



How Long Can an Identifiable Fingerprint Persist on an Exterior Surface?

Simon Bunter BSc FFS

April 2014

Abstract

Opinions have been offered that fingerprints at crime scenes were recently placed because, over time, they will fade, become damaged and ultimately disappear and the weather and environmental conditions will expedite this process.

Experiments by the author have shown that some fingerprints in residues from food and linseed oil can survive for over 2½ years on a non-porous surface despite being subjected to various UK weather conditions in an external environment. These fingerprints visualised readily, did not require persistent powdering to develop, were of good quality and suitable for identification. Some of the prints were already visible prior to powdering. The results refute generalised opinion and training regarding the age of a fingerprint based solely on its apparent freshness.

1. Introduction

The question regarding how long a fingerprint can survive is a common one in criminal cases when the defendant maintains that contact occurred on an earlier legitimate occasion. In previous casework, some fingerprint and forensic personnel have expressed the opinion that a fingerprint is ‘fresh’ due to several ‘indicators’ (summarised in 1.2. and 1.3.).

Correctly matched fingerprints are strong evidence in associating an individual to a place or object. The individual in question may accept the correctness of the identification but offer the explanation that contact occurred on an earlier occasion, not related to the crime. This will often prompt questions from the defence and prosecution such as; is it possible to establish when contact occurred or how long could the fingerprint have persisted?

1.1. Previous Scientific Research and Case Studies

Research regarding the age of fingerprints is not new, indeed there have been many published research papers detailing changes in fingerprint composition over time [1-7]. These appear to be mainly laboratory based tests that include measuring degradation of the constituents of fingerprints formed in eccrine sweat and sebaceous secretions. Merkel’s work [8, 9], however, employs a different approach, counting binary pixel for the approximation of a mathematical ageing function. Holyst [10] describes analysing changes in the perspiratory-adipose substance to determine a presumable time on smooth and unabsorptive surfaces within the limits from 24 hours to a few years. It is unclear, however, whether these tests would be satisfactorily accurate when dealing with crime scene marks that could contain other contaminants. Merkel [8] reports an average error of 13-40% for the ageing function of each series. Howorka [11] discusses the survivability of fingerprints explaining that “...it is impossible to arrive at safe conclusions as to when a trace was formed” and “...the substance used to make a print visible certainly play[s] a part as well”.



Although the research [1-10] appears to form a basis on which to develop a useful ageing method in the future, practical and accurate applications of these techniques have yet to be adapted to establish the age of a crime scene mark during criminal investigations. Wertheim [12] describes the challenges facing the development of such a technique, stating that the method must either account for all relevant factors affecting the latent print, including its initial quality, or it must hinge on a constituent in the print that is not significantly affected by the many different variables of environmental conditions, substrate and deposition. Further work would appear to be needed before any method is implemented as a reliable police tool. Merkel's 2012 paper [9] appears to acknowledge this challenge stating that their proposed method "...might provide the means to solve the so far unresolved issue of determining a fingerprint's age in forensics." Until such a method is found, however, it is likely that CSIs and Fingerprint Officers will continue to be invited to comment on the age of a crime scene mark.

Several published articles do relate to real-world practical examples regarding identifiable fingerprints that might be seen in everyday criminal casework [13-18]. De Alcaraz-Fossoul [13] reported that fingerprints exposed to direct sunlight degrade similarly to those in the dark and that sebaceous latent fingerprints on glass were still useful for identification after six months. Tweedy [14] reported that identifiable fingerprints can persist on plastic carrier bags for over seven years. Bunter [15] reported a case study where a surface bearing a left hand impression had been cleaned down several times and even painted over, however, the impressions had survived as they were formed in an old layer of paint, a matter not noted by the CSI. Cohen [16] reported a 'fixation' phenomenon of a fingerprint to a metal window frame allowing it to be recovered and identified more than two and a half years later. Cohen [17] further investigated the effect of cleaning products on the survivability of latent fingerprints and disputed the assumption that they do not survive cleaning agents.

An Australian case study [18] described that three members of a Fingerprint Bureau and a Scientist with "considerable research in experience in latent fingerprints" opined it was unlikely that the fingerprints of a Police Officer on an external window surface had survived two years, even though it was confirmed that he and a colleague had legitimately visited the premises two years earlier. The Fingerprint Officers and the scientist appeared to mainly base their opinion on the good quality of the ridge detail. Subsequent further investigation showed that other fingerprints on the window were made by the Police Officer's colleague who accompanied him to the premises two years earlier. These fingerprints were of the same good quality and showed good powder adherence. The police officer and his colleague had not worked together since they visited the premises. It was this information that allowed investigators to draw the conclusion that the police officer was telling the truth and contact had occurred two years earlier. The prints had survived two Australian summers and winters with a temperature range of 1°C to 40°C without any telltale signs of age. It was only when other factors were taken into consideration that the police officer was shown to be telling the truth and the three Fingerprint Officers and Scientist were shown to be wrong. This is an ideal example of the type of case that Midkiff [19] referred to when he concluded that "...speculation or court testimony concerning the



time when a latent print was placed is fraught with danger and may be hazardous to the reputation of the examiner”.

One case study by Schwabenland [20] describes undertaking research to determine whether fingerprints could last outside on aluminium cans for one week. The paper concluded that “it was determined that high-quality latent impressions with clear ridge detail could not have remained on the exterior surfaces of the aluminium beer cans for 1 week”. This raises the issue of the difference between proving a negative compared to proving a positive. A ‘positive’ result, even on a small scale, can often be useful and easy to prove whereas, unless considerable work is undertaken to cover all variables, a ‘negative’ result can be essentially meaningless. For example, the finding of a person’s fingerprint on an item demonstrates that they touched it. The lack of a person’s fingerprint on an item, however, does not demonstrate that they did not touch it. Similarly, if a limited set of variables by Schwabenland [20] provided a negative result, it cannot be assumed that another set of variables would not provide a positive result. This appears to be covered in a riposte by McRoberts and Kuhm [21], who argued that Schwabenland failed to fully consider the potential variables in the case.

In spite of the above published work and case studies, some CSIs and Fingerprint Officers still continue to proffer the opinion that a fingerprint was more likely to have been placed recently. Case studies [15, 16, 18] show that it is often a holistic examination of the surrounding evidence that can assist in establishing the age of a print rather than an examination of the quality of the fingerprint or assuming the weather conditions will have a damaging effect.

1.2. Previously Proffered Opinions

Questions regarding longevity are often answered by the police Crime Scene Investigator and/or police Fingerprint Officer, some of whom have, in the author’s experience, suggested that the mark was placed recently. Examples of their reasoning in previous casework include (paraphrased from actual cases):

- The fingerprint powder readily adhered to the latent impression and it did not require persistent powdering. This is an indication that the mark is fresh as the powder adheres to the wet constituents.
- The good quality and clarity of the mark is an indicator that the mark has suffered little deterioration or detrimental damage. This is consistent with the latent mark having been placed only a short period of time prior to the CSI’s examination.
- The fingerprint was treated with aluminium powder, which is a treatment used for fingerprints left in sweat. Sweat consists mainly of water (98% - 99.5%). If the weather had been inclement, I would expect the mark to be “washed away” due to the effects of the rain and, therefore, the mark would appear faint on the lift. If, however, the weather was generally good, I would still expect signs of deterioration. The sweat from the fingerprint is mainly made up of water and would evaporate and fade in the sun. This evaporation would also result in the mark to appear faint in the lift.



- They were the only identifiable fingerprints found which is suggestive of recent application. The lack of other identifiable impressions suggests that the surface and environmental conditions did not readily contribute to the successful retention of latent marks over a period of time.

These 'indicators' appear to be relied on because more scientific techniques (referred to in section 1.1) have yet to be adapted for practical use in criminal investigations.

1.3. Police Training in the UK

The above opinions appear to be backed-up by course notes for the fingerprint courses from the National Training Centre for Scientific Support for Crime Investigation (NTCSSCI) [22]. The notes contain a section entitled "Defences to Fingerprint Evidence" that appears to be aimed at refuting the possibility of legitimate access:

"Attempts may be made to prove that the scene of crime mark was left at the scene by the accused when he visited the premises lawfully on a previous occasion. There are a number of ways in which this allegation can be dispensed with and the question as to the age of the marks should be considered."

The notes then go on to consider the "Age of Fingerprints":

"If there is a lack of evidence to give any suggestion as to the age of the fingermark the officer's best answer to each question is 'I do not know', unless other factors or indications are present. In attempting to determine the age of fingerprints the following points should be borne in mind;

- a. If the fingerprint powder readily adhered to the impression and did not require persistent powdering, this is an INDICATION and nothing more that the mark is fresh as opposed to old.
- b. ...A fingerprint left on an object outside which is exposed to the elements of the weather will not usually last as long as a mark left inside premises which has been afforded some protection.
- c. If the occasion arises when the sweat deposit forming the fingerprint is visible prior to applying powder this is a GOOD INDICATION that the mark is fresh.
- d. Scenes of Crime and Fingerprint Officers should never attempt to indicate the age of a fingerprint unless they have considerable experience in developing and recovering fingerprints.
- e. Any attempt at refuting a defence allegation in this connection may entail a Scene of Crime Officer giving an informed opinion."



These notes, although appearing to suggest that more caution is needed than that shown in some of the above casework examples in 1.2., appear to be aimed towards rebutting the argument that a fingerprint could have been placed before the offence. Little published information, however, has been found to support this training approach.

Although the above quoted sections are from training notes published several years ago, they would have formed part of the training for many Fingerprint Officers and appear to reflect the recent opinions provided by the prosecution in section 1.2. I understand that, at the time of writing, the NPIA are in the process of updating the National Fingerprint Training Notes but these will not be available to non-police personnel.

1.4. Reasons for Undertaking this Research

Due to the findings in published research and the propensity to assume marks are fresh because they can be easily powdered, I studied the efficiency of fingerprint development on marks left on wood, uPVC and glass to ascertain whether they could survive prolonged periods of time. The manner in which any surviving marks were developed was noted to establish whether any of the 'indicators', relied on by some CSIs and Fingerprint Officers to show a mark was 'fresh', were also present in older marks.

2. Methodology

Prior to the main experiments regarding longevity of fingerprints on glass, two preliminary experiments were set up to provide a general indication of how long fingerprints can persist on painted wood in an interior environment and on uPVC in an exterior environment. The experiments also aimed to test whether the substance in which the prints were formed affected the results. The results of these preliminary tests were considered when preparing the main research for fingerprints on glass. One donor, capable of depositing good quality identifiable fingerprints, was used to place the fingerprints. For the purposes of this research no other donors were used.

2.1. Placement of the Marks

For both preliminary tests and the main experiments, the hands were prepared by initially washing with soap and water to remove any contaminants that may have been present. The forefinger, middle finger and ring finger (from the right hand for the preliminary tests and mainly from the left hand for the main experimentation) were wiped over the various substances (apart from those prints deposited in naturally secreted eccrine sweat) and any excess wiped off so that only a relatively small amount remained on the fingers. The excess was wiped off for two reasons; firstly, previous experience has shown that too much substance on a finger can result in poor quality fingerprints being deposited and, secondly, to try and replicate real life situations where a person may notice too much of a substance on their hands and wipe off the excess, leaving a relatively small amount.



The fingers were placed onto the substrate within a few seconds of the substance being touched. This helped regulate the type and amount of contaminant on the fingers. The intention was to initially deposit good quality fingerprints onto the substrate and, where possible, oblique lighting was used to confirm that the quality and clarity of those recently deposited fingerprints were identifiable.

2.2. Development and Assessment of the Marks

Initially, areas of each substrate were examined to establish whether the latent marks were visible to the naked eye before powdering. Marks were developed by brushing aluminium powder onto the substrate using the technique outlined in the Manual of Fingerprint Development Techniques by the Police Scientific Development Branch.

The enhanced marks were examined to determine whether they were identifiable. Whether a fingerprint is of suitable quality to be 'identifiable', however, is subjective, i.e. one Fingerprint Expert may opine that a mark is sufficient for identification but another Expert may disagree. Consideration was given to counting the number of ridge characteristics visible in each of the marks, however, this is also subjective. As such, where a fingerprint has been described as 'identifiable' in the results sections, it is the author's opinion based on his own personal experience that includes examining fingerprint identifications across police Fingerprint Bureaux in the United Kingdom and abroad. The photographs of marks on glass in 4.3. show what the author considers to be identifiable fingerprints. If it is unclear whether a fingerprint is identifiable, it has been described as such in the tables of results, e.g. 'possibly sufficient for identification'.

3.1. Preliminary Testing – Contact Marks on an Interior Surface (Wood)

3.1.1. Preparation

The substrate used was a piece of wood that had previously been painted white. The wood was kept indoors on top of a cupboard, away from further possible contacts and environmental conditions (although it was noted during the experiment that dust accrued on the wood over time). The wood was marked into five sections to be examined after five different time periods; 2 weeks, 2 months, 3 months, 6 months and over one year.

The substances on the fingers used to place the prints were as follows:

- **Eccrine sweat.** The donor's hand was thoroughly washed and left to dry and nothing else was touched prior to placement. This helped ensure that only the sweat secreted from the sweat pores in the finger was present on the skin and no contaminants were present. A few minutes elapsed before contact to allow a quantity of sweat to be secreted. The hand felt dry to the touch and was not obviously 'sweaty'.



- **Sebaceous Sebum and Apocrine Sweat.** The hand was wiped on the donor's head, face and armpit ensuring that sebum and sweat from these areas coated the fingers. This was to test whether the properties of different types of sweat had any effect on the longevity of fingerprints.
- **Glue stick.** The fingers touched the adhesive from a 'Pritt Stick' glue stick.
- **Dirt.** The fingers touched the external vertical surface of the luggage compartment (boot/trunk) at the back of a car that was dirty from general road use.

Eccrine sweat, sebaceous sebum and apocrine sweat were chosen as substances for this experiment as they are naturally secreted from the body's pores. Dirt from the back of a car was chosen as it may have had different properties to the colourless secreted sweat and could easily be deposited onto a person's hands, for example, when operating a vehicle's rear luggage compartment. The glue stick was chosen for its adhesive qualities and as a contaminant that could be deposited on a person's hands if they had been using it.

The three fingers bearing the substance were placed onto a designated area of the wood in one contact, resulting in three marks being deposited for development after two weeks. The fingers were then cleaned and the same substance reapplied in approximately the same quantity. This process of contact was repeated four more times for marks for development after two months, three months, six months and over one year respectively. This was carried out for all four substances.

Overall, this resulted in 15 prints being placed in each of the four substances, a total of 60 fingerprints on the wood. An area where three prints were deposited, in each of the four substances, were examined after each of the five time intervals.



3.1.2. Table of Results

| | 2 weeks | 2 months | 3 months | 6 months | Over 1 year |
|-------------------------------------|--|--|--|--|--|
| Eccrine sweat | No marks noted before powdering. All 3 marks good quality and identifiable. Developed easily. | No marks noted before powdering. All 3 marks of reasonable quality but still identifiable. Required a lot of powdering to develop. | No marks noted before powdering. Only 1 of 3 marks identifiable. Lots of powder needed to develop. | No marks noted before powdering. At least 2 of 3 marks clear and identifiable. Required a lot of powdering to develop. | No marks noted before powdering. All 3 marks poor and not identifiable. Marks very faint. |
| Sebaceous and Apocrine sweat | Marks visible before powdering. All 3 marks identifiable but some indistinct areas. Developed very easily. | Marks visible before powdering. 2 of 3 marks identifiable. Developed very easily and quickly. | Outline of marks visible before powdering. All 3 marks identifiable. Developed easily and quickly. | Outline of marks visible before powdering. All 3 marks identifiable. Developed easily and quickly. | Marks visible before powdering. 2 of 3 marks identifiable. Developed relatively easily but longer powdering time required than same marks at 6 months stage. |
| Glue stick | Marks visible before powdering. Poor quality with only 1 of 3 marks possibly identifiable. Required a lot of powdering to develop. | No marks noted before powdering. Poor quality insufficient area found. Very faint. | Small area of mark visible before powdering. 1 of 3 marks reasonable quality, possibly identifiable. Required a lot of powdering to develop. | Small area of mark visible before powdering. Poor quality ridge detail found. Not identifiable | No marks noted before powdering. Poor quality ridge detail found. Not identifiable |
| Dirt | 3 of 3 marks easily visible and identifiable before powdering. | 3 of 3 marks easily visible and identifiable before powdering. Appear visually similar to when first placed. | 2 of 3 marks easily visible and identifiable before powdering. Appear visually similar to when first placed. | 2 of 3 marks easily visible and identifiable before powdering. | 2 of 3 marks easily visible and identifiable before powdering. |

3.1.3. Summary of Results

The eccrine sweat marks were initially good quality and identifiable, however, with time they required the application of more aluminium powder in order to develop. Identifiable marks were still present after 6 months but not after one year.

Two of the sebaceous and apocrine sweat marks were still identifiable over one year later. These marks required less aluminium powder to develop than the eccrine sweat marks. These marks still developed easily and quickly after 6 months.

The glue stick appeared to be a poor matrix for which to leave identifiable marks and required a lot of powdering to develop even after only 2 weeks.

The marks in dirt were visible without powdering and did not appear to change in appearance after several months. Two of the marks were identifiable over one year after placement.



Many crime scene marks, however, are recovered from exterior surfaces that are exposed to environmental conditions. Further preliminary experimentation was therefore carried out to factor in any effects caused by the weather.

3.2. Preliminary Testing – Contact Marks on an Exterior Surface (uPVC)

3.2.1. Preparation

The substrate used was a piece of white uPVC guttering that was marked into several sections to be examined after five different time periods; 20 days, 40 days, 2½ months and two undefined periods. The uPVC was attached to a drainpipe in a back garden where it was exposed to weather conditions.

The substances on the fingers used to place the latent marks were as follows:

- **Eccrine sweat.** Method as described in 2.1.1.
- **Sebaceous Sebum and Apocrine Sweat.** Method as described in 2.1.1.
- **Coca-Cola.** The fingers were placed in a small amount of Coca-Cola. The excess was wiped of the fingers so they were 'sticky' rather than 'wet'.
- **Deodorant.** Deodorant was sprayed onto the fingers and then waited to dry before placement.
- **Crisps.** The fingers were wiped on the inside of a packet of crisps that contained 'Sunseed Oil'.
- **Grease.** The fingers touched the grease on the door hinges of a car.

Eccrine sweat, sebaceous sebum and apocrine sweat were chosen as substances for this experiment as they are naturally secreted from the body's pores. Coca-Cola and crisps were used as sugary and oily food stuffs that may be deposited on a person's hand. Crisps are generally eaten using bare hands and drinks can be spilt (the author had also noted many bottles of Coca-Cola were 'sticky' to the touch when handled in a shop, presumably from the drink itself being somehow spilt or leaked onto the bottles). Deodorant was chosen as it was an everyday item that, when sprayed, a small amount could fall onto the operator's hand. Grease was used as a non-specific alternative to the other substances and could be deposited on a person's hand if working on a vehicle, for example.

Similar to the test on wood, three fingers bearing the substance were placed onto a designated area of the wood in one contact. This time, however, the fingers were cleaned and the substance reapplied and a 'duplicate' three finger contact mark was deposited, resulting in six marks being deposited for development after 20 days. The fingers were cleaned again and the same substance reapplied in approximately the same quantity. This process of 'duplicate' contact marks was repeated four more times for development after 40 days, 2½ months and two further undefined time periods. This was carried out for all six substances.



Overall, this resulted in 30 prints being placed in each of the six substances, a total of 180 fingerprints on the uPVC. An area containing six prints in each of the six substances were examined after 20 days, 40 days and 2½ months. Due to the poor quality of the marks developed at the 2½ months stage, the remaining areas (designated for the fourth and fifth time periods) were examined and no identifiable quality marks were found. As such, the test was halted at this stage.

The prints were deposited in April so the weather over the 2½ months was a mixture of spring/summer conditions in North-East England.

3.2.2. Table of Results

| | 20 days | 40 days | 2½ months |
|-------------------------------------|---|--|--|
| Eccrine sweat | No marks noted before powdering. No marks developed. | No marks noted before powdering. No marks developed. | N/A |
| Sebaceous and Apocrine sweat | Marks visible before powdering. 1 of 6 marks identifiable. Developed quickly and easily. | Faint marks visible before powdering. All 6 marks visible but poor clarity. Possibly not identifiable. Marks still developed quickly and easily. | No marks noted before powdering. No identifiable marks developed. |
| Coca-Cola | Marks visible before powdering. 3 of 6 marks were very good quality and identifiable. Developed quickly and easily. | Some debris noted attached to marks before powdering. 3 of 6 marks of good identifiable quality. Developed quickly and easily. | No marks noted before powdering. No identifiable marks developed. |
| Deodorant | No marks noted before powdering. 2 of 6 marks possibly identifiable. | No marks noted before powdering. No marks developed. | No marks noted before powdering. No marks developed. |
| Crisps (with 'Sunseed Oil') | Marks visible and appear 'wet' before powdering. 3 of 6 marks very good quality and identifiable. All 6 marks developed quickly and easily. | Some debris noted attached to marks before powdering. All 6 marks poor quality and not identifiable. All 6 marks developed quickly and easily. | Some debris noted attached to marks before powdering. No identifiable marks. |
| Grease | Some marks easily visible before powdering. All 6 marks very good quality and identifiable. All 6 marks developed quickly and easily. | Some debris noted attached to marks before powdering. All 6 marks very good quality and identifiable. All 6 marks developed quickly and easily. | Some debris noted attached to marks before powdering. All 6 marks generally poor quality. Some detail visible but probably not identifiable. |

3.2.3. Summary of Results

It would appear that the weather had removed the eccrine sweat marks within the first 20 day period. One of the sebaceous and apocrine sweat marks survived for 20 days in an identifiable condition suggesting that this type of sweat was more durable than eccrine sweat.

All 6 marks in grease remained in an identifiable condition 40 days after they were placed. Three of the marks in Coca-Cola remained in an identifiable condition for 40 days.



All 6 marks in the residue from a crisp packet were identifiable after 20 days but had deteriorated after 40 days. The marks appeared 'wet' after they had been outside for 20 days.

There were no identifiable marks in deodorant after 20 days. It is possible that deodorant is a poor matrix in which to retain fingerprints.

These results tend to suggest that some contaminants that may be touched by a person (e.g. greasy substances) have more robust properties than sweat naturally secreted by the pores on the hands.

As a result of these findings, the main experiment was set up to see whether other contaminants that a person may find on their hands, could enable fingerprints to last for longer periods when exposed to environment conditions.



4. Main Experimentation – Marks on an Exterior Surface (Glass)

4.1. Preparation

Glass was used as a substrate due to its relative commonality as an external surface from which fingerprints are recovered at crime scenes. The substrate used was toughened glass, which was marked into several sections with 'permanent' marker, to be examined after five different time periods; 3 months, 1 year, 2½ years and two undefined periods. The glass was placed against an external wall in a rear garden where it was exposed to weather conditions.

The substances on the fingers used to place the latent marks were as follows:

- **Sausage and chips (from a fish and chip shop).** The food was eaten with bare hands and the oily residues on the fingers were placed on the glass.
- **Sweet Chilli dipping sauce.** The fingers were placed in a small amount of 'Blue Dragon' Sweet Chilli dipping sauce.
- **Linseed oil putty.** The fingers touched the contents of a tub of 'Vallance' Linseed oil putty.
- **Honey.** The fingers were placed into 'Tesco' Pure Clear Honey from a jar.
- **Extraction fan above hob on oven.** The fingers were wiped over the extraction fan vent above the hob of an oven. There was a control panel for the extraction fan and a light situated near the vent.
- **Children's paracetamol pain relief suspension.** The fingers were placed into the 'Boots' strawberry pain relief solution (120mg/5ml) that left a sticky residue on the fingers.
- **Fly spray.** 'Raid' fly and wasp killer spray was sprayed onto the fingers.

Eccrine, sebaceous and apocrine sweat were not used in this experiment as they had not persisted on the uPVC and this experiment was intended to be carried out over a longer period of time. The sausage and chips, chilli dipping sauce and honey were chosen as different food stuffs that a person might handle. Linseed oil putty was chosen for its use in windows and reported hardening qualities. Fingers were wiped over the extraction fan above the oven hob to test the fats, oils and greases given off by cooking. It was noted that the administration of paracetamol solution to a child often resulted in the deposit of a sticky residue onto the fingers. Fly spray, when sprayed, could result in some of it falling onto the operator's hand.

Similar to the test on uPVC, three fingers bearing the substance were placed onto a designated area of the glass in one contact. The fingers were then cleaned, the substance reapplied and a 'duplicate' three finger contact mark was deposited. This was repeated so that there were six prints placed in each of the seven substances for



each of the five time periods. A total of 210 fingerprints were deposited on the glass. An area containing six prints in each of the seven substances were examined after 3 months, 1 year and 2½ years. The remaining marks in the areas designated for the fourth and fifth time periods were used for other research purposes. As such, this test was halted at the 2½ years stage.










The experiments commenced in October 2008 and continued through to June 2011. The weather for the initial three months included heavy snowfall, severe frost, strong gale force winds, heavy rain and sunshine, although it was never ‘hot’ (as it was winter). The weather over the 2½ years covered most weather conditions normally encountered in North-East England.

4.2. Table of Results

| | 3 months | 1 year | 2½ years |
|--|---|--|--|
| Sausage and chips | Marks easily visible before powdering. At least 3 of 6 marks were of very good quality and identifiable. The powder adhered quickly and easily. | Marks easily visible before powdering. 5 of 6 marks were very good quality and identifiable. The powder adhered quickly and easily. | Marks easily visible before powdering. 2 of 6 marks were of reasonable quality and identifiable. The powder adhered quickly and easily. |
| Sweet Chilli sauce | Poor quality marks visible before powdering. No ridge detail. | No marks noted before powdering. No ridge detail in any of the remaining areas. | N/A |
| Linseed oil putty | Marks easily visible before powdering. At least 3 of 6 marks were of very good quality and identifiable. The powder adhered quickly and easily. | Marks easily visible before powdering. At least 5 of 6 marks were very good quality and identifiable. The powder adhered quickly and easily. | Marks easily visible before powdering. 3 of 6 marks were of very good quality, clarity and were identifiable. The powder adhered quickly and easily. |
| Honey | Poor quality marks visible before powdering. No ridge detail. | No marks noted before powdering. No ridge detail in any of the remaining areas. | N/A |
| Extraction fan | Marks visible before powdering. At least 3 of 6 marks were of very good quality and identifiable. The powder adhered quickly and easily. | Marks faintly visible before powdering. 3 of 6 marks of reasonable quality were identifiable. The powder adhered quickly and easily. | 1 of 6 marks reasonable quality, possibly sufficient for identification. More powdering required for development. |
| Children’s Paracetamol suspension | Poor quality marks visible before powdering. No ridge detail. | No marks noted before powdering. No ridge detail in any of the remaining areas. | N/A |
| Fly Spray | No marks noted before powdering. At least 2 of 6 marks of reasonable quality were identifiable. The powder adhered quickly and easily. | No marks noted before powdering. No ridge detail in any of the remaining areas. | N/A |



4.3. – Photographs of one of the identifiable marks in each substance that had persisted for each of the three time periods.

| | Sausage and Chips | Linseed Oil Putty | Extraction Fan | Fly Spray |
|---------------|---|---|---|---|
| 3 months |  |  |  |  |
| 1 year |  |  |  | |
| Over 2½ years |  |  | | |



4.4. Summary of Results

After 3 months several areas of the 'permanent' marker used to mark out the sections of the glass had been worn away.

The fingerprints placed in the oils from sausage and chips and the linseed oil putty were clearly visible before powdering, even after 2½ years. After three months, some of the areas of contact in the chilli sauce, honey, substances from extraction fan and paracetamol suspension were also visible before powdering but were fainter and oblique lighting had to be used. The marks in fly spray were not visible to the naked eye before powdering.

The marks from the sausage and chips and the linseed oil lasted for over two and a half years. Several of the marks were of very good quality, clarity and were identifiable. The aluminium powder adhered to the marks quickly and easily. After two and a half years some of the marks in the oils from the sausage and chips appeared to have less clarity than those in the linseed oil putty, although two were still good quality and identifiable.

The marks in the greases from the extraction fan above the oven hob were identifiable after one year, however, the quality and clarity was less than those from the oils from the sausage and chips and the linseed oil.

Some of the marks in the fly spray remained in an identifiable condition for three months but no longer.

The chilli sauce, honey and paracetamol suspension appeared to be a poor matrix to retain fingerprints for the initial three month period.

5. Discussion

5.1. Summary of Findings

The oily residues from the sausage and chips and the linseed oil appeared to be very good matrices in which fingerprints could persist in an identifiable condition for prolonged periods of time. It could be argued that the chances of a person handling Linseed Oil before leaving a fingerprint are fairly slim (unless they have reason to come into contact with it, e.g. through their employment or hobby). The types of residues from sausage and chips, however, could be fairly commonly encountered.

The marks in the residues from the sausage and chips and the linseed oil putty were not permanent yet remained very good quality and were identifiable. These marks had survived the environmental conditions that had appeared to remove many of the other marks and some of the ink from the 'permanent' marker pen on the glass.



These findings show that latent fingerprints can last for prolonged periods of time, even in an outdoor environment exposed to the weather. Identifiable marks in four of the seven contaminants on the glass lasted for three months and some lasted for over 2½ years. Several of the marks were very good quality and remained in an identifiable condition. The majority of these marks required little aluminium powder to develop.

In light of these findings, the common assumptions referred to in 1.2. and 1.3. of this paper can be addressed as follows:

i. The crime scene mark was left in sweat.

A person may pick up small amounts of different substances on their hands from touching different objects and surfaces. Any resultant latent fingerprints deposited could therefore be eccrine sweat, sebaceous sebum, various contaminants or a mixture of eccrine sweat, sebum and contaminants. When contaminated fingerprints are placed they may appear visually indistinguishable to fingerprints placed in sweat or sebum. There is currently no routine test to establish whether a mark is formed in sweat or a contaminant such as oil or grease. As such, it is not possible to determine the proportion of recovered crime scene marks that are in sweat, contaminants or a mixture of both. A developed latent fingerprint, therefore, should not be assumed to be in sweat.

ii. Aluminium powder adheres to the moisture component of sweat.

Aluminium powder lifts can highlight the slightest change in apparently smooth surfaces with no moisture present. Fingerprint lifts often contain background detail that shows the texture of a surface and small details in it.

iii. Fresher marks visualise more easily than older marks.

The experimentation has shown that latent marks over 2½ years old can be visualised easily, quickly, readily and require only a minimal amount of aluminium powder. The ease and speed with which a latent mark develops appears to be at least partially dependant on the substance in which it was formed.

iv. The weather damages fingerprints.

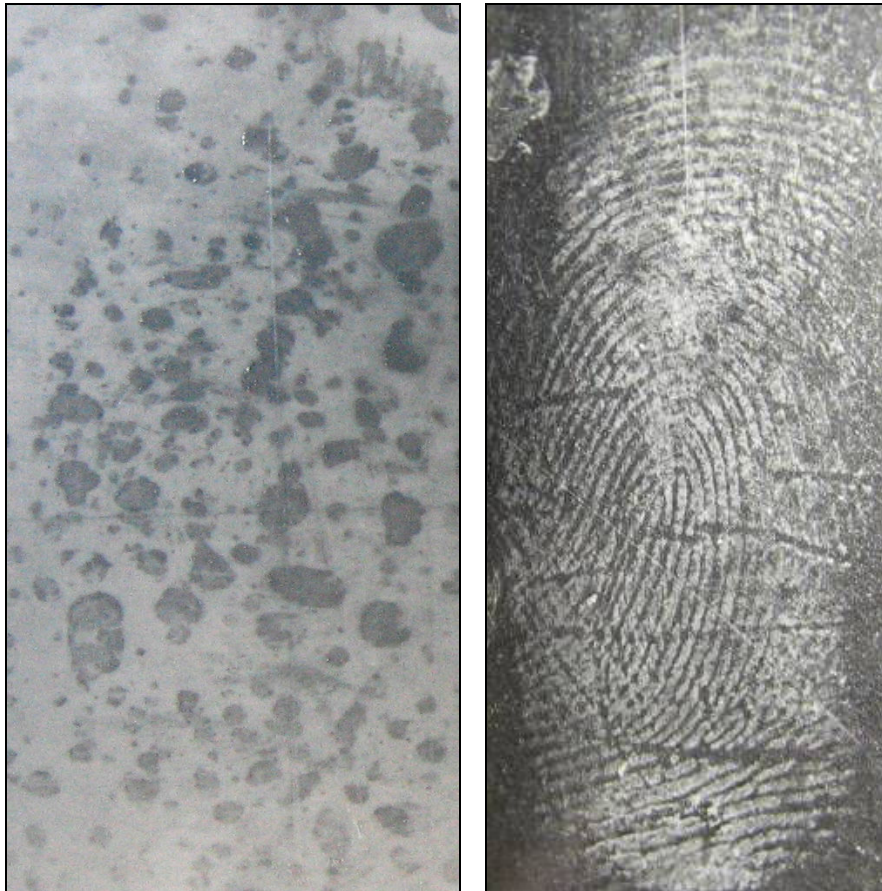
The experimentation has shown that the weather can damage and destroy some marks, however, others can persist relatively undamaged for prolonged periods of time.

v. The quality of a mark deteriorates over time.

Although the quality of some marks can deteriorate over time, the good quality of other marks can persist. This can result in some old marks being of very good quality. Image 1 below shows two marks that enhanced readily with aluminium powder. Both marks were deposited by the same donor. One of the marks is less than three weeks old and one is one year old. Is it possible to tell which is relatively recent and which is old due to their quality or appearance?



Image 1 – Which mark is the oldest?



The mark on the left in image 1 is 20 days old and was one of the poor quality marks formed in Coca-Cola and recovered from an external uPVC surface (as described in table 3.2.2.). The mark on the right is over one year old and was one of the identifiable marks formed in oils from sausage and chips. It was recovered from an outside surface exposed to environmental conditions (as described in table 4.2. and shown in photographs 4.3.). These two photographs demonstrate that the quality of the mark cannot be relied upon as an indicator of age.

vi. The lack of other fingerprints suggests the marks that were found were recently placed.

Different fingerprints placed in different contaminants may produce varied results over time. Therefore, the lack of other fingerprints on a surface that may or may not have been subsequently touched is essentially irrelevant.

vii. A mark that is visible before applying powder is a good indication that it is fresh.

Several of the marks that persisted for long periods were visible before being powdered, including those that lasted for over 2½ years. The marks were in a colourless substance that was visually indistinguishable from sweat.



5.2. Potential Further Work

These experiments, although proving that some fingerprints can persist for prolonged periods could be expanded to include other variables. For example:

- Using a larger number of donors could assist in establishing whether the eccrine sweat and sebaceous sebum secreted from different people's pores produces results that significantly affect how long fingerprints in these substances can persist.
- More specific experiments could be carried out in relation to the substrate, e.g. do certain substrates possess properties which may make a fingerprint robust (similar to that described by Cohen [16, 17]) or does UV degradation to a surface 'fix' a fingerprint?
- Other 'fast foods' could also be handled to test whether they possess the same robust properties as those displayed by the marks in oils and greases from sausage and chips.
- The time periods between the contaminant being placed onto the fingers and subsequent contact with the substrate could be increased. For example, does leaving a few hours between the contaminant arriving on the fingers and contact affect the result? A difficult issue with this type of test might be that it may be hard to regulate other contacts that the donor might have in that intervening time period. For example, if the donor goes about their daily routine they may pick up other contaminants on their hands or wash off the original contaminants. The resulting fingerprints would be placed in an unknown substance. This set of experiments dealt with known contaminants.
- Depletion series of fingerprints could be used to determine what effect, if any, the quantity of the substance has on longevity.

6.1. Conclusion

The purpose of the experiments undertaken in this paper was to determine whether an identifiable fingerprint could persist for prolonged periods of time when exposed to environmental conditions. The findings showed that this occurred with several marks.

The longevity of a fingerprint is variable and dependant on several factors including the substance in which it is formed. Some fingerprints are fragile and can be relatively easily removed by environmental conditions. The sweat secreted by the eccrine pores in the hands appears to be one of those substances that can be easily damaged. Indeed, the older marks placed in eccrine sweat in the preliminary testing required further powdering and were faint fitting with the CSIs and Fingerprint Officers comments in 1.2. and 1.3. In a person's day-to-day activities, however, they will often touch other items and surfaces which can result in the transfer of contaminants to their hands. For example, touching one's own face or hair may result in sweat from sebaceous pores being transferred to one's hands. The constituents of sebaceous sweat can make it more durable than eccrine sweat and it can therefore last



longer. Eating food stuffs can transfer a variety of substances to a person's hands. Only small amounts of contaminants are required to deposit a fingerprint, so much so that a person's fingers may appear relatively clean. Some of these marks persisted for over 2½ years yet still displayed the 'indicators' that some CSIs and Fingerprint Officers relied on to suggest a mark was 'fresh', i.e. they visualised easily, quickly, readily and required only a minimal amount of aluminium powder.

The apparent assumptions that fingerprints are made in eccrine sweat and can be damaged or removed by environmental conditions will only be true some of the time. It follows, therefore, that some fingerprints will not be formed in only eccrine sweat, will not be damaged or removed by environmental conditions and can last for prolonged periods of time. It is generally not possible to establish what medium latent fingerprints were left in by a visual examination.

The findings of this research show that the aging of fingerprints is neither simple nor based on a formula. Depending on the conditions, well-defined identifiable fingerprints can be recovered many months or years after their placement even in harsh environments. To make an assumptive comment that a fingerprint is 'fresh' without scientific reasoning can bias a case, provide a false evaluation of the evidence and mislead a court.

References

- [1] Giorgia De Paoli et al, Photo- and Thermal-Degradation Studies of Select Eccrine Fingerprint Constituents, J Forensic Sci, July 2010, Vol. 55, No. 4, 962-969
- [2] Céline Weyermann et al, Initial Results on the Composition of Fingerprints and its Evolution as a Function of Time by GC/MS Analysis, Vol 56, Issue 1, 102-108 January 2011
- [3] Dikshitulu YS et al, Aging Studies on Fingerprint Residues Using Thin-layer and High Performance Liquid Chromatography, Forensic Science International, 1986, 31 (4): 261-266
- [4] Ricci C et al, Chemical Imaging of Latent Fingerprint Residues, Applied Spectroscopy 2007, 61(5): 514-522
- [5] Stephan Barcikowski et al, Contribution to the Age Determination of Fingerprint Constituents Using Laser Fluorescence Spectroscopy and Confocal Laser Scanning Microscope, Optical Materials in Defence Systems Technology, 23 (December 16, 2004)
- [6] Krystyna Baniuk, Determination of the Age of Fingerprints, Forensic Science International, 46(1-2) May-June 1990, 133-137
- [7] Nia E Archer et al, Changes in the Lipid Composition of Latent Fingerprint Residue with Time after Deposition on a Surface, 154 (2-3) 25 November 2005 224-239



- [8] Merkel R et al, Approximation of a Mathematical Aging Function for Latent Fingerprint Traces Based on First Experiments Using a Chromatic White Light (CWL) Sensor and the Binary Pixel Aging Feature, Communications and Multimedia Security 2011 59-71
- [9] Merkel R et al, On Non-invasive 2D and 3D Chromatic White Light Image Sensors for Age Determination of Latent Fingerprints, Forensic Science International 2012, 222 (1-3): 52-70
- [10] Holyst B, Criminal Assessment of the Age of Fingerprints, Arch Kriminol, 1987 Mar-Apr; 179(3-4):94-103
- [11] Horst Howorka, Questions Relating to the Determination of the Age of Objects Assuming Relevance in Criminal Investigations, Fingerprint Whorld, July 1989, 23-28
- [12] Kasey Wertheim, Fingerprint Age Determination: Is There Any Hope? Journal of Forensic Identification 2003 53(1) 42-49
- [13] De Alcaraz-Fossoul J, Determination of Latent Fingerprint Degradation Patterns – A Real Fieldwork Study, Int J Legal Med 2013 Jul;127(4):857-70
- [14] Catherine Tweedy, How long can Fingerprints Survive on – Plastic bags? FDI AI News April – June 2010 18-21
- [15] Simon Bunter, Fingerprints in Paint, Fingerprint Whorld, Vol 34, No 130, December 2007, 21-23
- [16] Yaron Cohen, Eran Rozen, Myriam Azoury, David Attias, Beni Gavrielli, Michal Levin Elad, Survivability of Latent Fingerprints Part I: Adhesion of Latent Fingerprints to Smooth Surfaces, Journal of Forensic Identification, 62 (1), 2012 \ 47-53
- [17] Yaron Cohen, Myriam Azoury, Michal Levin Elad, Survivability of Latent Fingerprints Part II: The Effect of Cleaning Agents on Survivability of Latent Fingerprints, Journal of Forensic Identification, 62 (1), 2012 \ 54-61
- [18] Sgt Dean Greenlees, Age Determination – Case Report, Fingerprint Whorld, April 1994, 20(76): 50-52
- [19] Charles R. Midkiff, Lifetime of a Latent Print, How Long? Can You Tell? J. Forensic Ident. 43 (4) 1993 386-392
- [20] J F Schwabenland, Determining the Evaporation Rate of Latent Impressions on the Exterior Surfaces of Aluminium Beverage Cans, Journal of Forensic Identification, 42(2) March/April 1992 84-90



[21] A L McRoberts, K E Kuhn, Review of the Case Report: Determining the Evaporation Rate of Latent Impressions on the Exterior Surfaces of Aluminium Beverage Cans, *Journal of Forensic Identification*, 42(3) May/June 1992: 213-218

[22] National Training Centre for Scientific Support for Crime Investigation, fingerprint course notes, dated 20/06/97 (more recent notes not available to non-police personnel)