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The University of Southern Mississippi

CHEMICAL PROCESSING OF FINGERPRINTS ON THERMAL PAPER

by

Megan Elizabeth Dutton

A Thesis
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Master of Science

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August 2011

ABSTRACT

CHEMICAL PROCESSING OF FINGERPRINTS ON THERMAL PAPER

by Megan Elizabeth Dutton

August 2011

This research seeks to determine how well muriatic acid and acetic acid fuming develop the thermal side of thermal paper using aged prints. Additionally, the research seeks to determine how well ninhydrin develops the paper side of thermal paper using aged prints after exposure to the fuming. Twenty-four random individuals placed a total of thirty sets of fingerprints per person on thermal paper over a 10-day period. Each set of fingerprints consisted of three fingerprints on the thermal side of paper and three fingerprints on the nonthermal side of paper. During the 30 to 40-day time period, however, more specifically around the 35-day time period, the fingerprint quality diminishes to a point of not being able to process fingerprints adequately.

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CHAPTER I

INTRODUCTION

Fingerprint identification and usage has existed for an extended period time; however depending on the source you hear from the time period could vary. “The first systematic attempt at personal identification was devised and introduced by a French police expert, Alphonse Bertillion in 1883” (Saferstein, 2007, p. 428). Saferstein states that in 1901 the first use of fingerprints for personal identification in the United States was by the New York City Civil Service. However there are several people throughout history that have played a vital role in where fingerprinting is today.

One of the earliest uses of a fingerprint was used for pictures inside books by using a stamp with wooden engravings of the print, which was completed by Thomas Bewick. “Bewick made wooden engravings of fingerprints and published their images in his books” (Ashbaugh, 1999, p. 20). “Bewick’s carvings demonstrated extreme knowledge of friction ridge structure and overall pattern shape” (Ashbaugh, 1999, p. 20). The carvings were very intrinsic and had extreme detail such as pores engraved in the ridges.

Later, Sir William J. Herschel was the first European to use fingerprints for identification purposes. “Herschel noticed the locals using inked finger and palm prints on contracts” (Ashbaugh, 1991, p. 19). Herschel spent time working with the Civil Service of India where he witnessed people using their finger or hand print as a method of signing contracts and discovered that method could be used for other aspects of life. “Herschel began to use the process to identify laborers in an effort to prevent impersonations” (Ashbaugh, 1991, p. 19).

Around the same time frame, Dr. Henry Faulds determines that fingerprints can be easily classified and that fingerprints could be a good use for apprehending criminals. “In 1880, another British subject, Henry Faulds, published an article in the British journal, Nature, describing the value of fingerprints for identification purposes” (Ashbaugh, 1991, p. 19). That was the first article written relating fingerprints to crime scene investigation. “Sir William Herschel responded to Faulds’ letter by writing to *Nature*; his letter was published on November 25, 1880, and the controversy in British fingerprint circles dates from this time” (Gaensslen & Lee, 2001, p. 29).

“Sir Francis Galton is credited with being the first scientist of friction skin identification, although he played as much a role of a promoter as a researcher” (Ashbaugh, 1991, p. 19). Galton was a promoter of fingerprint identification even though he did not fully follow through in his research at first. Galton was very interested in Bertillon age however after observing the system, Galton became even more interested and focused on fingerprint identification.

Sir Edward Henry is most commonly known for the classification system he created called the Henry Classification. This classification system was the foundation for the current classification system in today’s society, AFIS.

> In 1897, two clerks working under Edward Henry in Calcutta, India, overcame the largest hurdle that fingerprint identification had encountered thus far. They developed a classification system for fingerprints that had 1,024 primary classifications with secondary breakdowns for each. This classification system was named the Henry System and is still used in many countries in one form or another. The Henry system of classification

> overcame the problem of how to file, retrieve, and search a collection of thousands of fingerprints. Its discovery established fingerprint identification as the most practical and simple personal identification method then available. (Ashbaugh, 1991, p. 20)

Automated Fingerprint Identification Systems (AFIS) is one example of the technological equipment which entails having a database of fingerprints. AFIS is used to attempt to match a fingerprint with a known print. AFIS is a computer system that is available to any agency with the FBI housing the overall database. The process for AFIS is that an agency scans in either a single fingerprint or a 10-print card into the database for comparison to other fingerprints already stored. AFIS compares the minutae points and produces a list of potential matches with the highest potential of a match being listed first. A fingerprint examiner then must visually confirm or deny the match.

AFIS is a newer, more technology friendly version of the Henry System that was originally created. To use the Henry System, an individual would have to sort through the actual 10-print fingerprint cards to compare. The 10-print cards were classified by specific characteristics and stored in large filing systems. For an examiner to need to determine whose fingerprint was found, the fingerprint would need to be semi-classified to determine where to start in the manual search through files. The Henry System was the start to modern fingerprinting classification system era.

Thomas Taylor was the second individual during this time frame of late 1800s that believed fingerprints could be used to solve crimes. It is not fully understood if Taylor or Faulds made the claim first, however it is published that Taylor supposedly lectured on the topic of solving crimes by use of fingerprints before July 1877.

Additionally as mentioned earlier, Alphonse Bertillon discovered that not only fingerprints differ from each individual but also their anatomical measurements.

> He decided to use various body measurements such as head length, head breadth, length of left middle finger, length of left cubit (forearm), length of left foot, body height, face breadth, face height, and other descriptors including features such as scars and hair and eye color to distinguish criminals. (Ashbaugh, 1999, p. 27)

In 1894, Mark Twain was the first to write a book about how fingerprints were used to solve a crime. In the book, the entire town is fingerprinted to attempt to find a match after a bloody fingerprint is found on the murder weapon. Later on in the book he describes fingerprint knowledge to the courts. There is no known knowledge on where the fingerprint information Twain used came from however it is suspected to be from previous writings. "He lectures the court and jury on the basics of fingerprinting, how fingerprints are immutable and that two fingerprints will never be found to be the same" (Ashbaugh, 1999, p. 35).

The purpose behind this research is to determine the quality of aged fingerprints and how aged fingerprints can have quality ridge detail after chemical testing on thermal paper. Thermal paper is classified as a porous surface due to it being a piece of paper. Thermal paper is most common form of receipts, which is a part of everyday life.

> Generally, there are two types of thermal paper: one type has two thermal surfaces, the other has one thermal surface and one nonthermal surface that is composed of ordinary paper (base paper). It is easy to develop fingerprints on the nonthermal surface, but it is difficult on the thermal

> surface, because substances in the paper react with the processing solvents, turning the surface dark and yielding poor results. (Ma & Wei, 2006, p. 364)

The nonthermal side of the paper is similar to any other type of paper (porous surface) however the thermal side of the paper has a different surface causing processing fingerprints more difficult to do. "It has a glossy finish on the face (printed side), and plain texture on the reverse side" (Broniek & Knapp, 2002, p. 427).

One previous research used muriatic acid as the chemical processing choice for development of fingerprints on thermal paper.

> Dipping of the thermal paper directly into the acid was attempted, but resulted in the entire emulsion side of the paper turning dark in color, rendering it unsuitable for further examination. (Broniek & Knapp, 2002, p. 428)

Therefore it was determined that muriatic acid fuming would be the best solution to processing the prints on the thermal paper. Broneik and Knapp completed their experiment by muriatic acid fuming that allowed for one side of the thermal paper to be exposed fully to the muriatic acid resulting in better ridge detail.

> The thermal paper that had been fumed by means of exposure to the muriatic acid vapors developed latent fingerprint impressions with remarkable first, second, and third level friction ridge detail. (Broniek & Knapp, 2002, p. 430)

The outcome of muriatic acid fuming provided overall decent results that can be built upon for future years. The amount of time for processing generally is a short period of time. “Generally, fingerprint impressions reached their maximum clarity within approximately 5-10 seconds of exposure to the muriatic acid vapors” (Broniek & Knapp, 2002, p. 430).

Therefore it is essential to assure that a prolonged period of time does not lapse as the thermal paper can alter.

> Exposure to the muriatic acid vapors did not cause the written portion of the documents to bleed, but left them in a legible state. Prolonged exposure to the vapors caused the entire exposed area of the emulsion surface to change color to green or gray. (Broniek & Knapp, 2002, p. 430)

“Using muriatic acid vapors to develop latent fingerprint impressions on the emulsion side of thermal paper is extremely fast and provides excellent results” (Broniek & Knapp, 2002, p. 432).

In another research study, the thermal paper that was used in the study had a thermal and nonthermal surface. The thermal paper was suspended above each chemical with the thermal surface facing down. There were nine different chemicals used: (a) acetone, (b) ethyl acetate, (c) acetate acid, (d) ethanol, (e) methanol, (f) iso-propyl alcohol, (g) hydrochloric acid, (h) HFE-7100 or (i) n-hexane, and depending on the chemical being tested, the time the thermal paper was suspended was anywhere from a few seconds to no more than twenty seconds. From the several experiments tested for which the purpose was to determine which chemical produced the highest quality of ridge detail, acetic acid yielded the best results of quality ridge detail. “100% fresh fingerprints were developed and were suitable for identification, often with good third-level characteristics” (Ma & Wei, 2006, p. 367).

However, in Ma and Wei's experiment two the purpose of the experiment was to determine the effect of chemical fuming on aged fingerprints. The breakdown of time intervals was one week, one month, two months and four months for acetic acid. The results of the mini experiment show that after thirty days the quality fingerprint ridge detail starts to diminish slowly. "The data from experiment 2 show that acetic acid fuming is as effective for old fingerprints as for fresh fingerprints, but ninhydrin is less effective for old fingerprints" (Ma & Wei, 2006, p. 370).

Ma and Wei's experiment three's purpose was to determine the effect of chemical processing of the nonthermal side to the thermal side of thermal paper. The experiment was carried out by placing fingerprints on both sides of the paper.

> After two days, one-half of the fingerprints were developed sequentially by acetic acid fuming (only on the thermal surface) and then with ninhydrin. At the same time, the other half of the fingerprints were developed by ninhydrin directly as a control. (Ma & Wei, 2006, p. 366)

The results of this specific experiment were that for both chemical processes, acetone and ninhydrin, for both sides of the thermal paper, 100% development of quality ridge detail occurred.

Lastly, Ma and Wei's experiment four's purpose was to examine the effect of chemical processing on actual receipts. "Among the 100 receipts, 50 were developed by acetic acid fuming and ninhydrin sequentially; the other 50 were developed by ninhydrin directly" (Ma & Wei, 2006, p. 366). The results of the experiment were that the receipts that were developed by acetic acid and ninhydrin, 35 of 50 samples were of good quality for the thermal side and 18 of 50 samples were of good quality for the nonthermal side.

The results also showed that if the chemical processing was just ninhydrin then 41 of 50 samples were of good quality for the thermal side and 30 of 50 samples were of good quality for the nonthermal side.

There were some potential errors of the overall experiment that are suspected to have an impact on the last mini experiment, experiment four. "It is difficult to evenly fume large exhibits, which might result in some fingerprints being missed; but this will not happen with ninhydrin" (Ma & Wei, 2006, p. 370). Ma and Wei concluded that acetic acid fuming is a practical method to develop fingerprints on the thermal surface of thermal paper. Acetic acid is inexpensive and available everywhere, and the operational procedure for acetic acid fuming of fingerprints is relatively easy.

This research seeks to determine how well muriatic acid and acetic acid fuming develop the thermal side of thermal paper using aged prints. Additionally, the research seeks to determine how well ninhydrin develop the paper side of thermal paper using aged prints after exposure to the fuming.

It is essential in the research that the fingerprints are consistent and exact. Additionally it is vital to have a variety of individuals' fingerprints to depict the variety of minutae points as well as sebaceous oil depletion.

CHAPTER II

LITERATURE REVIEW

"The skin is the heaviest organ and is almost the largest, being approximately two yards square" (Ashbaugh, 1999, pp. 61-62). There are two types of human skin, smooth skin and volar skin. "Smooth skin contains hair, sebaceous glands and sweat glands while volar skin contains only sweat glands" (Ashbaugh, 1999, p. 62). The term friction ridges come from the concept that volar skin has a textured surface which includes narrow ridges (friction ridges). Friction ridges vary in width and length for each individual. "In general they are narrower in females and wider in males" (Ashbaugh, 1999, p. 63).

The epidermis is the outer layer of the volar skin whereas the inner layer of the volar skin is called the dermis. There are five layers of the epidermis, which are the basal layer, spinous layer, granular layer, hyalin layer and horny layer (in respective order from deepest layer to top layer). "Due to the key role the basal layer plays in generating new skin cells, it is often referred to as the generating layer" (Ashbaugh, 1999, p. 68). The shape of the cells start as columnar shape in the basal layer and as they move more up to the top of the epidermis, the cells become more flat and parallel to the skin. The dermis, also known as true skin, is composed of loose connective tissue composed of fibrous proteins. "The dermis serves the function of feeding nutrients to the outer layer of friction skin as well as giving physical protection to the internal body" (Ashbaugh, 1999, p. 70). The layer that separates between the epidermis and dermis is called the basal lamina. When the skin is cut, bleeding will only occur when the basal lamina is cut. Once that occurs and the dermal layer as well is cut, then there is a possibility that the fingerprint could change or scared resulting in a characteristic marking due to the damage.

The growth of friction skin starts at a very early stage of fetal development. At three weeks the epidermis is approximately one cell thick (Ashbaugh, 1999). Throughout the first few months the basal cells located within the basal layer divide being able to add depth to the epidermis. At six weeks, the friction skin on the volar pads becomes noticeable with a paddle like formation. The volar pads that appear in the arrangement of second, third and fourth interdigital pads, as well as the thenar and hypothenar pads on the palm. Around approximately eight weeks, the pads start to become more pronounced and then thumb rotates which creates the thenar flexion crease on the palm. At approximately 12 weeks, the basal layer starts to have friction skin ridges develop. For the next few weeks the volar pads start to decrease and continue until the pads blend in with the friction skin (Ashbaugh, 1999).

There are three types of fingerprints: latent, patent and plastic. Latent prints, invisible prints, result from the sweat, oil, etc. deposited when a finger presses a surface. A fingerprint is composed of 98.5 – 99.5% water. Latent prints must be properly developed for examination due to most of them being invisible. Patent prints, visible prints, are made when a finger has a visible foreign matter on it and the print is applied to a surface. A few examples of patent prints are blood, dust and ink. Lastly, plastic fingerprints are when a negative impression is left on an object such as wax. The finger is pressed into or onto a surface and when the finger is removed, a fingerprint is left in the surface.

Fingerprints are individual and therefore vary from person to person. There are three basic types of minutae points that allow for individualism to occur. The first type of minutae point is a ridge that ends abruptly which is known as an ending ridge. The second type of minutae point is a ridge that separates into two ridges which is called a bifurcation. The last basic type of minutae point is a short ridge which is called a dot.

Due to the fingerprints being individualistic, fingerprint identification is a great way to identify an individual. For fingerprint comparison, the three levels of detail are used to help determine individualization based off of clarity and quality. "Clarity is how well the details from 3-D ridges that are reproduced in the 2-D print" (Ashbaugh, 1999, p. 93). "Clarity is the key link between the premises of friction ridge identification, dealing with friction skin and the scientific identification process which deals with the comparison of friction ridge prints" (Ashbaugh, 1999, p. 93).

The details clarity discusses are broken down into three levels of detail. The first level of detail entails the least amount of detail and individualization. The first level of detail includes primarily the fingerprint patterns. There are three basic fingerprint pattern classifications, loops, whorls and arches. "Sixty to sixty-five percent of the population have loops, thirty to thirty-five percent have whorls and about five percent have arches" (Safarstein, 2007, p. 433). Specifically for the whorl classification, it can be subdivided into four groups, plain, central pocket loop, double loop and accidental. In regards to arches, there are two groups which are plain arches and tented arches. For loops, there are two specific types, either ulnar loops or radial loops. It is believed that the size of the volar pad and tension present while as a fetus, plays a part in the fingerprint patter development.

> If the volar pad is tall the friction ridges will form a concentric pattern. If the volar pad is flat the pattern will tend to be at the other end of the spectrum and form an arch. A pad of medium height will tend to have a concentric looping formation. (Ashbaugh, 1999, p. 76)

However, the pattern classifications give the least amount of detail and individualization.

The second level of detail entails some individualization and includes major ridge characteristics such as bifurcations and islands. A bifurcation is a branching ridge that diverges from the ridge path and continues on (Ashbaugh, 1999). An island is a development of one ridge unit to several others causing the ridges to go around other ridges. In the result that the island does not fully develop the ridge is called an incipient ridge.

The third level of detail includes the most amount of individualization with the comparison of more specific ridge characteristics and pores. “Each ridge unit has one sweat gland and a pore opening randomly somewhere on its surface” (Ashbaugh, 1999, p. 64). Additionally, specific damages to the fingerprints such as scars classify as third level of detail. “The small intrinsic details of the friction ridges have tremendous individualizing power” (Ashbaugh, 1999, p. 143). The one thing to note is that third level of detail is always used in conjunction with second level of detail. Overall, for a fingerprint to be compared, there needs to be some first, second and third levels of detail to assure a correct decision are made for a match or not.

Chemical processing, instrumental processing and physical processing are three ways to process fingerprints. To determine which process is most appropriate it is essential to know what type of surface the fingerprint is found on.

There are two types of surfaces a fingerprint can be found on, porous or non-porous. A porous surface is one in which the surface can absorb moisture such as paper. Whereas a non-porous surface is one in which the surface cannot absorb moisture such as glass.

Chemical processing entails any type of chemical that assists in developing the fingerprint. Once an individual determines the surface the print is on, then a chemical method can be determined. Some examples of chemical processing are superglue fuming, ninhydrin, amido black and small particle reagent.

Superglue fuming, which is also known as the chemical name cyanoacrylate ester, is a fingerprint technique to process prints on non porous surfaces. The cyanoacrylate ester is heated to produce fumes and the chemical will adhere to any type of moisture. "Development occurs when fumes from the glue adhere to the latent print, usually producing a white-appearing latent print" (Saferstein, 2007, p. 445). One unique aspect of superglue fuming is that once the development occurs the fingerprint is not susceptible to damage and can be processed continuously with fingerprint powder (Gardner, 2005). Ninhydrin is a chemical that is being used in this current research experiment therefore is explained in detail later on.

Amido black is a sensitive chemical that reacts with proteins in blood. "Blue-black protein stain used to enhance bloody friction ridge detail" (Triplett, 2010, n.p.). One method amido black is a water-based amido-black that can be sprayed onto the surface (Gardner, 2005). The overall reaction of amido black should take around thirty seconds to three minutes.

Small particle reagent is used for latent prints that are suspected of being wet. “Suspension in which molybdenum disulphide adheres to fats and oils, allowing for visualization of friction ridge detail” (Triplett, 2010, n.p.). Small particle reagent is sprayed onto the surface suspected of being a latent print. Spraying continues until the print starts to develop. Small particle reagent is used for most nonporous surfaces that are wet.

Instrumental processing entails the technological use of equipment to enhance fingerprints for identification. Examples are alternate light sources also known as high intensity arc lamps and lasers which is an acronym for light amplification by stimulated emission of radiation. Alternate light sources and lasers vary in wavelengths, which are a main reason why the instruments can potentially be damaging to the eye.

Physical processing entails the addition of anything to enhance the visual ability of the fingerprint. Fingerprint powder is the most known source of physical processor. “The choice of powder depends partly on the kind of surface on which the print is found and partly on how it is to be preserved” (Fisher, 2004, p. 98). Black, white, colored and magnetic are just a few of the types of fingerprint powders available. The color of the powder is dependent solely on the background color of the surface on which the fingerprint is located. Magnetic powder cannot be used on ferrous surfaces whereas the other types of powders do not have limitations to ferrous surfaces.

To apply the powder, specific brushes must be used to develop the fingerprints. Fiberglass, animal hair, and synthetic/natural fiber brushes are used however it is vital to assure the brush is not wet or oily. This causes the powder to clump given the purpose of the powder is to adhere to the moisture in fingerprints. Additionally, the brush with the powder applied must lightly touch the area the fingerprint is believed to be because if a lot of pressure is applied then the print may possibly be destroyed. If magnetic powder is used, then a special magnetic brush is essential to use. The benefits of magnetic powder being used over regular powder are that the brush never actually touches the fingerprint and it is the rays of the powder that adhere to the print. Additionally, there is a smaller amount of waste and amount of cleaning to have to deal with afterwards and any extra powder left on the fingerprint can be removed with the Magna-Brush®.

Ninhydrin, triketohydrindene hydrate, reacts with amino acids in perspiration. Amino acids are concentrated around pores when sweat flows causing the fingerprint to be spotty after being processed.

> Other media such as ninhydrin tend to break a ridge into a series of units. The catalysts of ninhydrin, amino acids, are usually found around the pores and are frequently absent on the areas of the friction ridge between the pores. (Ashbaugh, 1999, p. 121)

According to Triplett (2010),

> One of the organic components in eccrine sweat. Amino acids are the basic structure of protein, protein is a chain of amino acids. The human body uses 20 amino acids to build the various proteins for growth, repair, and maintenance of body tissues. (n.p.)

When applying ninhydrin to a porous surface, the methods in which it is completed is usually either dipping or spraying. Either method used there is a post treatment technique that serves as a catalyst. Heat or moisture applied to the porous surface post treatment will help the fingerprints develop faster than having to wait for the prints to dry naturally. “In most cases, treatment after ninhydrin includes the application of heat. It is clear, however, that elevated temperatures also accelerate the formation of background discoloration” (Gaensslen & Lee, 2001, p. 187). The outcomes of latent fingerprints that are chemically processed with ninhydrin are typically purple-blue in color.

Muriatic acid is also known as hydrochloric acid. The chemical names are changed throughout language today however it is the history of the words that are the reasoning why.

> Hydrochloric acid was formerly called muriatic acid. Terms such as muriatic and muriate were used in association with chloride substances before the discovery and nature of chlorine were fully understood. The Latin term *muriaticus* means pickled from *muri*, which is the Latin term for brine. Chlorides were naturally associated with seawater salt solutions, as chloride is the principal ion in seawater. (Myers, 2007, n.p.)

According to Triplett (2010), “A chemical used to process thermal paper to develop friction ridge detail” (n.p.).

Acetic acid is also known as ethanoic acid where vinegar is actually a diluted solution of acetic acid. The acetic acid gives vinegar its strong odor and sour taste. Acetic acid is a hydrophilic protic solvent, which is also known as polar. It is able to dissolve polar and nonpolar compounds.

CHAPTER III

MATERIALS AND METHODS

Preliminary Research

An undergraduate student at The University of Southern Mississippi did some preliminary research to insure that the chemical process of muriatic acid fuming does work. The objective of this experiment was to find out how well muriatic acid fuming develops the thermal side of thermal paper using aged prints. Another objective was to determine how well Ninhydrin, DFO, and Indanedione develop the paper side of thermal paper using aged prints after exposure to the muriatic acid fuming. The researcher was able to determine at approximately days 29–30 the fingerprint quality started to decrease. It was also shown that the older the prints got the less moisture was present causing a lower visibility rate during testing. It is not known exactly how aged the prints can be and still have quality ridge detail however that is the purpose and background of this research.

Materials

The materials that are needed for the research are 810 pieces of thermal paper, muriatic acid, acetic acid and ninhydrin. The chemicals and thermal paper all need to be new to assure no cross contamination or prior fingerprints were on the paper.

The concept behind the 810 pieces is that a piece of thermal paper is needed per set of fingerprints. Due to there being three sets of fingerprints per person per day and there being 27 people and 10 days, 810 pieces were calculated.

Methods

Therefore, 24 random individuals placed a total of 30 sets of fingerprints per person on thermal paper over a 10-day period. Each set of fingerprints consisted of three fingerprints on the thermal side of paper and three fingerprints on the nonthermal side of paper. The prints for each set were placed on the thermal paper simultaneously causing the prints on the thermal and nonthermal side to be very close in location, just on opposite sides of the thermal paper.

Each day, three sets were taken from each individual; however each set was separated into three groups to complete the depletion series sampling method. According to Kent (2010), the depletion series sampling method is when fingerprints are deposited in a series without reapplying sweat or other oils. With this method, the oil found within the fingerprints will deplete as the series grows longer. It was essential that when the individuals placed their prints onto the thermal paper, only the sebaceous oils from their fingertips be used and they not rub their forehead or hair for extra oil. This process enhanced the fingerprints and caused them to have damaging effects.

Additionally, on the pieces of thermal paper there were markings on the paper to make it easier to decipher. The markings separated each generation of fingerprint (1^{st}, 2^{nd}, and 3^{rd}) along with labeled the thermal and nonthermal side. Lastly the sets were numbered to assure they do not get out of order for processing purposes. Each set got a number, each generation got a letter (a for 1^{st} generation and so on) and then each side got another letter, L for left side and R for right side.

Furthermore, it was essential to avoid deposition pressure and pressure distortion therefore the researcher assisted the participants in printing. The issue that would arise with deposition pressure was that the size and shape of the fingerprint would be inaccurate if too little or too much pressure was added when the print was taken. If deposition pressure was to occur then the size on the shape would be wider than actual causing the furrows and ridges to be depicted inaccurately. Additionally, the smearing of the prints would result if the horizontal movement occurred resulting in pressure distortion. If pressure distortion occurs, then there was a potential to not be able to even find any levels of detail.

Processing the fingerprints was essential for the analysis. The process of fingerprints took place over a 46-day time period and measured the effects of muriatic acid, acetic acid and ninhydrin chemical processing on the quality of prints that ranged from being one day old to 40 days old. The processing schedule for the fingerprints is in Appendix A.

Chemical Processing

To compare the effects of each reagent, each print was cut in half for a side by side comparison. Kent (2010) stated that the use of split fingerprints allows for a true side-by-side comparison to be made between two treatments. Unfortunately, Kent (2010) also stated that the disadvantage is “reducing the area of print available for assessment” (p. 373).

Every left side piece of the thermal paper’s thermal surface was processed with muriatic acid fuming. A large glass beaker was placed in the ventilated fume hood with approximately 25mL of concentrated muriatic acid placed inside the dish. Once everything was prepared, a test strip with a latent fingerprint on the thermal side was necessary to assure that the chemical was properly combined.

The thermal paper was suspended over the glass container with the thermal surface facing down so the fumes could react with the fingerprints. The fuming process was approximately 20–30 seconds per print.

The right side of the thermal paper's thermal side was processed with acetic acid fuming. Similar to the muriatic acid fuming, a large glass beaker was placed in the ventilated fume hood with approximately 25 mL of acetic acid placed inside the dish. A test strip was prepared with a latent fingerprint on the thermal side to assure the chemical was properly combined.

Next, the left and right sections of the nonthermal side of the thermal paper were processed with ninhydrin. The ninhydrin was applied via blotting with a cotton ball. After the application of the ninhydrin, all of the pieces of thermal paper were laid out to air dry and then stored in aluminum foil until the research was complete.

Scoring/Analysis

To assess the quality of the fingerprint after the chemical processing of muriatic acid, acetic acid and ninhydrin, a scale was needed.

Kent (2010) measures fingerprint quality as:

0 – No sign of fingerprint,

1 – some detail over a small area of the fingerprint showing ridge detail,

2 – a major portion of the fingerprint showing ridge detail and

4 – full development of whole fingerprint area with ridge detail.

The measurement scheme is a basic scale that does not worry about the amount of ridge characteristics but a general description of fingerprint ridge quality. Therefore, Kent's (2010) scale has been adopted for analysis purposes of this research.

Once the fingerprints were measured for quality, interactions and descriptive statistics were run. The independent variables were time (measured in days), side of thermal paper, generation of fingerprint and chemical used. The dependent variable was the quality of the fingerprint which was measured by the scoring mentioned earlier.

To perform the statistical analysis, the computer program SPSS was used. SPSS was capable of storing all the data and then running any necessary statistical analyses needed. The first variable that was entered into SPSS was the generation variable, which was coded as 0, 1, 2 for the respective generations 1, 2 and 3. The second variable that was entered into SPSS was the side of the thermal paper, which was coded 0 for thermal side and 1 for nonthermal side. The third variable that was entered into SPSS was the chemical used, which was coded 0 for muriatic acid, 1 for acetic acid and 2 for ninhydrin. The fourth variable that was entered into SPSS was the fingerprint quality score, which was coded 0, 1, 2 and 3. 0 is for no sign of fingerprint; 1 is for some detail over a small area of the fingerprint showing ridge detail; 2 is for a major portion of the fingerprint showing ridge detail; 3 is for full development of whole fingerprint area with ridge detail. The coding was different than the literature because of the typo discovered after contacting the author of the literature. The fifth variable that was entered into SPSS was the time, which was coded for the respective time period that had lapsed.

Lastly, Internal Review Board (IRB) permission was obtained due to the fact that humans' fingerprints were used (see Appendix B). The Internal Review Board insured that all experiments were done with discretion and with the safety of the subjects in mind. This experiment insured the safety of the subjects and the subjects' identities were kept safe.

CHAPTER IV

DATA AND RESULTS

No research was conducted until approval was received from the Internal Review Board of The University of Southern Mississippi in regards to a written application submitted by the primary investigator. The IRB committee approved the research and the researcher received verification via letter which is included in Appendix B.

Once research was initiated, the fingerprints were collected by the index finger of both the right and left hands from twenty four participants. Each participant signed a consent form allowing participation in the research. All fingerprints were placed on the thermal and nonthermal sides of the paper in a generation series.

Statistical Analysis

Once all fingerprints were collected and processed chemically as described in the methods section, the fingerprints were analyzed by the researcher using the scoring analysis described in the methods section. Once each fingerprint was analyzed and given a score, the scores were inputted into Microsoft Excel, then finally being converted into SPSS.

In order to compare the numerous variables, an interaction was selected to be the statistical analysis method. The first interaction that was run was comparing the day and score variables to the chemical variable. The results are as follows:

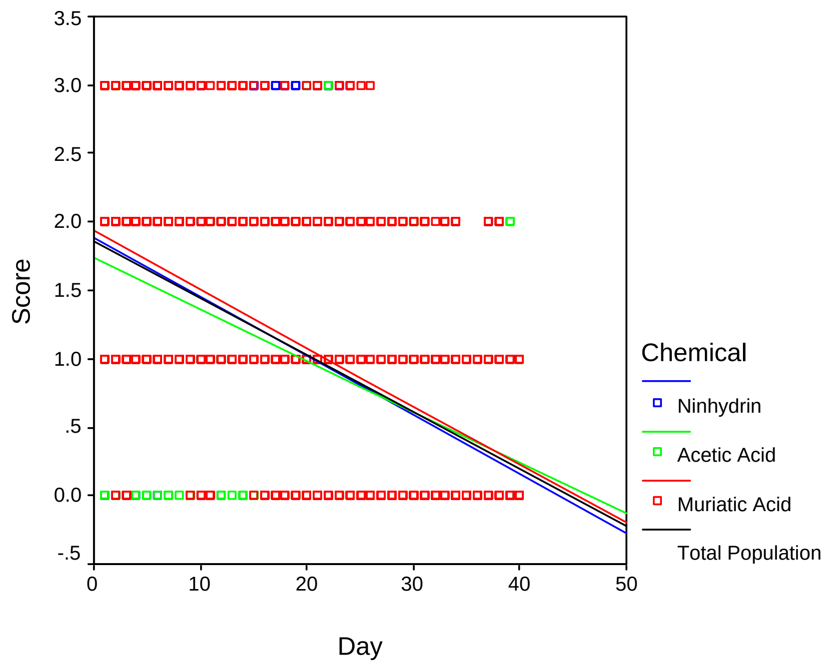

Figure 1. Statistical Analysis of the Chemical Variable Comparing Day and Score Variables. This figure represents an interaction between the three chemicals (ninhydrin (blue), acetic acid (green) and muriatic acid (red) while comparing the day and score variables.

When looking at Figure 1, if the researcher does not account for the interaction, then the researcher overpredicts for the chemical one, acetic acid and under predict for chemicals zero, muriatic acid and two, ninhydrin during the earlier days. The graph depicts a steady decrease in the scores as the days increase which was to believe to have occurred. In general around day 35 the scores of the fingerprints overwhelmingly were predominantly zero.

After analyzing the interaction overall, splitting the file so the generation variable could be tested based off of each generation was completed. Next descriptive statistics were run to observe the variables for each generation, 0, 1 and 2. When comparing the average score between each generation, Table 1 depicts that generation 0 has the highest mean with a score of 1.54 whereas Table 2 depicts that generation 1 has a mean of .95

and Table 3 depicts that generation 2 has a mean of .52. All the other variable means are equivalent across the three generations due to the variables all not varying.

Table 1

Descriptive Statistics for 1st Generation

	N	Minimum	Maximum	Mean	Std. Deviation
SCORE	2868	0	3	1.54	.872
GENERATI	2880	0	0	.00	.000
SIDE	2880	0	1	.50	.500
CHEMICAL	2880	0	2	1.25	.829
Valid N (list wise)	2868				

Table 2

Descriptive Statistics for 2nd Generation

	N	Minimum	Maximum	Mean	Std. Deviation
SCORE	2868	0	3	.95	.756
GENERATI	2880	1	1	1.00	.000
SIDE	2880	0	1	.50	.500
CHEMICAL	2880	0	2	1.25	.829
Valid N (list wise)	2868				

Table 3

Descriptive Statistics for 3rd Generation

	N	Minimum	Maximum	Mean	Std. Deviation
SCORE	2868	0	2	.52	.571
GENERATI	2880	2	2	2.00	.000
SIDE	2880	0	1	.50	.500
CHEMICAL	2880	0	2	1.25	.829
Valid N (list wise)	2868				

After observing the descriptive statistics, an interaction was run again based off of the split file from earlier. The day and score variables were compared to the chemical variable for each generation.

Figure 2 depicts that if the researcher does not account for the interaction then the researcher overpredicts for the chemical one and underpredict for chemical zero and two during the earlier days for generation 0. Figure 2 also depicts that throughout the entire forty day time period, chemical zero has the smallest slope therefore depicting to have the best results between the three chemicals. As the days increase, the chemicals start to slowly have a lesser score however the chemical zero has the overall best results.

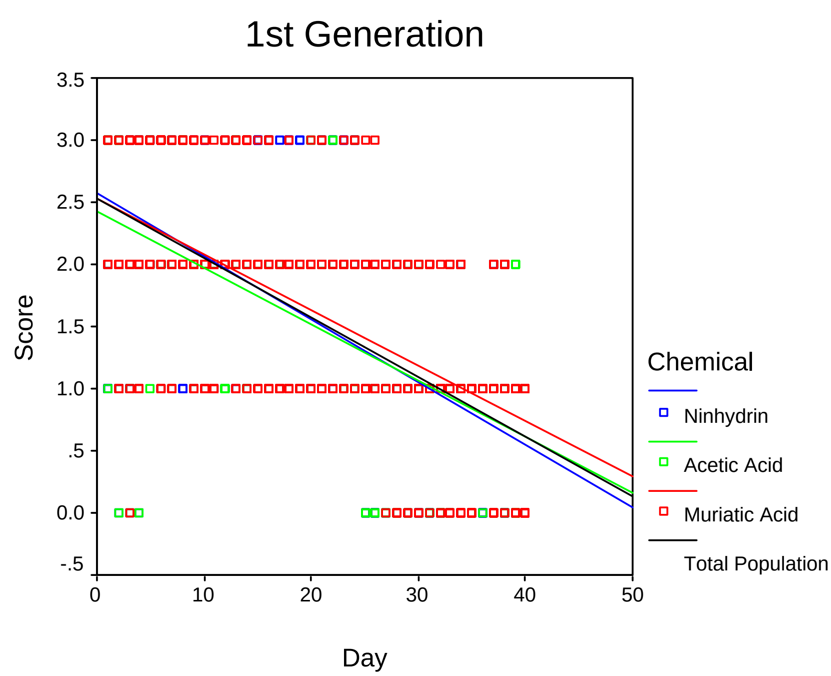

Figure 2. Statistical Analysis of the Chemical Variable Comparing Day and Score Variables for First Generation Fingerprints. This figure represents an interaction between the three chemicals (ninhydrin (blue), acetic acid (green) and muriatic acid (red) while comparing the day and score variables for the first generation fingerprints.

When looking at Figure 3, if the researcher does not account for the interaction then the researcher overpredicts for chemical one and underpredict for chemical zero and two for the earlier days for generation 1. Similar to Figure 2, Figure 3 depicts that as the days increase, the scores for all three chemicals decrease. However, in Figure 3 as the days increase chemical one has the better results around day thirty unlike Figure 2.

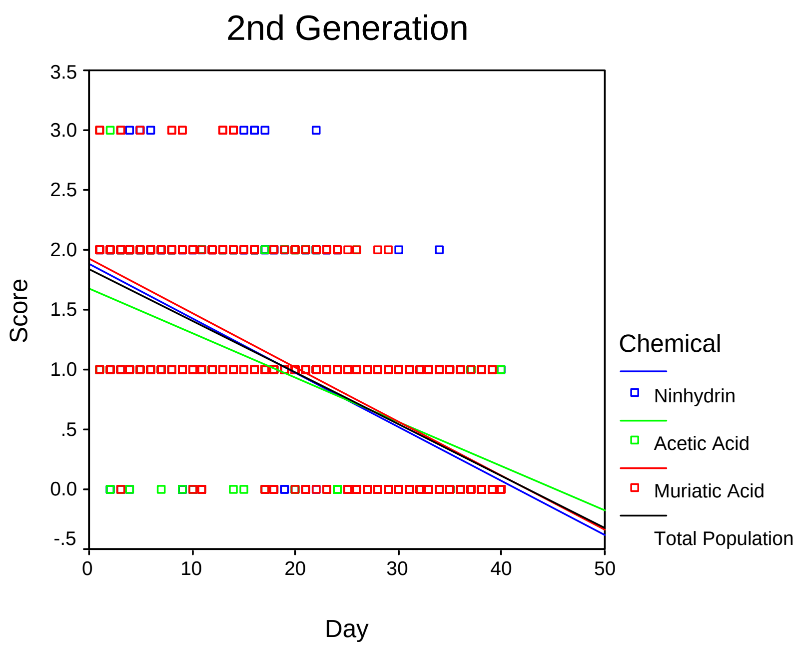

Figure 3. Statistical Analysis of the Chemical Variable Comparing Day and Score Variables for the Second Generation Fingerprints. This figure represents an interaction between the three chemicals (ninhydrin (blue), acetic acid (green) and muriatic acid (red) while comparing the day and score variables for the second generation fingerprints.

When looking at Figure 4, if the researcher does not account for the interaction then the researcher overpredicts for chemical one and underpredict for chemical zero and two for generation two. Similar to Figures 2 and 3, the earlier days, all three chemicals' overall scores decrease. Similar to Figure 3, as the days increase, chemical one starts to have better results than the other chemicals in between the thirty to forty day time period.

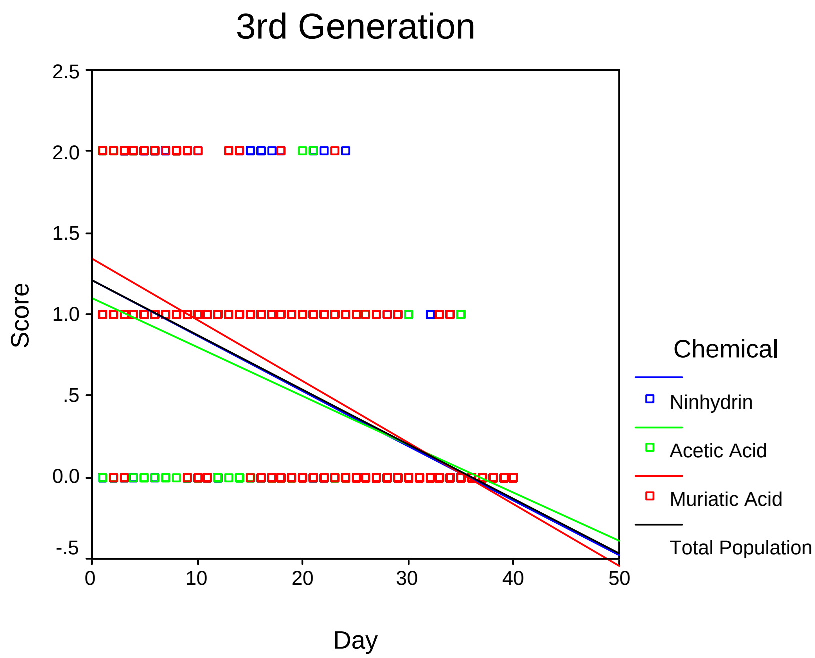

Figure 4. Statistical Analysis of the Chemical Variable Comparing Day and Score Variables for the Third Generation Fingerprints. This figure represents an interaction between the three chemicals (ninhydrin (blue), acetic acid (green) and muriatic acid (red) while comparing the day and score variables for the third generation fingerprints.

Next, a split file was done to compare the day and score variables to the chemical variable for the sides, thermal and nonthermal. When looking at Figure 5, the thermal side shows that chemical zero has a higher score than chemical one during the earlier days. When the day time period is around day 35, the chemicals start to differ and chemical zero starts to have a less result than chemical one. If the researcher does not account for the interaction, then the researcher overpredicts for chemical one and the researcher underpredicts for chemical zero during the earlier days.

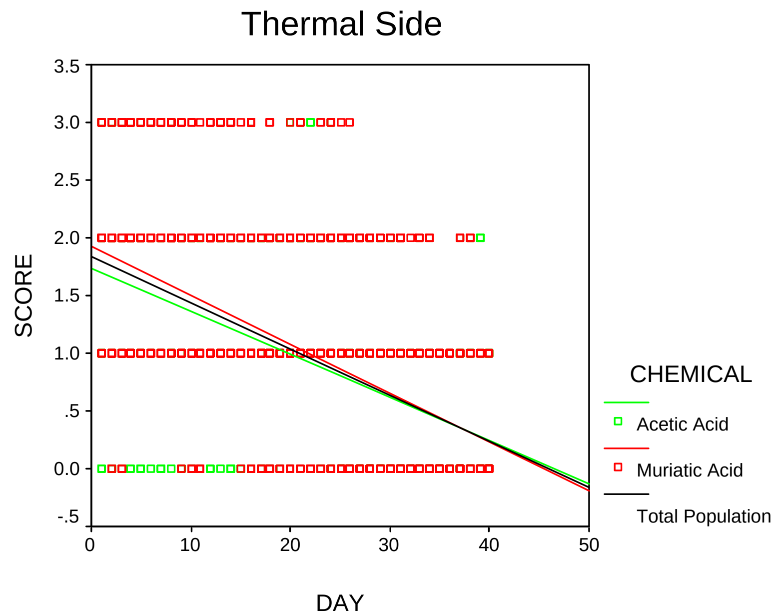

Figure 5. Statistical Analysis of the Chemical Variable Comparing Day and Score Variables for the Thermal Side. This figure represents an interaction between the two chemicals (acetic acid (green) and muriatic acid (red) while comparing the day and score variables for the thermal side of the thermal paper.

Next, a split file was created and an interaction was run comparing the day and score variables to the chemical variable based off of side and generation variables. When looking at Figure 6, if I do not account for the interaction, then I overpredict for chemical one and underpredict for chemical zero during the entire time period. Figure 6 also depicts that the thermal side of the paper for generation zero has the best results of fingerprints with chemical zero during the entire forty day time period.

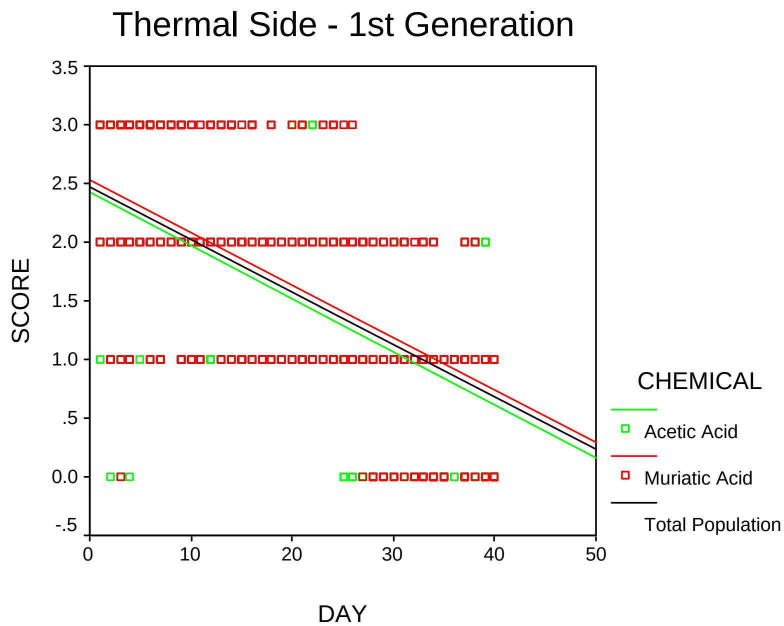

Figure 6. Statistical Analysis of the Chemical Variable Comparing Day and Score Variables for the First Generation Fingerprints for the Thermal Side. This figure represents an interaction between the two chemicals (acetic acid (green) and muriatic acid (red) while comparing the day and score variables for the first generation fingerprints for the thermal side of the thermal paper.

When looking at Figure 7, if the researcher does not account for the interaction, then the researcher overpredicts for chemical one and underpredict for chemical zero during the earlier days. The thermal side of the paper for generation one, has the best results with chemical zero during the earlier days however at approximately day 30, chemical one starts to have better results.

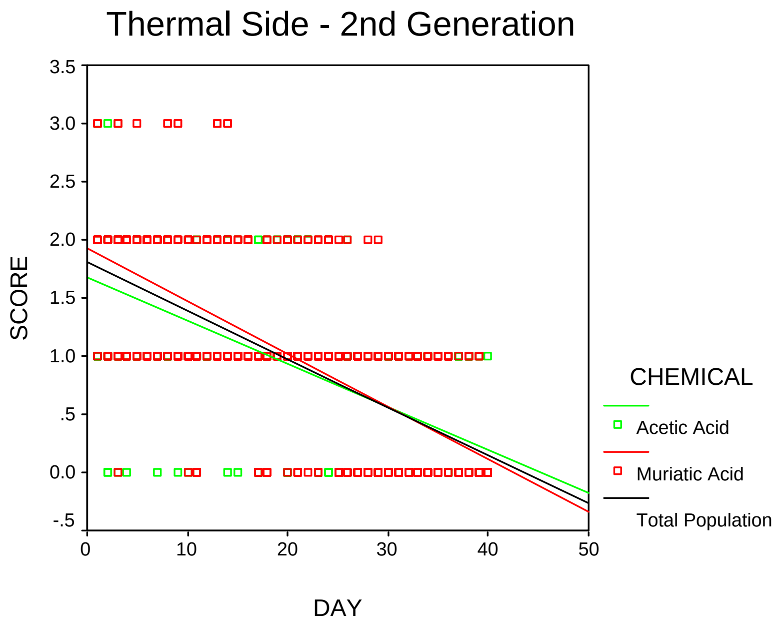

Figure 7. Statistical Analysis of the Chemical Variable Comparing Day and Score Variables for the Second Generation Fingerprints for the Thermal Side. This figure represents an interaction between the two chemicals (acetic acid (green) and muriatic acid (red) while comparing the day and score variables for the second generation fingerprints for the thermal side of the thermal paper.

Similar to Figure 7, Figure 8 has better results for the thermal side of the paper at generation two when chemical zero is used during the earlier days. Additionally, similar to Figure 7, Figure 8 has better results for the thermal side of the paper at generation two when chemical one is used from approximately day 30 onward. If the researcher does not account for the interaction, then the researcher overpredicts for chemical one and underpredict for chemical zero during the earlier days.

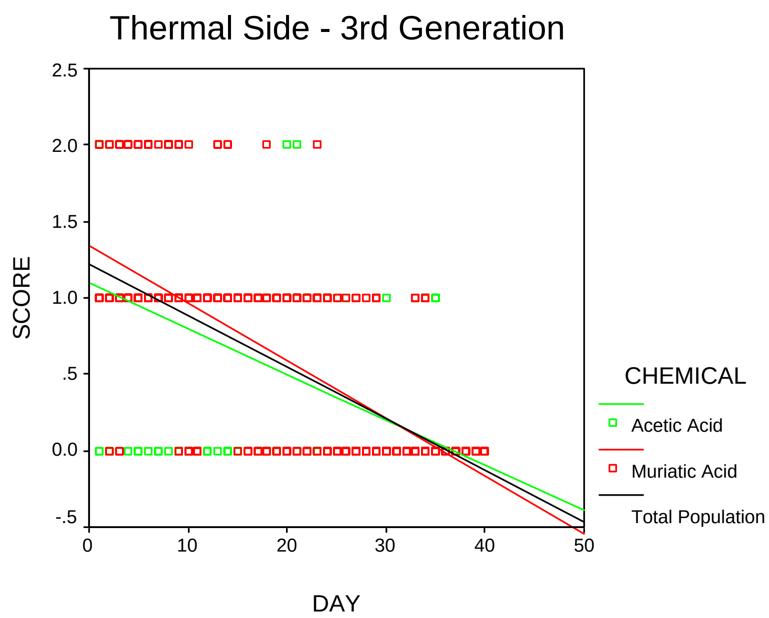

Figure 8. Statistical Analysis of the Chemical Variable Comparing Day and Score Variables for the Third Generation Fingerprints for the Thermal Side. This figure represents an interaction between the two chemicals (acetic acid (green) and muriatic acid (red) while comparing the day and score variables for the third generation fingerprints for the thermal side of the thermal paper.

CHAPTER V

DISCUSSION

Processing of Fingerprints

When completing the processing of the fingerprints, it was determined that the fingerprints would appear to be green in color when they developed on the thermal side of the paper. However when the ninhydrin was applied to the nonthermal side of the paper, the fingerprints from the thermal side were destroyed as the chemical bled onto the thermal side of the paper. It was also noted that the best application method of the ninhydrin was by cotton ball and blotting the fingerprints. This allowed for not as much contact and smudging of the fingerprints as other methods of applications could have resulted in. The total amount of time it took for each print to be processed was approximately 30 seconds total which was determined on the strength of the chemical being used. Each day the fingerprints were processed the chemicals were freshly used allowing for the best strength of acid for the thermal side of the paper.

Scoring of Data

The scoring of the fingerprints was based off of a piece of literature however upon reading the literature the researcher asked the question of why was the literature stating the distribution of scoring numbers was not evenly distributed. Upon researching the literature, it was decided to recode all the scores of fours to threes to have an evenly distributed scoring analysis.

Statistical Analysis

This research allowed for a statistical analysis of chemicals, sides, time period and generation. With an average of 1.54 for the total score compared to generation one with an average of .95, it is clearly shown that generation zero had the better fingerprint quality scores compared to the other generations. When looking at graphs, it was also shown the chemical zero, muriatic acid had the best results for all generations especially for the first twenty days of the research. It was seen that as the days increase there is a decrease in the fingerprint quality which was believed to have happened in the initial research. However, when looking at the hypothesis and research goals, the questions that wanted to be answered were when exactly fingerprint quality diminishes to a point of not being able to process. The answer to that question based off of the research appears to be during the thirty to forty day time period however more specifically around the 35-day time period. The time period best represents when the fingerprint quality when none of the chemicals produce adequate fingerprints quality to sufficiently score in all three generations.

Throughout the 35-day time period, the muriatic acid overwhelmingly produces great results during the start of the research. However with time, sides and generations, allow for acetic acid to be a better fingerprint processer instead.

Throughout the research, there were chances for error such as scoring of the fingerprint quality and processing of the prints. In regards to the scoring of the fingerprint quality, the scale was based off of literature for a specific scale. When using the scale, the scoring becomes subjective to the researcher and time is needed between each fingerprint to adequately and efficiently score without having bias or continuously comparing each print. With the large amount of sample size, there is a chance of error in regards to scoring due to the continuation of scoring after reviewing several prints prior.

Another error that could have occurred was the processing of the prints. Each day the chemicals were freshly prepared however there is always the possibility that the strengths of the acids were not the same strength everyday causing a potential for less fingerprint development or more fingerprint development. Unfortunately at times the fingerprints were overexposed to the chemicals causing for some slightly more developed prints than others.

Further Research

This research allowed for a time period to be determined in when exactly fingerprints can be developed after being deposited onto thermal paper. Additional research could be done to determine what other chemicals process fingerprints on thermal paper in a time period similar to this research. The goals of the further research would be to determine a higher fingerprint development quality and a longer time period. Lastly, the research could be furthered by changing the variables such as sides and generations, etc.

APPENDIX A

FINGERPRINT PROCESSING SCHEDULE

		Day	Sample Day (sets)	Amount of sets to be processed	Sample From Day #	Testing Elapsed Time fo Day #	Amount of sets to be processed	Sample From Day #	Testing Elapsed Time fo Day #
M	21-Mar	1	81						
t	22	2							
w	23	3	81						
th	24	4	81						
fr	25	5	81						
sa	26	6							
s	27	7							
m	28	8	81						
t	29	9	81	20	8	1	20	4	5
w	30	10		20	8	2	20	4	6
th	31	11	81	20	8	3	20	4	7
fr	1-Apr	12	81	20	8	4	20	4	8
sa	2	13							
s	3	14							
m	4	15	81						
t	5	16	81	20	3	13			
w	6	17		20	3	14			
th	7	18		20	3	15			
fr	8	19		20	3	16			
sa	9	20							
s	10	21							
m	11	22							
t	12	23		20	5	17	20	16	9
w	13	24		20	5	18	20	16	10
th	14	25		20	5	19	20	16	11
fr	15	26		20	5	20	20	16	12
sa	16	27							
s	17	28							
m	18	29							
t	19	30		20	9	21			
w	20	31		20	9	22			
th	21	32		20	9	23			
fr	22	33		20	9	24			
sa	23	34							
s	24	35							
m	25	36							
t	26	37		20	1	37	20	12	25
w	27	38		20	1	38	20	12	26
th	28	39		20	1	39	20	12	27
fr	29	40		20	1	40	20	12	28
sa	30	41							
s	1	42							
m	2	43							
t	3	44		20	15	29	20	11	33
w	4	45		20	15	30	20	11	34
th	5	46		20	15	31	20	11	35
fr		47		20	15	32			

APPENDIX B

IRB APPROVAL FORM

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Institutional Review Board

118 College Drive #5147
Hattiesburg, MS 39406-0001
Tel: 601.266.6820
Fax: 601.266.5509
www.usm.edu/irb

HUMAN SUBJECTS PROTECTION REVIEW COMMITTEE
NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Human Subjects Protection Review Committee in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months. Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: **11011802**
PROJECT TITLE: **Chemical Processing of Fingerprints on Thermal Paper**
PROPOSED PROJECT DATES: **01/10/2011 to 05/31/2011**
PROJECT TYPE: **Dissertation or Thesis**
PRINCIPAL INVESTIGATORS: **Megan Dutton**
COLLEGE/DIVISION: **College of Science & Technology**
DEPARTMENT: **Criminal Justice**
FUNDING AGENCY: **N/A**
HSPRC COMMITTEE ACTION: **Exempt Approval**
PERIOD OF APPROVAL: **01/20/2011 to 01/19/2012**

Lawrence A. Hosman
Lawrence A. Hosman, Ph.D.
HSPRC Chair

1-21-2011
Date

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