# DIRECT TRANSFER: OBTAINING LATENT PRINTS FROM THE SKIN OF A LIVING PERSON

by

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## Dedication

This is dedicated to my beautiful wife, Amber, and children, Parker and Madison.

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I would like to thank everyone who has helped and supported me throughout my career. This includes family, friends, subordinates, peers, mentors, and leaders. Thank you to the U.S. Army and the Criminal Investigation Command for this incredible opportunity. Thank you to Chief Investigator Joe Medrano, Fingerprint Specialist Doug Gudakunst, and Professor Rule for your mentorship and advice throughout this project. Thank you, CW2 Matthew James and Dr. Falsetti, for your invaluable mentorship in statistics. Lastly, thank you to everyone who assisted and reviewed this project until its completion.

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**Abstract**

Fingerprint identification has been at the core of Forensic Science for more than 100 years. It remains one of the most valuable tools to assist law enforcement in identifying suspects and solving crimes. Over time techniques have made it possible to recover latent prints from the skin of human remains and, in some cases, a living person's skin. Identifying latent prints from human skin could directly corroborate or refute statements or provide investigative leads. One technique is called direct transfer, in which paper is pressed against the skin to transfer latent prints present on the skin. The paper is then processed with various techniques to develop the potential latent prints. This study examined the direct transfer technique in obtaining latent prints deposited on the skin of a living person utilizing kromekote, thermal, and ink/laser jet paper. Magnetic powder and Indanedione were utilized to process each type of paper to develop the potentially transferred latent prints. This research consisted of 1,035 trials conducted at several time intervals: immediately after print deposit, 5, 10, 15, and 30 minutes after deposit. The purpose of this research was to identify the most effective transfer paper substrate, fingerprint development technique, and timeframe to recover latent prints from the skin. The substrate and development technique did not have a significant impact on the results; however, time of recovery after deposition had a significant impact. After five minutes, there was a drop in the level of identification which grew more significant over time.

**DIRECT TRANSFER: OBTAINING LATENT PRINTS FROM THE SKIN OF A LIVING PERSON**

Police officers are dispatched to a domestic violence call. Upon arrival, the officers separate the parties involved and interview them to ascertain what occurred prior to their arrival. An individual claiming to be the victim indicates their significant other grabbed and squeezed their neck while threatening them. The officer does not see any apparent injuries during the interview. Meanwhile, the supposed subject is giving a different side to the story and says it is all made up so the victim can use it in court for the impending divorce. Who to believe? What can law enforcement do without any physical evidence to support the claims of the victim? In contrast to injuries from hitting, many strangulation injuries are not visible to the layperson and are often only detected during autopsy, even when the cause of death was not strangulation (Kuriloff & Pincus, 1989; Taliaferro et al., 2001). If latent prints of the assaulter were collected from the skin of a living victim, it would provide validity to the victim's statement. At the very minimum, recovering latent prints from the neck could corroborate or refute statements and be later verified through latent print comparison.

Every time a person enters an environment, something is added to and removed from the environment is the basis of Locard's Exchange Principle (Fay, 2016), which essentially states every contact leaves a trace. Locard also stated, "physical evidence cannot be wrong, it cannot perjure itself, it cannot be wholly absent. Only human failure to find it, study and understand it, can diminish its value." Fingerprints are believed to have been used for identification as early as 300 B.C. in China and 702 A.D. in Japan (Barnes, 2014). Fingerprint's uniqueness was not identified until 1788 in Europe (Barnes, 2014). The United States did not start conducting fingerprint analysis until 1902 (Barnes, 2014). Development of latent fingerprints and fingerprint identification remains to be one of the most utilized forensic tools to this today.

Latent prints gathered at the scene of a crime and or on recovered evidence help identify suspects, corroborate statements, and help law enforcement solve crimes. Before the 1960s, there had been no developed technique to recover latent prints from the skin of a living or deceased human (Singh, 2020). In the mid-1960s to the 1970s, forensic scientists began to conduct significant research into developing these techniques with minimal success (Singh, 2020). In the late 1970s, several documented cases involving the successful development of latent print from the skin of homicide victims were reported. One of these included the Miami-Dade Police Department, Miami, FL, which led to the first known murder conviction based on latent print identification from human skin (Singh, 2020). Although there have been some successes like this case in obtaining latent prints from deceased remains, there have not been as many documented success stories with obtaining latent prints from the skin of a living person. If latent prints were obtained from victims or even suspects of crimes such as child assault, sexual assault, attempted kidnappings, domestic violence, and others, it could lead to more successful prosecutions and, or identifications of suspects.

Understanding skin is the most crucial aspect in obtaining latent prints from the skin of a living person. The skin is an organ composed of three anatomical layers: epidermis, dermis, and hypodermis. These anatomical layers function together to provide the body with a protective barrier, regulate body temperature, provide sensation, excretion, immunity, a blood reservoir, and vitamin D synthesis (Tortora and Grabowski, 1993). Skin, when healthy, continuously produces new cells and repairs itself through several glands throughout the body secreting chemicals. These secretions help create a barrier on the skin's surface. When the barrier is disturbed, a metabolic response to restore the barrier to normal is enacted. This is done through a burst of body secretions to replenish the skin's surface (Vincent, Unknown Year). During this process, fingerprints deposited on the skin would most likely be impacted. Another complication is the composition of the fingerprint closely resembles the barrier of the skin. Fingerprints are detected by exploiting the differences between the physical or chemical natures of the fingerprint and the underlying surfaces (Thomas, 1978). If the fingerprint composition resembles the surface it touches, it could potentially obscure the fingerprint itself.

Skin temperature and relative humidity both can influence fingerprints. Wilkinson et al. (1996) reported that if the skin's surface is 89.6° F or higher, the secretions will be in a liquid state or diffuse. If the secretions are in this state, the fingerprints that were deposited could wash away (Donche and Hebrard, 1994). Mieremet et al. (2019) completed a study that showed reduction in relative humidity influenced the uppermost epidermal layers resulting in epidermal cell activation. This cell activation happened at below 60% relative humidity levels. Therefore, with cells continuously being activated in low humidity environments, one can assume fingerprints deposited on the skin would be significantly impacted. This can be in a predominantly low humidity environment or a seasonal change in the weather. Egawa et al. (2002) conducted research that suggested even a short exposure to a low-humidity environment, such as three to six hours, could induce changes in the moisture content of the skin.

Since the 1970s, research on recovering latent prints from the skin of a living person has progressed. One of the first recorded successful methods was the iodine fume-silver plate method. Futrell (1996) described the iodine fume-silver plate method as heating iodine in an iodine fuming gun, directing the fumes onto the skin, laying a thin sheet of silver on the skin, removing the silver plate, and finally, exposing the plate to a strong light, which causes the prints to become visible. In 1976, Shin and Argue examined this method. Their research indicated only 25% of prints were identifiable initially, with 10% being identified after one hour and 7% after one and a half hour. Adcock (1977) conducted similar research with similar results. In 1978, Gray followed the previous research by Shin and Argue and conducted similar research on the iodine-silver plate method. Gray's results differed from Shin and Argue significantly. Gray identified 76.5% of the prints were identifiable when collected immediately after deposit, when Shin and Argue's research identified only 25%. In addition, Gray discovered prints on living skin deteriorated rapidly with time and showed the recovery rate of the prints dropping to 31.3% after 10 minutes and 2.9% after 15 minutes. Gray stated no prints were identified after 15 minutes, which again differed from Shin and Argue, who was still able to identify prints after an hour.

Reichardt et al. (1978) conducted the first research involving the direct transfer technique onto a porous surface with the kromekote lift method. In this method, he used a kromkeote paper card with high gloss on one side to lift latent prints deposited on the skin. Reichardt reported that the kromekote method developed prints up to one and a half hour after the print was deposited; however, it did not indicate any statistical data or any controls put in place for temperature or humidity. Reichardt did identify that heavy perspiration would have harm the latent print. Also, Reichardt identified that the latent print might be obscured by the skin's secretions, and the pattern could be affected by the target area of the skin's pattern. Reichardt's study indicated the target areas' hair, oiliness, and elasticity characteristics would govern the success of recovering a latent print. Rechardt's research also showed stretching out the skin of the location in which the latent print was deposited, resulted in better latent print pattern identification.

Fortunato and Walton (1998) conducted research to identify the best technique or combination of techniques to lift latent prints from human skin. Fortunato and Walton identified that superglue fuming and magnetic powder to be the most effective for developing latent prints on human skin; however, they acknowledged the inability to use this technique on living individuals due to toxicity and chemical reaction. During this research, they also examined other methods such as the lifting method (direct transfer) and dye staining. The substrates used in this research included several glossed or coated paper types, silver transfer plates, and standard paper. Fortunato and Walton stated due to only producing latent fingerprints through this technique, 50% of the time, this technique was deemed unreliable. Applying magnetic powder directly to the skin was also completed by Fortunato and Walton. This method received more inferior results than the lifting method.

Sampson and Sampson (2005) discussed a review of pertinent data on actual cases in which prints were recovered from human skin. They evaluated the common factors, developed an outline, and conducted a week-long course to verify their methods. They published guidelines in a course handout along with three additional articles published in 1992, 1996, and 1997. Sampson and Sampson followed up these activities with ongoing surveys of peers and individuals who used their techniques in the field, which also included questionnaires of attendees of workshops, classes, and seminars provided by Sampson and Sampson. Of note, Sampson and Sampson indicated approximately 1% of the respondents attended formal training courses in recovering latent prints from human skin, with 12% indicating they had processed human skin for latent print evidence based on instructions.

Sampson and Sampson identified the direct transfer method, which included kromekote card, 20 lb bond paper, cash register tape, and iodine silver plate, to be the most successful. Their review did not support the chemical development or superglue fuming as the primary method to be used. Sampson and Sampson indicated the review showed the optimal humidity to be at 58%

with an acceptable humidity range of 40% to 60% for the overall environment. They identified the optimal ambient temperature range to be at 68°F to 72°F with the acceptable ambient temperature range to be at 68°F to 78°F for the overall environment. They also related the optimal skin surface temperature of a living person to be 86°F with the acceptable skin surface temperature range to be 85°F to 86°F. Sampson and Sampson discussed that different parts of the body may be at different temperatures and may require different methods of cooling to assist in latent print development. Additionally, they discussed the responsibility in discretion and common sense when processing the skin of a living person to ensure no irresponsible or demeaning actions are taken. Sampson and Sampson indicated the transfer substrate used in workshops was relatively equal and that its success was determined by skill in the application and processing of that substrate. They indicated towards the end of the workshop, after several hours of practice, the final attempts of recovering latent prints were the most successful.

To establish which technique will have the most success this study will evaluate the direct transfer technique provided in past research to determine the most effective means to extract latent prints from living skin. For this study, three substrates and two processing methods were selected to be evaluated. These substrates and processing methods would also be compared to timeframes in which latent prints were deposited and recovered from living skin to determine the affect each variable had on the recovery and development of the latent print. The researcher also evaluated the timeframes in which the substrates combined with processing method would recover comparable latent prints from a living person's skin. In addition, environmental conditions such as room temperature control and skin temperature control would assist in identifying variables that may be controlled as indicated in previous research.

All previous research had some form of success when dealing with different substrates and obtaining latent prints from human skin. Sampson and Sampson (2005) indicated all the substrates identified in their review were equal; therefore, it was hypothesized there would be minimal difference in results from the substrates used in this research. Based on previous studies, this research will corroborate that latent prints on the skin of a living person would begin to deteriorate quickly over time due to the skin's metabolic response. Finally, it appears to be crucial to control the environment and skin temperature. Although this study did not control humidity the hypothesis was that cooling the skin surface temperature as quick as possible will increase the success in obtaining latent prints from a living individual's skin.

## Materials and Methods

### Materials

Three substrates were selected which included kromekote paper, thermal paper, and ink/laser jet paper. CTI paper was the brand used for kromekote paper, which was white 8 ½ X 11, and 12pt Cover Glossy C/1S; Pen + Gear, multipurpose bright inkjet & Laser paper which was also 8 ½ X 11; and Pen + Gear- 1/8" X 190' thermal receipt paper was allocated for the substrates. Arrowhead Forensics black magnetic latent fingerprint powder with a Zenith magnetic applicator was utilized for the magnetic powder processing technique. Arrowhead Forensics indanedione, ethyl acetate, and HFE 7100 were obtained to complete the indanedione processing. These items need to be mixed. According to the Chesapeake Bay Division-International Association for Identification (IAI) the proper mixture was 2g of indanedione, 70ml ethyl acetate and 930ml HFE 7100, in that order. A sunbeam iron was utilized as the heat activation source for the indanedione. For safety purposes gloves and a fingerprint powder mask was worn during processing. In addition, the indanedione processing was conducted under an exhaust fan to limit the potential risk of exposure to the mixed chemicals. A regular sponge without a scratch pad and gloves were utilized to protect the experiment to ensure no prints were present on the substrates, which could have impacted the research results.

The Fujifilm X-T1, with a tripod, wired remote, SD card, and 60mm lens, were utilized to capture images of the processed latent prints for examination. The Foster and Freeman's Crime-Lite 82s ALS kit was utilized for this research. Violet (400nm-430nm), blue-green (450nm-510nm), and green (480nm-560nm) were the light sources utilized from the ALS kit. The orange and red filters/goggles were utilized with blue-green ALS wavelength, red filter/goggle used with green ALS wavelength and yellow filter/goggle used with violet ALS wavelength. A latent print standards pad from Sirchie was utilized to ensure enough oils, acids, and salts were deposited for this research. A timer on an Apple iPhone was utilized to track time. To cool the skin temperature for the research, a Honeywell whole room tower fan was utilized at its coldest settings. An iHealth digital no-touch thermometer was utilized to capture the skin temperature following the collection of latent prints from the target area.

During the initial phase of setting up the research, bichromatic powder, magnetic powder, and indanedione were compared on each substrate to determine their effectiveness before conducting the research. Indanedione was successful on all substrates, magnetic powder was successful on kromekote and thermal paper, during this phase. The bichromatic was not successful on either thermal or ink/laser jet; therefore, this powder was removed as a processing technique for this study. Magnetic powder and Indanedione were selected as the processing methods of the substrates. Magnetic powder was selected based on success using this technique in many of the previous research. Indanedione was selected based on its growing use on porous surfaces and its success in adhering to amino acids from fingerprints.

Magnetic fingerprint powder, produced by mixing iron grit with aluminum flake, may be applied to a surface using a magnetic wand (Lennard, 2007). This technique was selected due to its previous success in the previous studies such as Reichardt et al. (1978) and its less destructive technique as no bristles contact the fragile latent print. Indanedione reacts to amino acids in a similar fashion as ninhydrin. Indanedione proved to be a viable alternative to traditional methods for the detection of fingermarks on porous surfaces, with more fingermarks being developed using this reagent on real samples than both DFO and ninhydrin and a combination of the two reagents (Wallace-Kunkel, 2006). For this reason, indanedione was selected as a processing technique in this study. Several processing techniques were identified for providing a heat source for indanedione processing. These included steam method, oven method and heat press method, based on what was available at the time and provided the best control for this study the iron was selected for the heat press method.

**Methods**

Direct transfer is a technique in which the paper is pressed against the skin to presumably transfer latent prints that are present on the skin. This technique was selected due to the highest success rate amongst techniques reported in Sampson and Sampson (2005). Two participants, one 36-year-old male and one 32-year-old female, participated in this research. The anterior portion of the wrist area was utilized for all research due to the size of the wrist and ability to cool this area quicker than other parts of the body and least amount of hair in that area for each participant. During each of the different processing methods the room temperature was maintained at 69° F. For the first latent print deposition method, the participant was asked to place their thumb, utilizing oils, salts and acids provided by their own fingerprints, on the wrist area with minimal hair and hold between two timed seconds applying pressure. Once the selected amount of time had elapsed either immediately after depositing, 5 minutes after deposit, 15 minutes after deposit or 30 minutes after deposit, the selected substrate was placed on the area where the fingerprint deposit was made. For this processing method no further environmental controls were made.

The second deposition method was identical to the first method; however, the latent print standard pad from Sirchie was utilized. In this method the participant placed their finger on the standard pad for one second and held it in the air for an additional five seconds to allow excess moisture to evaporate prior to depositing the latent print. At the conclusion of five seconds, they placed their finger on their wrist for an identical amount of time as the first method. The third method was identical to the second method with the standard pad; however, during the 15 minute and 30 minute recovery times, the participant placed their target area in front of a fan for the final minutes of the waiting period to cool the skin. The fourth and final method of depositing a latent print was again identical to the second and third methods; however, during the 15 minute and 30 minute recovery times, the participant placed their target area in front of a fan for the entirety of waiting period to cool the skin.

When applying the substrate to the area of the fingerprint deposit, it was applied with firm pressure and equal distribution via a sponge on the back of the substrate to ensure no impressions of the researcher's fingers were captured by the substrate. The pressure was maintained for three timed seconds and then was carefully removed by removing the sponge and pulling one side of the substrate up to ensure no rubbing of the substrate on the skin occurred. The substrate was set aside and stored at room temperature, allowing for any moisture to evaporate from the substrate. The skin's temperature was recorded, utilizing the iHealth no touch thermometer, from the target area prior to processing the substrate. The substrates identified to be processed with magnetic powder were completed with the designated magnetic powder and magnetic wand to develop the print.

Once a latent print was developed, it was photographed and submitted to a latent print examiner with seven years of experience to identify the level of identification within the latent print. Those that were designated for indanedione were dipped into the indanedione that had already been mixed to ensure the entire substrate was covered and removed. The substrate was air dried, and the substrate was stored in a dark cabinet for approximately two hours. After the two hours were complete, the substrate was removed and placed between two pieces of white copy paper and a heated iron with no water at the cotton setting was placed on top of the copy paper.

Following this, various wavelengths of the ALS were utilized to identify the latent print. **Table 1** identifies which nominal wavelength (nm) and filter was used. The respective goggles associated with the filter was also used to assist prior to photographing. The latent print was then photographed utilizing filters associated with table one wavelengths and submitted to the same latent print examiner to identify the level of identification within the latent print. According to Daluz (2019) latent prints processed with Indanedione can be viewed with an alternate light source or laser set to ~520 nm (green light); however, based the wavelength's success varies based on the substrate. For this reason, several wavelength and filter combinations were utilized to ensure the best possible photographs capturing potential latent prints.

| | Wavelength | Filter |
|---|---|---|
| Kromekote | Blue-Green (450-510nm) Peak 480 | Orange |
| Kromekote | Blue-Green (450-510nm) Peak 480 | Red |
| Thermal | Violet (400-430nm) Peak 410 | Yellow |
| Thermal | Green (490-560nm) Peak 530 | Red |
| Thermal | Blue-Green (450-510nm) Peak 480 | Orange |
| Ink/Laser Jet | Blue-Green (450-510nm) Peak 480 | Orange |
| Ink/Laser Jet | Blue-Green (450-510nm) Peak 480 | Red |

***Table 1- ALS Wavelength and Filter used for Indanedione per Substrate***

## Levels of Identification

The levels of identification were separated to determine the potential for a comparable identification of a recovered latent print. Level 4 identification was the most successful level with a latent print having distinguishable patterns that were identified. This would allow the examiner to ascertain minutiae within the pattern to include relative position with the identification of the depositor being likely if the depositor's fingerprints were submitted for comparison. Level 3 identification indicates there was some ridge detail identified with no distinguishable pattern. This level of print could still be possible to make an identification of the depositor if the depositor's fingerprints were submitted; however, the chances decreased significantly. Level 2 identification documents a fingerprint outline being present; however, no ridge detail or patterns present. There is no chance of an identification with this level of identification. Level 1 identification indicates no fingerprint present.

# Results

When utilizing the first processing method, where the participant only used their fingerprint with no standard print, no prints were able to be lifted during any time frame with any substrate or processing technique. After realizing latent prints were unable to be lifted with this processing method due to the hypothesis of lack of moisture on the skin the standard pads were utilized for the remainder of the processing methods which resulted in observable fingerprints on all substrates tested. A univariate analysis was conducted on all variables as one data set and then individually to identify significant factors within the study. The dependent variable was the level of identification. The factors were the type of substrate (paper), timeframe, processing technique, and the skin temperature when the latent print was recovered. The results indicate that each factor independently appeared to be significant **(See Table 2)**. The data indicated that a latent print could be recovered no matter what type of substrate was used. The significant different results for level of detail were impacted by the processing method, timeframe and the skin temperature which is discussed later.

**Tests of Between-Subjects Effects**

Dependent Variable: Level of Identification

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 541.303[a] | 315 | 1.718 | 10.740 | <.001 |
| Intercept | 2834.012 | 1 | 2834.012 | 17712.500 | .000 |
| TypeofPaper | 3.399 | 2 | 1.699 | 10.621 | <.001 |
| Timeframemin | 95.385 | 4 | 23.846 | 149.038 | <.001 |
| Processing | 1.943 | 1 | 1.943 | 12.146 | <.001 |
| SkinTemperature | 32.559 | 53 | .614 | 3.839 | <.001 |
| TypeofPaper * Timeframemin | 2.044 | 8 | .255 | 1.597 | .122 |
| TypeofPaper * Processing | .004 | 1 | .004 | .024 | .877 |
| TypeofPaper * SkinTemperature | 11.311 | 65 | .174 | 1.088 | .304 |
| Timeframemin * Processing | 1.271 | 4 | .318 | 1.986 | .095 |
| Timeframemin * SkinTemperature | 8.488 | 53 | .160 | 1.001 | .475 |
| Processing * SkinTemperature | 6.313 | 29 | .218 | 1.361 | .099 |
| TypeofPaper * Timeframemin * Processing | .112 | 4 | .028 | .175 | .951 |
| TypeofPaper * Timeframemin * SkinTemperature | 5.335 | 33 | .162 | 1.010 | .453 |
| TypeofPaper * Processing * SkinTemperature | .519 | 9 | .058 | .360 | .954 |
| Timeframemin * Processing * SkinTemperature | 5.348 | 18 | .297 | 1.857 | .017 |
| TypeofPaper * Timeframemin * Processing * SkinTemperature | .437 | 1 | .437 | 2.728 | .099 |
| Error | 115.040 | 719 | .160 | | |
| Total | 10476.000 | 1035 | | | |
| Corrected Total | 656.344 | 1034 | | | |

a. R Squared = .825 (Adjusted R Squared = .748)

***Table 2. Overall analysis of substrate (paper), timeframe, processing technique, and skin temperature***

A post hoc test was completed on the substrate type and showed a significant difference; however, some of this difference can be attributed to the ink/laser jet substrate only being processed with Indanedione and not magnetic powder like the other two substrates. The results showed overall that although the difference between the substrates was small, the average level of identification was higher with ink/laser jet substrate, which was only processed with Indanedione, and the thermal substrate was the lowest **(See Table 3 and Figure 1). Figure 1** shows the difference in the substrates; however, it also shows a similar trend in decreased level of identification over time. This indicates that the substrate is an independent variable; however, when combined with other variables during an analysis it no longer is independent.

**Multiple Comparisons**

Dependent Variable: Level of Identification

Bonferroni

| (I) Type of Paper | (J) Type of Paper | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| Kromekote | Thermal | .23* | .028 | <.001 | .16 | .29 |
| | Ink/Laser Jet | -.19* | .034 | <.001 | -.27 | -.11 |
| Thermal | Kromekote | -.23* | .028 | <.001 | -.29 | -.16 |
| | Ink/Laser Jet | -.42* | .034 | <.001 | -.50 | -.34 |
| Ink/Laser Jet | Kromekote | .19* | .034 | <.001 | .11 | .27 |
| | Thermal | .42* | .034 | <.001 | .34 | .50 |

Based on observed means.
The error term is Mean Square(Error) = .160.

*. The mean difference is significant at the 0.05 level.

***Table 3. Comparison analysis of substrate type significance***

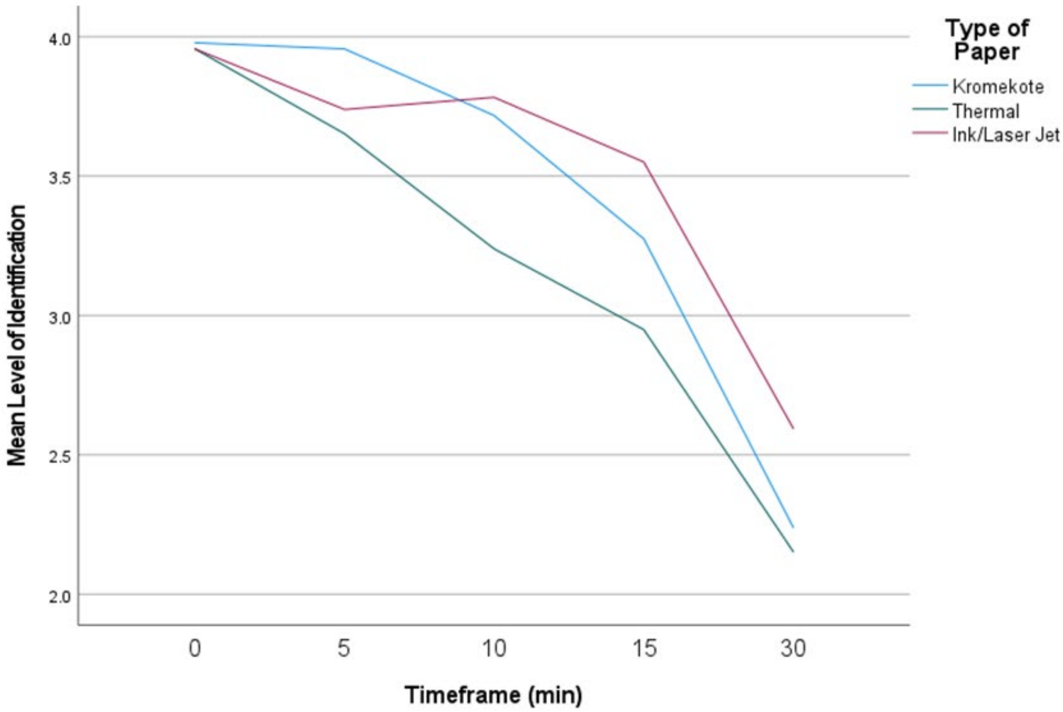


***Figure 1. Average Level of Identification per substrate compared to timeframe***

A post hoc test was completed on the timeframe, which identified there was no statistical difference between the 0- and 5-minute timeframe; however, it showed significant difference across the 10-, 15-, and 30-minute timeframes. Essentially 0–5-minute timeframes showed little to no difference between the level of identification across timeframes. After 5 minutes, a significant degradation was identified and decreased the likelihood of recovering a suitable latent print **(See Table 4).**

**Multiple Comparisons**

Dependent Variable: Level of Identification
Bonferroni

| (I) Timeframe (min) | (J) Timeframe (min) | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 0 | 5 | .17* | .053 | .010 | .03 | .32 |
| | 10 | .43* | .053 | <.001 | .28 | .57 |
| | 15 | .77* | .043 | <.001 | .64 | .89 |
| | 30 | 1.69* | .043 | <.001 | 1.57 | 1.81 |
| 5 | 0 | -.17* | .053 | .010 | -.32 | -.03 |
| | 10 | .25* | .053 | <.001 | .10 | .40 |
| | 15 | .59* | .043 | <.001 | .47 | .71 |
| | 30 | 1.52* | .043 | <.001 | 1.39 | 1.64 |
| 10 | 0 | -.43* | .053 | <.001 | -.57 | -.28 |
| | 5 | -.25* | .053 | <.001 | -.40 | -.10 |
| | 15 | .34* | .043 | <.001 | .22 | .46 |
| | 30 | 1.26* | .043 | <.001 | 1.14 | 1.39 |
| 15 | 0 | -.77* | .043 | <.001 | -.89 | -.64 |
| | 5 | -.59* | .043 | <.001 | -.71 | -.47 |
| | 10 | -.34* | .043 | <.001 | -.46 | -.22 |
| | 30 | .92* | .030 | <.001 | .84 | 1.01 |
| 30 | 0 | -1.69* | .043 | <.001 | -1.81 | -1.57 |
| | 5 | -1.52* | .043 | <.001 | -1.64 | -1.39 |
| | 10 | -1.26* | .043 | <.001 | -1.39 | -1.14 |
| | 15 | -.92* | .030 | <.001 | -1.01 | -.84 |

Based on observed means.
The error term is Mean Square(Error) = .160.

*. The mean difference is significant at the 0.05 level.

***Table 4. Overall Analysis of time frames 0, 5, 10, 15, and 30 minutes.***

The processing technique was evaluated next. Indanedione and magnetic powder were analyzed and compared. The analysis showed magnetic powder had similar levels of identification as indanedione in the 0-5 minute ranges, but during the 10, 15 and 30 minute timeframes indanedione had the average higher level of identification. This analysis did not include the effects of implementing a skin temperature control, such as the fan. This most likely can be attributed to the water within the fingerprint evaporating and leaving behind amino acids which indanedione is known to adhere to, which allowed for higher levels of identification than magnetic powder **(See Figure 2)**.

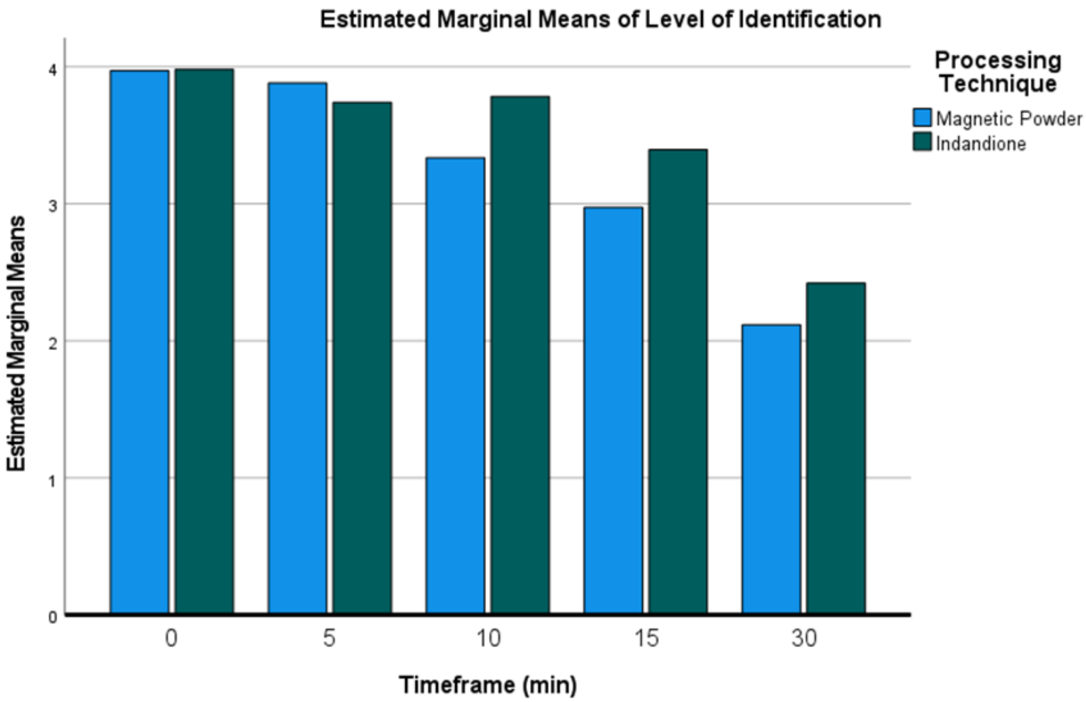


***Figure 2. The average level of identification per processing technique compared to the timeframe***

Finally, the percentages of the level of identifications 1 through 4 were identified for each substrate paired with processing technique for each time frame and temperature control. In all of the research, there were no level 1s identified for any of the time frames used, except for the first processing method. **Table 5** shows the percentages at 0 minutes of collection, while **Table 6** shows the percentages at 5 minutes. Although there is a drop in percentage, the drop was not as significant as the later timeframes were. Additionally, you can see the thermal-magnetic combination had a significant drop in levels of identification compared to the others. This can be seen when all combinations had a level above 70% level 4 identification while the thermal-magnetic combination fell under 60%. **Table 7** contains the percentages at the 10 minute time frame. This again shows thermal-magnetic underperforming the rest of the combinations as only 4.3% were level 4 identifications. This table also showed a continued degradation of the level of identification with indandione processing having a higher percentage of the level of identification than magnetic powder.

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | — | — | 100% |
| Thermal-Magnetic | — | — | 8.7% | 91.3% |
| Kromekote-Indanedione | — | — | 4.3% | 95.7% |
| Thermal-Indanedione | — | — | — | 100% |
| Ink/Laser Jet | — | — | 4.3% | 95.7% |

***Table 5- Level of Identification at 0 minutes***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | — | 4.3% | 95.7% |
| Thermal-Magnetic | — | — | 43.5% | 56.5% |
| Kromekote-Indanedione | — | — | 4.3% | 95.7% |
| Thermal-Indanedione | — | — | 26.1% | 73.9% |
| Ink/Laser Jet | — | — | 26.1% | 73.9% |

***Table 6- Level of Identification at 5 minutes***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | 4.3% | 34.8% | 60.9% |
| Thermal-Magnetic | — | 8.7% | 87% | 4.3% |
| Kromekote-Indanedione | — | — | 13% | 87% |
| Thermal-Indanedione | — | — | 47.8% | 52.2% |
| Ink/Laser Jet | — | — | 21.7% | 78.3% |

***Table 7- Level of Identification at 10 minutes***

**Tables 8-10** contain the percentages of all methods used for the 15-minute time frame. An analysis identified that over time, the level of identification continued to degrade. When using a fan for the last 5 minutes of the time frame there was slight improvement. When the fan was utilized the entire timeframe to cool the skin, there was an increase in level 4 identifications with all substrate combinations; but primarily the highest in kromekote and ink/laser jet substrate combinations with indanedione.

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | 8.7% | 78.3% | 13% |
| Thermal-Magnetic | — | 30.4% | 69.6% | — |
| Kromekote-Indanedione | — | 8.7% | 65.2 | 26.1% |
| Thermal-Indanedione | — | 17.4% | 73.9% | 8.7% |
| Ink/Laser Jet | — | — | 65.2% | 34.8% |

***Table 8- Level of Identification at 15 minutes***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | 13% | 65.3% | 21.7% |
| Thermal-Magnetic | — | 30.4% | 69.6% | — |
| Kromekote-Indanedione | — | 4.3% | 69.6% | 26.1% |
| Thermal-Indanedione | — | 4.3% | 91.4% | 4.3% |
| Ink/Laser Jet | — | — | 60.9% | 39.1% |

***Table 9- Level of Identification at 15 minutes (Fan utilized last 5 minutes)***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | 8.7% | 47.8% | 43.5% |
| Thermal-Magnetic | — | — | 91.3% | 8.7% |
| Kromekote-Indanedione | — | 4.3% | 13% | 82.7% |
| Thermal-Indanedione | — | — | 65.2% | 34.8% |
| Ink/Laser Jet | — | — | 8.7% | 91.3% |

***Table 10- Level of Identification at 15 minutes (Fan utilized entire time)***

**Tables 11-13** contain the percentages of all methods used for the 30-minute time frame. Much like the 15-minute time frame, little significance was identified when the fan was utilized for the last 5 minutes of the time frame; however, a significant increase in level 3 identifications was identified when using the fan, the entire time to cool the skin temperature. The increase in the level of identification when cooling the skin the entire time can be further shown with the level 4 identifications that none of the other methods at 30 minutes were able to achieve.

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | 91.3% | 8.7% | — |
| Thermal-Magnetic | — | 100% | — | — |
| Kromekote-Indanedione | — | 91.3% | 8.7% | — |
| Thermal-Indanedione | — | 95.7% | 4.3% | — |
| Ink/Laser Jet | — | 78.3% | 21.7% | — |

***Table 11- Level of Identification at 30 minutes***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | 82.6% | 17.4% | — |
| Thermal-Magnetic | — | 95.7% | 4.3% | — |
| Kromekote-Indanedione | — | 87% | 13% | — |
| Thermal-Indanedione | — | 91.3% | 8.7% | — |
| Ink/Laser Jet | — | 65.2% | 34.8% | — |

***Table 12- Level of Identification at 30 minutes (Fan utilized last 5 minutes)***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | 73.9% | 26.1% | — |
| Thermal-Magnetic | — | 87% | 13% | — |
| Kromekote-Indanedione | — | 30.4% | 69.6% | — |
| Thermal-Indanedione | — | 43.5% | 52.2% | 4.3% |
| Ink/Laser Jet | — | — | 78.3% | 21.7% |

***Table 13- Level of Identification at 30 minutes (Fan utilized entire time)***

## Discussion

This study addressed the direct transfer technique and its ability to lift latent prints from the skin of a living person. Previous studies established that prints were able to be obtained from an hour up to 5 hours after being deposited on the skin of a living person. This study showed that due to the degradation of prints from 10-30 minutes, the ability to obtain prints an hour or more after deposit is very unlikely. Although there was a significant drop in success with the thermal substrate combined with the magnetic powder processing technique, the thermal paper still successfully lifted prints from the skin. The difference between the various substrates in obtaining latent prints was minimal. The most significant factor in determining success was the timeframe. The skin temperature followed as the second most significant factor as when the skin was cooled the entire time the levels of identification increased across variables. Finally, once the processing technique became significant when dealing with the longer timeframes with indanedione being more successful with longer time frames.

This study was limited on the number of participants due to the COVID-19 pandemic for safety reasons. Additionally, this study occurred during winter months that is a significantly drier and less humid environment. This significantly affects the skin metabolic responses and the number of oils and secretions that compose fingerprints create. For this reason, the latent print standard print pad was used to ensure the proper number of sebaceous oils, amino acids, and salts were deposited to properly analyze the direct transfer technique and its effectiveness.

The timelines within this study identified a need for quick response and the need for this technique to be utilized for latent print recovery. Waiting minutes can severely degrade the level of identification of the latent prints that could potentially be collected. Lee et al. (2017) identified that the Houston Police Department, Houston, TX, established response time goals specifically for domestic incidents. If a weapon was involved, a 5-minute response time was the goal and if no weapon an 18-minute response time. Not accounted for was the amount of time for first responders to ascertain the situation, which is valuable time lost. Based on this study and timeframes, if attempts are to be made to obtain comparable latent prints from the skin of a living person, the first responders should be trained in the controls to help slow the degradation process, such as cooling of the skin, or other controls in different environments, and the proper collection of these utilizing the direct transfer technique. Although the direct transfer technique is not the only technique, it appears to be the least harmful and intrusive.

During the study, it was observed that leaving a substrate out overnight did not develop prints with magnetic powder; however, indanedione was still able to develop the latent print. Indanedione is rarely available for first responders, so policies should be established in time frames for processing the substrate with powders or getting to the appropriate technician to process with indanedione. This study showed higher percentages of level 3 identifiable latent prints over time rather than level 4. Stoney et al. (2019) identified that previous fingerprints labeled as insufficient for identification had enough ridge detail that would fit in level 3 for potential comparison. Although, level 3 is not comparable to level 4, the possibility for identification is still present.

Law enforcement should consider the timeframe of the assault and actions after the assault when determining to use the direct transfer technique. Delayed reports do happen and those that do not fit within the timeframe of this research need not use the direct transfer technique. Understanding the actions of the victim is important as well. Victims tend to rub the areas due to pain or discomfort, and they have been known to wash the locations as well. In these instances, if you are in the timeframe, latent print recovery should be attempted; however, expectations should be tempered. One of the most essential things to brief a latent print examiner after a successful latent print recovery is to brief them on the methods used because this method creates a mirror image of the fingerprint.

## Conclusion

This study had 1035 trials overall with 23 trials per combination of substrate, processing technique, timeframe, and skin temperature control. Being limited to two participants reduced the possibility of comparing age, gender, and race in the analysis. Additionally, studies could identify how much oil, acids, and salts that are deposited by fingerprints based on these different categories. The same could identify the metabolic response of the skin for each of these different categories. This would most likely need to be in a completely controlled environment, which would include control over humidity. The studies, much like “Sampson” discussed, should focus on air temperature control, humidity, and the skin temperature to further analyze the differences between age, gender, and race.

Victims typically do not get assaulted in the most controlled environments, so additional studies should be conducted not to identify the best environment to obtain the latent prints, but to find out the best methods to counteract the fingerprint degradation over time. Some methods to consider are techniques to help cool the skin rapidly due to it being a hot day, dry the skin without damaging latent prints, or other means of controls that may need to be implemented to assist in latent print recovery.

Studies should also identify what are the best locations of the body to use the direct transfer technique. This study solely focused on the wrist, but future studies should identify ease of access to those locations and ways to control skin temperature of that area. Further analysis of the different substrates and best processing techniques need to continue and be pushed to the field as this will have a direct impact on the direct transfer technique if implemented in the field. Few documented studies have been conducted since 2015; however, studies should continue to narrow down proper procedures for this activity in the field by conducting additional studies. If the research continues, and there is training conducted with first responders on collecting this key physical evidence, latent prints from the skin of a living person could provide key evidence in many cases where physical evidence is currently lacking.

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# Appendix A

| | Wavelength | Filter |
|---|---|---|
| Kromekote | Blue-Green (450-510nm) Peak 480 | Orange |
| Kromekote | Blue-Green (450-510nm) Peak 480 | Red |
| Thermal | Violet (400-430nm) Peak 410 | Yellow |
| Thermal | Green (490-560nm) Peak 530 | Red |
| Thermal | Blue-Green (450-510nm) Peak 480 | Orange |
| Ink/Laser Jet | Blue-Green (450-510nm) Peak 480 | Orange |
| Ink/Laser Jet | Blue-Green (450-510nm) Peak 480 | Red |

***Table 1- ALS Wavelength and Filter used for Indanedione per Substrate***

**Tests of Between-Subjects Effects**

Dependent Variable: Level of Identification

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 541.303[a] | 315 | 1.718 | 10.740 | <.001 |
| Intercept | 2834.012 | 1 | 2834.012 | 17712.500 | .000 |
| TypeofPaper | 3.399 | 2 | 1.699 | 10.621 | <.001 |
| Timeframemin | 95.385 | 4 | 23.846 | 149.038 | <.001 |
| Processing | 1.943 | 1 | 1.943 | 12.146 | <.001 |
| SkinTemperature | 32.559 | 53 | .614 | 3.839 | <.001 |
| TypeofPaper * Timeframemin | 2.044 | 8 | .255 | 1.597 | .122 |
| TypeofPaper * Processing | .004 | 1 | .004 | .024 | .877 |
| TypeofPaper * SkinTemperature | 11.311 | 65 | .174 | 1.088 | .304 |
| Timeframemin * Processing | 1.271 | 4 | .318 | 1.986 | .095 |
| Timeframemin * SkinTemperature | 8.488 | 53 | .160 | 1.001 | .475 |
| Processing * SkinTemperature | 6.313 | 29 | .218 | 1.361 | .099 |
| TypeofPaper * Timeframemin * Processing | .112 | 4 | .028 | .175 | .951 |
| TypeofPaper * Timeframemin * SkinTemperature | 5.335 | 33 | .162 | 1.010 | .453 |
| TypeofPaper * Processing * SkinTemperature | .519 | 9 | .058 | .360 | .954 |
| Timeframemin * Processing * SkinTemperature | 5.348 | 18 | .297 | 1.857 | .017 |
| TypeofPaper * Timeframemin * Processing * SkinTemperature | .437 | 1 | .437 | 2.728 | .099 |
| Error | 115.040 | 719 | .160 | | |
| Total | 10476.000 | 1035 | | | |
| Corrected Total | 656.344 | 1034 | | | |

a. R Squared = .825 (Adjusted R Squared = .748)

***Table 2. Overall Analysis of substrate (paper), timeframe, processing technique, and skin temperature***

**Multiple Comparisons**

Dependent Variable: Level of Identification

Bonferroni

| (I) Type of Paper | (J) Type of Paper | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| Kromekote | Thermal | .23* | .028 | <.001 | .16 | .29 |
| | Ink/Laser Jet | -.19* | .034 | <.001 | -.27 | -.11 |
| Thermal | Kromekote | -.23* | .028 | <.001 | -.29 | -.16 |
| | Ink/Laser Jet | -.42* | .034 | <.001 | -.50 | -.34 |
| Ink/Laser Jet | Kromekote | .19* | .034 | <.001 | .11 | .27 |
| | Thermal | .42* | .034 | <.001 | .34 | .50 |

Based on observed means.
The error term is Mean Square(Error) = .160.

*. The mean difference is significant at the 0.05 level.

***Table 3. Comparison analysis of substrate type significance***

**Multiple Comparisons**

Dependent Variable: Level of Identification

Bonferroni

| (I) Timeframe (min) | (J) Timeframe (min) | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 0 | 5 | .17* | .053 | .010 | .03 | .32 |
| | 10 | .43* | .053 | <.001 | .28 | .57 |
| | 15 | .77* | .043 | <.001 | .64 | .89 |
| | 30 | 1.69* | .043 | <.001 | 1.57 | 1.81 |
| 5 | 0 | -.17* | .053 | .010 | -.32 | -.03 |
| | 10 | .25* | .053 | <.001 | .10 | .40 |
| | 15 | .59* | .043 | <.001 | .47 | .71 |
| | 30 | 1.52* | .043 | <.001 | 1.39 | 1.64 |
| 10 | 0 | -.43* | .053 | <.001 | -.57 | -.28 |
| | 5 | -.25* | .053 | <.001 | -.40 | -.10 |
| | 15 | .34* | .043 | <.001 | .22 | .46 |
| | 30 | 1.26* | .043 | <.001 | 1.14 | 1.39 |
| 15 | 0 | -.77* | .043 | <.001 | -.89 | -.64 |
| | 5 | -.59* | .043 | <.001 | -.71 | -.47 |
| | 10 | -.34* | .043 | <.001 | -.46 | -.22 |
| | 30 | .92* | .030 | <.001 | .84 | 1.01 |
| 30 | 0 | -1.69* | .043 | <.001 | -1.81 | -1.57 |
| | 5 | -1.52* | .043 | <.001 | -1.64 | -1.39 |
| | 10 | -1.26* | .043 | <.001 | -1.39 | -1.14 |
| | 15 | -.92* | .030 | <.001 | -1.01 | -.84 |

Based on observed means.
The error term is Mean Square(Error) = .160.

*. The mean difference is significant at the 0.05 level.

***Table 4. Overall Analysis of time frames 0, 5, 10, 15, and 30 minutes.***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | — | — | 100% |
| Thermal-Magnetic | — | — | 8.7% | 91.3% |
| Kromekote-Indanedione | — | — | 4.3% | 95.7% |
| Thermal-Indanedione | — | — | — | 100% |
| Ink/Laser Jet | — | — | 4.3% | 95.7% |

***Table 5- Level of Identification at 0 minutes***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | — | 4.3% | 95.7% |
| Thermal-Magnetic | — | — | 43.5% | 56.5% |
| Kromekote-Indanedione | — | — | 4.3% | 95.7% |
| Thermal-Indanedione | — | — | 26.1% | 73.9% |
| Ink/Laser Jet | — | — | 26.1% | 73.9% |

***Table 6- Level of Identification at 5 minutes***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | 4.3% | 34.8% | 60.9% |
| Thermal-Magnetic | — | 8.7% | 87% | 4.3% |
| Kromekote-Indanedione | — | — | 13% | 87% |
| Thermal-Indanedione | — | — | 47.8% | 52.2% |
| Ink/Laser Jet | — | — | 21.7% | 78.3% |

***Table 7- Level of Identification at 10 minutes***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | 8.7% | 78.3% | 13% |
| Thermal-Magnetic | — | 30.4% | 69.6% | — |
| Kromekote-Indanedione | — | 8.7% | 65.2 | 26.1% |
| Thermal-Indanedione | — | 17.4% | 73.9% | 8.7% |
| Ink/Laser Jet | — | — | 65.2% | 34.8% |

***Table 8- Level of Identification at 15 minutes***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | 13% | 65.3% | 21.7% |
| Thermal-Magnetic | — | 30.4% | 69.6% | — |
| Kromekote-Indanedione | — | 4.3% | 69.6% | 26.1% |
| Thermal-Indanedione | — | 4.3% | 91.4% | 4.3% |
| Ink/Laser Jet | — | — | 60.9% | 39.1% |

***Table 9- Level of Identification at 15 minutes (Fan utilized last 5 minutes)***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | 8.7% | 47.8% | 43.5% |
| Thermal-Magnetic | — | — | 91.3% | 8.7% |
| Kromekote-Indanedione | — | 4.3% | 13% | 82.7% |
| Thermal-Indanedione | — | — | 65.2% | 34.8% |
| Ink/Laser Jet | — | — | 8.7% | 91.3% |

***Table 10- Level of Identification at 15 minutes (Fan utilized entire time)***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | 91.3% | 8.7% | — |
| Thermal-Magnetic | — | 100% | — | — |
| Kromekote-Indanedione | — | 91.3% | 8.7% | — |
| Thermal-Indanedione | — | 95.7% | 4.3% | — |
| Ink/Laser Jet | — | 78.3% | 21.7% | — |

***Table 11- Level of Identification at 30 minutes***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | 82.6% | 17.4% | — |
| Thermal-Magnetic | — | 95.7% | 4.3% | — |
| Kromekote-Indanedione | — | 87% | 13% | — |
| Thermal-Indanedione | — | 91.3% | 8.7% | — |
| Ink/Laser Jet | — | 65.2% | 34.8% | — |

***Table 12- Level of Identification at 30 minutes (Fan utilized last 5 minutes)***

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Kromekote-Magnetic | — | 73.9% | 26.1% | — |
| Thermal-Magnetic | — | 87% | 13% | — |
| Kromekote-Indanedione | — | 30.4% | 69.6% | — |
| Thermal-Indanedione | — | 43.5% | 52.2% | 4.3% |
| Ink/Laser Jet | — | — | 78.3% | 21.7% |

***Table 13- Level of Identification at 30 minutes (Fan utilized entire time)***

**Appendix B**

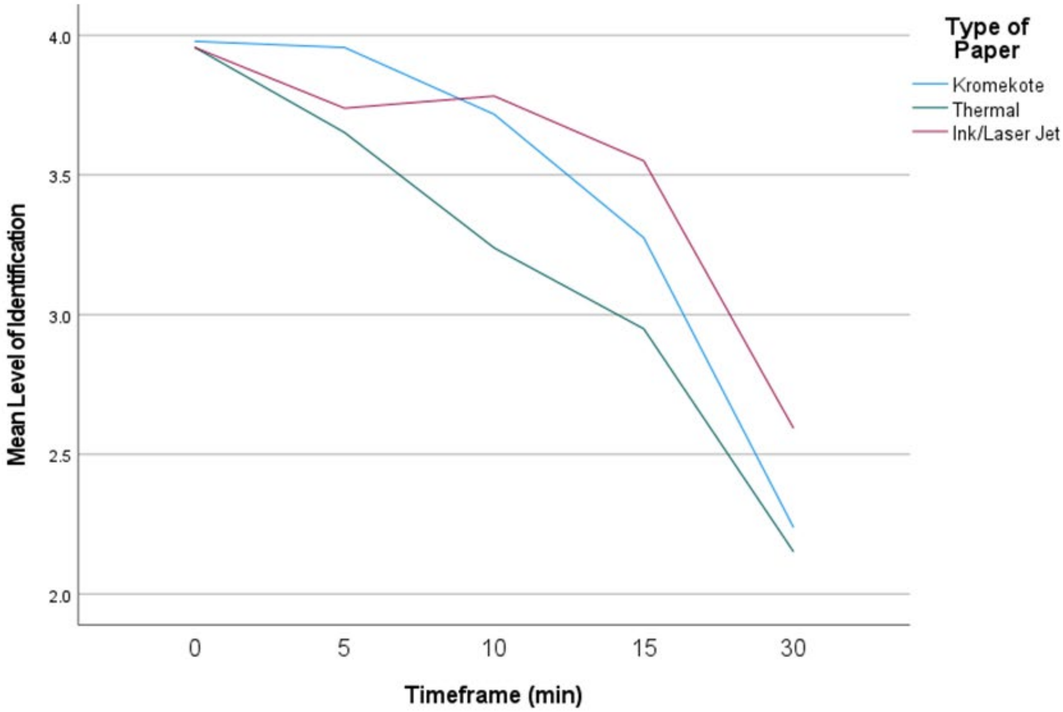


***Figure 1. Average Level of Identification per substrate compared to timeframe***

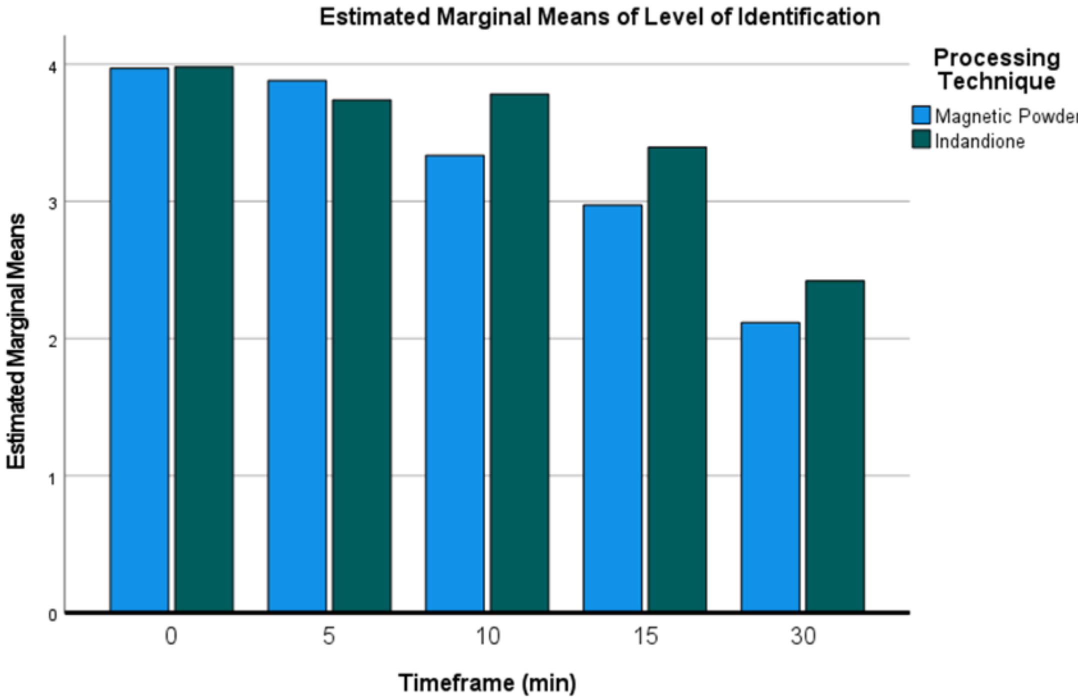


***Figure 2. Average level of identification per processing technique compared to timeframe***