. All information is presented through logged paperwork, pictures and statements. Questioned document testimonies are admissible in court, for assisting the jury with unknown areas of examination.

9.3 Expert Testimony Visuals

9.3a Benefits

There are a majority of benefits to displaying evidence through visual representations in the courtroom. Information is presented through expert opinion, which supports sample reliability (Brunelle & Crawford, 2003). To aid with the understanding of how experts come to conclusions regarding evidence, visuals including demonstrations and pictures are utilized (Slyter, 1995).

A widely used presentation method involves photographs displayed on exhibit boards (Slyter, 1995). Words satisfy the hearing aspect of the five senses, but pictures add even more power to a testimony by building up on the sense of sight. The use of photographs enhances the comparison process and furthers the knowledge of scientific laboratory concepts for the judge and jury (Slyter, 1995). If an exhibit is comprehensible and an explanation is logical, then concrete weight will be added to a case (Slyter, 1995, p. 85). Visuals are essential in providing closure and will be utilized throughout time.

9.3b Problems

Problems may arise from demonstrations of evidence. Extra time and effort should be avoided prior to and during the presentation of materials (Slyter, 1995). For instance, “Any malfunction or difficulties with equipment, electrical supplies, or the brightness of the room lights can severely handicap a presentation” (Slyter, 1995, p. 84).

If the explanation is lengthy and not easily comprehensible, then negative impacts may result from a scientist’s testimony (Slyter, 1995). Examiners unable to come to the courtroom,

due to reasons including transportation, timing and affordability, impact cases (Slyter, 1995). This lack of physical, in-person demonstrations, may be detrimental in providing a greater understanding for the trier of fact.

Any problems faced by an expert will become a focal point in the attorney's interrogation (Slyter, 1995). Specialists must contain their composure, re-collect their thoughts and proceed with confidence (Muth, 1999). Avoidance of conflicting scenarios within an expert testimony are necessary, but occasionally situations arise where scientists are unable to caution away from problematic outcomes.

Chapter 10: Student Experiments

10.1-10.2 Handwriting Authenticity

For additional assistance with the understanding of handwriting analysis, students may perform investigations in their homes. Below are experiments 1 and 2, adapted from:

Beck, E. (2009). *Cool written records: the proof is in the paper : the proof is in the paper*. Checkerboard Library.

which further expand forensic science knowledge through experience.

10.1 Experiment 1 (Beck, 2009, pp. 16-17)

10.1a Participant Materials

- One black, paper mate ballpoint pen
- Two small pieces of loose leaf paper

In this particular experiment, one specific pen and two pieces of paper were provided for each subject. In total, eight samples were obtained from the four participants.

10.1b Participant Procedure

- Use the pen and piece of paper provided to write the phrase ‘I killed the cat’ and print or sign the name ‘Jamie’, on the following line, any way you prefer.

- Write the same phrase from the proceeding step with the same pen on a separate piece of provided loose leaf paper, any way you prefer. You may replicate your last sample or write differently on this new paper.
- On the back of both pieces of paper, draw one symbol to verify the sample was created by you.

The four participants were each asked to write the unique phrase ‘I killed the cat’, followed by the name ‘Jamie’. This was done on two separate pieces of loose leaf paper, with the same pen, provided by the student examiner. The subjects were told to either keep their handwriting the same or distinguish the words on a second paper. The handwriting style was under the participant’s own discretion. The subjects were then asked to mark the backs of their papers, with a specific symbol, for authenticity purposes.

10.1c Questioned Document Examination

- Line up the eight pieces of paper in four columns with two in each row.
- Look at the style of writing of each of the papers through a regular, naked eye visualization technique. View characteristics including the use of capital letters, lowercase letters, print, script, grammar, slant of writing, spacing between words, margin indentations, placement of writing on paper, punctuation usage and unique features within the letters themselves.
- Compare all papers and separate into four groupings of two, based on individual features.

- Once the examination process is complete, verify your conclusions by matching the symbols on the backsides of the paper groupings.

The student analyst viewed all samples for distinction and matching purposes. Individual features were identified, compared and verified.

10.1d Questioned Document Presentation

- Display paperwork in a marble notebook, regarding the samples. Include evidential inspections on individual features detected.
- Present information in court through visual images, verbal explanations and physical samples from the participants.

The authorship was detected for each subject's handwriting, in all eight samples, through student analysis. Professional expert witness testimony would include descriptions of materials, procedures and examinations to assist the trier of fact, judge and jury, with reaching an ultimate decision.

10.2 Experiment 2 (Beck, 2009, pp. 27-28)

10.2a Participant Materials

- One paper mate 0.7 mm mechanical pencil
- One loose leaf sheet of paper

The supplies of a unique pencil and paper were used in this test.

10.2b Participant Procedure

Participant One:

- Write the words ‘name’, ‘address’ and ‘signature’ on lines of a provided sheet of loose leaf paper, in descending order.
- Fill in your information, in reference to the lines, on the paper.
- Hand the sample to another participant.

Participant Two:

- Replicate the first participant’s information, next to that individual’s writing, on the same piece of loose leaf paper.

Participants One and Two:

- Repeat the above procedure, five lines below the previous writing, with reversed roles of participants one and two.

This experiment involved two participants. The first person was told to use a controlled pencil and paper to write his or her age, address and signature. After, a second individual was asked to replicate this personal information next to the original. The procedure was then repeated with both participants swapping roles.

10.2c Questioned Document Examination

- Integrate the naked eye visualization technique to locate individualized characteristics including the writing slant, spacing between words and unique features within the letters themselves.

The original and replicated writing samples were examined by the student experimenter. The authenticity of the samples were in question and interpreted.

10.2d Questioned Document Presentation

- Use expert descriptions from a marble notebook to explain techniques involved with the investigation of specific writing features.
- Show the trier of fact the analyzed materials with understandable descriptions.

Information from participants one and two, in the first and second samples, were interpreted by the student investigator. All of the unique features were considered and identified to confirm the second writing production differed from the first. This investigative procedure was repeated on the next sample and the same conclusions arose. As a result, authenticity differences were determined to have been produced from the writing. A questioned document analyst would further emphasize the importance of the scientific examination process, while testifying.

10.3 Handwriting and Ink Authenticity

Experiments specific to handwriting and ink may be conducted by students. Below is experiment 3, adapted from:

Muth, A. S. (Ed.). (1999). *Forensic medicine sourcebook: Basic consumer information for the layperson about forensic medicine*. Omnigraphics.

which focuses on comparison analysis.

10.3 Experiment 3 (Muth, 1999, pp. 253-254)

10.3a Participant Materials

- One black, paper mate ballpoint pen
- One black, GP Zebra G 301 0.7 mm pen
- One black, BIC Round Stic M pen
- One dull Dixon Ticonderoga HB #2 black pencil
- One paper mate 0.7 mm mechanical pencil
- One yellow fluorescent highlighter marker #2359X
- One black permanent fine point sharpie marker
- Two loose leaf sheets of paper
- Twenty small pieces of loose leaf paper

Unique pens, pencils, one highlighter, one sharpie and sheets of paper were displayed to the participant for selection purposes.

10.3b Participant Procedure

- Choose one of the writing tools provided.
- Use the selected instrument to write any phrase you prefer, on one sheet of given loose leaf paper, until you are comfortable.
- Listen and replicate the phrase stated by the student analyst, at a normal pace, below the previous material.
- Sign and date the sample, underneath the sentence.
- Put the paper aside and converse with the examiner for five minutes.
- Pick a second writing tool from the remaining.

- Repeat the process by writing anything on a second sheet of provided loose leaf paper, until you are comfortable with the tool.
- Write down the same phrase the scientist says, but this time produce the output quicker with the new instrument.
- Put this paper to the side with the original sample.
- Use a combination of your dominant and less dominant hands to print or sign your signature, with the first writing tool you had chosen, on ten separate slips of provided loose leaf paper.
- Label the papers one to ten, respectively.
- Repeat the previous two steps, with the second writing tool, on ten additional slips of loose leaf paper.

A selection of writing tools were provided for the participant to choose from. Loose leaf paper was also utilized. The subject was asked to take one of the writing instruments and produce any phrase, to become comfortable with the tool. Next, the individual was asked to listen and write the words ‘I want a million dollars, otherwise everyone dies’, followed by his or her signature and the date. The paper was then placed to the side as the participant conversed with the examiner for five minutes. The procedure was repeated with a second instrument of the participant’s choosing, to represent another formation of the unknown sample. Ten slips of loose leaf paper were given to the subject, to serve as known samples. A signature was produced with the first chosen tool, in print and script, with dominant and less dominant hands. This experiment was repeated with the second instrument and ten additional pieces of loose leaf paper.

10.3c Questioned Document Examination

- Apply the naked eye visualization method to interpret unique handwriting and ink features including style, slant, spacing and speed.

The two documents produced were analyzed by the student scientist. There were no specifications regarding writing production, so the inspector investigated multiple incriminating factors within the words. Known samples were also examined, for repetitive qualities, and compared to the unknowns.

10.3d Questioned Document Presentation

- Present marble notebook information, concentrating on the importance of authorship and differences within appearance.
- Demonstrate interpretative evidence in the courtroom by in-person representations.

Results displayed differences in phrase production between the two samples. The student expert determined the second paper was created at a rushed pace, due to a lack of stability within the letters. Extra lettering features and wide word spacing, in the second sample, may have resulted from the time break and fast production of writing. However, the writing tool used did not have a detrimental impact on the appearance. Known samples, from the first and second writing tools, displayed consistencies. When compared with unknown documents, these signatures were used to confirm authorship. Although not seen in this particular study, the paper utilized may impact the writing and be detected through experimental analysis. In a court setting,

a scientist would have expanded this evidence for the jury through visual representations of this area of expertise.

10.4 Writing through Diverse Body Features

Handwriting styles from various body features create characteristics that may be investigated by students. Below is experiment 4, adapted from:

Muth, A. S. (Ed.). (1999). *Forensic medicine sourcebook: Basic consumer information for the layperson about forensic medicine*. Omnigraphics.

which interprets the impact of unique writing concepts.

10.4 Experiment 4 (Muth, 1999, pp. 258-259)

10.4a Participant Materials

- One dull Dixon Ticonderoga HB #2 black pencil
- One blank sheet of printer paper

An individualized pencil and piece of paper were provided to complete this experiment.

10.4b Participant Procedure

- For the following steps, sign the given printer paper in descending order.
- Hold the provided pencil in your dominant hand and sign your name normally, at the top.

- Keep the pencil in your dominant hand and clench your fist. Leave about an inch of space, after your last signature, then sign your name by relying on your wrist and arm.
- Bend your dominant arm fully, hold the pencil in the fold of your arm's elbow and sign your name on the paper, about an inch of space below.
- Put the pencil on the tip of your nose and sign your name, another inch below, by moving the pencil across the paper.
- Place the pencil in the space between your toes and sign your name, an inch below, using your foot muscles.

A study was conducted where the participant was asked to utilize diverse body parts for signature production. The individual was directed to sign normally, followed by a focus on all muscles. Signatures were created with a hand, through a clenched fist, inside an elbow, on the nose and in between toes. All signatures were produced on a blank sheet of printer paper, one after another.

10.4c Questioned Document Examination

- Incorporate the naked eye visualization test to view differences within the document.
- Since each of the styles utilize diverse muscles, locate changes in consistency, effort and dimensions.
- Also consider the muscle power, placement of the pen within that specific body part and stance of the writer, when viewing the documents.

All of the signatures created from this study were examined by the student experimenter. Unique qualities were seen through visual analysis. The impact multiple features have on writing were viewed and interpreted.

10.4d Questioned Document Presentation

- Demonstrate expertise through a marble notebook, focusing on the outcome of diverse, physical muscle movements on evidence.
- Exhibit information for the judge and jury through scientific, admissible knowledge.

The student examiner noticed that common structures such as the hands, fingers and wrists, produced contained writing. However, the involvement of an elbow, nose and toes resulted in a disorganized signature. As the student analyst progressed further down the paper, a shift was observed and recorded. The signature changed from neat, smooth motions to enlarged, undetectable writing. In a criminal setting, these nontraditional formations of words would become extremely important for individualization purposes.

10.5 Handwriting, Paper and Ink Indentations

Students may utilize experiments to advance their knowledge on handwriting, paper and ink indentations. Below is experiment 5, adapted from:

Beck, E. (2009). *Cool written records: the proof is in the paper : the proof is in the paper*. Checkerboard Library.

which prioritizes the impact of writing pressure on paper.

10.5 Experiment 5 (Beck, 2009, pp. 18-19)

10.5a Participant Materials

- One black, paper mate ballpoint pen
- One dull Dixon Ticonderoga HB #2 black pencil
- One paper mate 0.7 mm mechanical pencil
- One yellow fluorescent highlighter marker #2359X
- One black permanent fine point sharpie marker
- Two loose leaf sheets of paper

The materials required in this study included a specific pen, different types of pencils, one highlighter, one sharpie and individual sheets of paper.

10.5b Participant Procedure

- Position one provided loose leaf paper on top of another given sheet.
- Write on the visible paper any note you prefer, unknown to the examiner, using the provided pen. Press down hard on the paper to create possible indentations underneath.
- Repeat the previous step through a separate phrase, with a provided pencil, two lines down.
- Continue to replicate the second step, with another given pencil, and personalize your sentence two lines further down.

- Use a provided highlighter to write differently, with the same method as the second step, another two lines down.
- Utilize a given sharpie to duplicate the second step, with another phrase, an additional two lines down.
- Remove the top sheet of paper and place it out of view.
- Mark the underlying sheet with arrows, to represent locations of sentence production, and hand this paper to the examiner for analytical purposes.

The participant was asked to place one piece of loose leaf paper on top of another sheet. He or she was then told to use different writing tools, in a specific order, and create unique phrases. The paper was pressed down firmly, with the same force, for all of the samples. The second sheet, below the written paper, was marked with arrows to demonstrate the locations of writing output.

10.5c Questioned Document Examination

- Use the naked eye visualization technique to locate indentations on the second sheet of paper.
- Utilize a flashlight to shine on the paper, from a sideways angle, for assistance purposes.
- Rub the side of a pencil on the section where indentations should have formed, indicated by arrows.

- View the paper after all of the previous steps have been taken, through naked eye visualization, normal room lighting, without room lighting, with a flashlight and without a flashlight.

On the second sheet of paper, each of the phrases were examined by the student scientist at all of the arrow marked locations. To assist with the process of writing detection, a multitude of lighting sources and methods were utilized.

10.5d Questioned Document Presentation

- Gather a marble notebook with expert information pertaining to the samples. Include notes regarding indentations and processes behind letter identification.
- Use picture demonstrations and expert testimony to further explain the investigation of evidence.

The student scientist concluded the order of most difficult detection to easiest identification consisted of the highlighter, sharpie, Dixon Ticonderoga pencil, mechanical pencil and lastly, the pen. Out of all of the samples, the examiner was only able to detect handwriting from the pen. However, this particular pen writing was still difficult to completely identify. All of the techniques assisted with the emergence process, but detrimental impacts on evidence may arise from pencil rubbing of indentations (*Evidence Submission*, 2019, pp. 4-5). As a result, professional cases avoid this method of analysis (*Evidence Submission*, 2019, pp. 4-5). The amount of pressure applied to the paper, tool utilized and type of paper all impact the writing outlook. In the courtroom, this evidence would be presented and explained through a scientist's personal knowledge, skills and expertise.

10.6 Chromatography Ink Analysis

Ink may be interpreted through experiments focusing on chemical composition, which may be investigated by students. Below is experiment 6, adapted from:

Beck, E. (2009). *Cool written records: the proof is in the paper : the proof is in the paper*. Checkerboard Library.

which demonstrates the importance of ink analysis.

10.6 Experiment 6 (Beck, 2009, pp. 20-23)

10.6a Participant Materials

- One black, paper mate ballpoint pen
- One black, GP Zebra G 301 0.7 mm pen
- One black, BIC Round Stic M pen
- One dull Dixon Ticonderoga HB #2 black pencil
- Four pieces of coffee filter paper
- One blank sheet of printer paper
- One paper towel
- One ruler
- One scissor
- One glass
- Water source

Three diverse pens of the same color, one unique pencil, four pieces of filter paper, one sheet of printer paper, a paper towel, one ruler, one scissor, one glass and a water source were used in this study.

10.6b Participant Procedure

- Label the pens ‘one’, ‘two’ and ‘three’ with a piece of tape, any way you prefer.
- Use a scissor to cut the coffee filter paper into four rectangular pieces, all one inch wide.
- Pick one of the pens and place a dot, about half of a centimeter in width, one and a half centimeters from the bottom of one piece of coffee filter paper. Draw a line with a pencil and ruler, where the dot was created, to represent the solvent level. On the top, write the word ‘note’ and draw another line with a pencil and ruler, one and a half centimeters down, to represent the solvent front.
- Replicate the previous step with pen number one, on a different piece of coffee filter paper. On the top, write the word ‘one’ instead of the word ‘note’.
- Repeat step three with pen two and write the word ‘two’ on the top of the filter paper.
- Continue to duplicate step three with pen three and write the word ‘three’ on the top of the filter paper.
- Tape a pencil to the top of the ‘note’ paper, and place the paper in a glass. Position the pencil so it is lying flat on the upper rim of the glass, to ensure paper stability.

- Fill the provided glass with water, from the water source, until it reaches the bottom of the coffee filter paper and does not touch the dot.
- Leave the paper in the glass for five minutes.
- Once the five minutes are finished, remove the paper from the glass and lay it on a clean piece of paper towel to dry.
- Repeat the previous four steps for paper samples ‘one’, ‘two’ and ‘three’, to showcase the movement of water up the strips.

The participant was asked to produce an unknown, in addition to three known samples. One of the coffee filter papers utilized a pen, only known to the participant, and a tiny dot was created. The other three filter papers were labeled with pens one, two and three, respectively. The papers were separately taped to a pencil, placed in a glass of water for five minutes and then moved to a paper towel to dry.

10.6c Questioned Document Examination

- Utilize the naked eye visualization test to determine diverse ink qualities, within the coffee filter papers.
- Look at each of the samples separately for individual features within the movement of ink.
- Compare the known samples with the unknown, separately from one another, and identify the pen that produced the ‘note’ markings.

This study involved student analysis of ink samples to determine which pen was used to produce the unknown. Unique features were compared and analyzed for conclusive purposes.

10.6d Questioned Document Presentation

- Showcase analytical knowledge through marble notebook explanations of the ink separation technique.
- Display representations of evidence from all samples with methods of visual and verbal appeal, to further emphasize information for the jury.

In this specific experiment, the student interpreter was unable to identify which pen produced the unknown, ‘note’ sample. Since the pen ink did not result in capillary action, experimental error had occurred. Water traveled up the paper, but the ink movement was inadequate. In a successful procedure, a questioned document scientist would compare samples to locate individualized qualities for court value.

Conclusion

Handwriting, paper and ink analysis are the foundations of questioned document examination. Identities are determined from unique traits left at a crime scene, by individuals. Forensic scientists are essential in preserving, handling and inspecting samples through proper analytical techniques. Whether evidence is found at a crime scene, transported in a vehicle or brought to a crime laboratory, protection from outside contamination must be maintained. Scientific testimonies are admissible in courtrooms through demonstrations and representations of evidence, regarding tests, methods and instrumental use. Criminals believe they can hide their true identities, but forensic experts utilize a multitude of scientific approaches to ensure justice is served and closure is obtained.

Bibliography

Agius, A., Jones, K., Epple, R., Morelato, M., Moret, S., Chadwick, S., & Roux, C. (2017). The use of handwriting examinations beyond the traditional court purpose. *Science & Justice : Journal of the Forensic Science Society*, *57*(5), 394-400. http://doi.org/10.1016/j.scijus.2017.05.001

Beck, E. (2009). *Cool written records: the proof is in the paper : the proof is in the paper*. Checkerboard Library.

Brunelle, R. L., & Crawford, K. R. (2003). *Advances in the forensic analysis and dating of writing ink*. Charles C Thomas.

Dunlap, D., CFDE. (2003). *Debra Dunlap, CFDE forensic handwriting and document examiner*. Library Investigative Services. http://www.questioned-documents.com/care-and-handling-of-documents.php

Evidence submission. (2019). Norwitch Document Laboratory. http://www.questioneddocuments.com/evidence-handling/

Guide for the development of forensic document examination capacity. (2010). United Nations

Publications.

Leaver, W. L., BS, D-ABFDE. (2006). Introduction to forensic document examination. In A. Mozayani & C. Noziglia (Eds.), *The forensic laboratory handbook procedures and practice* (pp. 223-248). Humana Press. http://eknygos.lsmuni.lt/springer/658/223-248.pdf

Lewis, G. D. (2005). *Bates' I.S.Q.D. : Identification system for questioned documents* (Vols. 2nd ed.). Charles C Thomas.

Medical detectives (Forensic Files) - Season 8, ep 4: Sign here [Video]. (2004). https://www.youtube.com/watch?v=EuNnxHZrhh8

Medical detectives (Forensic Files) - Season 13, ep 36: Writing on the wall [Video]. (2003). https://www.youtube.com/watch?v=uFEzYqMTzv4

Muth, A. S. (Ed.). (1999). *Forensic medicine sourcebook: Basic consumer information for the layperson about forensic medicine*. Omnigraphics.

Nickell, J. (1996). *Detecting forgery : Forensic investigation of documents*. The University Press of Kentucky.

Parsons, L., M.Sc., Sharfe, G., & Vintiner, S., B.Sc. (Hons). (2015). DNA analysis and document examination: The impact of each technique on respective analyses. *Journal of Forensic*

Sciences, *61*(1), 26-34. http://doi.org/10.1111/1556-4029.12848

Slyter, S. A. (1995). *Forensic signature examination*. Charles C Thomas.

Sun, Q., M.Sc., Luo, Y., M.Sc., Zhang, Q., Ph.D., Yang, X., B.Sc., & Xu, C., B.Sc. (2016). How much can a forensic laboratory do to discriminate questioned ink entries? *Journal of Forensic Sciences*, *61*(4), 1116-1121. http://doi.org/10.1111/1556-4029.13067