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Impressions/Ink Intersection Sequencing — A Comprehensive Overview

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This paper explores the sequencing technique between ESDA detectable impressions and ink strokes. The method assists in the determination of the execution order of visible ink lines and intersecting ESDA impressions. Critical factors, suggested procedures, interpretation and tips on conducting the work are considered and addressed in detail. Consideration is also given to conflicting papers on this topic.

Introduction

The impression/ink sequencing method was first published in 1993 and has been applied in many high-profile cases where issues arose regarding the backdating of entries. Although it has broad application to casework, the authors note that its use by forensic document examiners (FDEs) has been quite limited. Further, it is within the experience of both authors that the technique has been adopted by some FDEs in an improper, casual manner without proper study and practice, or a full understanding of the process and interpretation of results. It must be stressed that in order to become competent at this technique, a considerable amount of research and practice has to be completed by the FDE in order to comprehend and clearly identify the features of critical importance. One would not go to court and give evidence on handwriting without proper expert theoretical and practical training yet it appears that offering opinions based on a scant understanding of the sequencing process has been noted in court proceedings.

In the past two years, workshops on its application have been presented at the American Society of Questioned Document Examiners annual meeting in August 2009, the American Academy of Forensic Sciences meeting in March 2011, and most recently at the Forensic Science Society conference in April 2011. These presentations have focused heavily on the proper application of the technique and accurate interpretation of results. In an effort to further FDEs' understanding of the method this paper provides a comprehensive, detailed overview of all pertinent issues. This article may be of assistance as a procedure manual while doing actual casework.

What is Impression/Writing Line Sequencing?

The technique can utilize either the Electrostatic Detection Apparatus (ESDA) or similar equipment such as the Indentation Materializer Electrostatic Detection Device (IMEDD). Detectable impressions can be developed using either the cloud or cascade method.

Electrostatic detection devices are utilized to highlight and identify impressions of writings caused by the pen pressure exerted through a sheet of paper onto an underlying document. For ease of reference "ESDA impression lines" or "ESDA impressions" will refer to the detectable indented writing impressions developed as dark lines on the ESDA or IMEDD lift. The term "physical impression" will relate to the groove, or trough, created in the paper surface by the pressure being applied via a writing instrument, often a ballpoint pen, during the deposit of ink on the paper.

The sequencing technique is the study of the ESDA impression lines and the visible ink lines at the points of intersection on the document being tested, to establish their sequence of production, i.e. to determine whether the impressions were made before or after the visible ink was produced on the sheet.

The technique was reported by Radley (1993, 1995) and further commented on by Lindblom (2006) and Ellen (2006). The application has been expanded on by Allen (1997) and Mohammed (1997) with respect to the intersection of writ-

ing impressions with highlighter markings and ink jet printing respectively. This paper explores various applications and tips for the production of useful and reliable results.

The obvious sequences for ESDA impressions and visible ink are that (1) indentations are created on a blank underlying document that is subsequently written on, or (2) impressions are created on a sheet already bearing handwriting by writing on an overlying document.

The applications are numerous as many questions arise regarding the sequence of production for entries in, for example, diaries, agendas, meeting notes, police incident books, medical and legal files, minutes of meetings, forms said to be signed in blank, different dated documents produced en masse, etc.

The sequencing technique can be applied in situations where the writings are on different sides of a single sheet of paper. For example, one may examine the sequence of writings on the obverse and reverse of a single sheet in a diary, journal, or medical progress note, etc.

The Basic Premise of the Method

When liquids and chemicals come into contact with a document, existing ESDA impression lines will be permanently destroyed. The outcome is the same when an ink (a combination of chemicals) overwrites ESDA impression lines provided the ink coverage is continuous, without striations or skips at the points of intersection. This latter point is an immensely important criterion for the reliability of the technique and is discussed in more detail later in the paper.

From the above premise, the following results might be expected - although in practice this is not necessarily always the case:

- If the visible ink line was produced **before** the ESDA detectable impressions, then the dark ESDA impression lines may appear unbroken at the point of intersection – in other words, they run (or partially run) across the visible ink line.
- Alternatively, if the visible ink lines were written after the ESDA detectable impressions were made, then no ESDA impression will run across the intersection, or even partially across it, as the ink line will destroy the ESDA impressions. This presumes that the ink line is free of striations, skips or other voids at the points of intersection. The ESDA impression line will not be destroyed in the un-inked areas. This latter point is addressed in detail later.

The question of whether all intersection points provide an answer to the sequence of production is emphatically **NO**. Many factors come into play that impact on the suitability of a particular intersection to provide a result. Consequently, it is desirable to have as many intersection points for examination as possible, although in some cases only very limited intersections can give very positive evidence of sequence.

Variables that Must be Considered

It has long been known that good ESDA results depend on a variety of factors, such as:

- Pen type – fiber tip, ballpoint, gel, or marker
- Pen pressure – light to heavy, sometimes causing a significant groove in the paper surface, and sometimes not; contrast between light upstrokes and heavy downstrokes
- Paper surface – smooth, rough or fibrous
- Underlying surface – hard, soft or irregular
- Impressions made over wet ink

Sequence Determination

This part of the discussion will be divided into two categories based on pen type. The first deals with non-ballpoint pens including fiber tip, porous tip, and nib; the second with ballpoint writing instruments. Experimentation and practical casework reveal that the sequence of writing/ESDA impression lines is more easily and more often conclusively identified in the former group of writing implements. It is believed that the nature of nib or tip used and the type of ink applied have a considerable impact.

As will be covered later, the interpretation of ballpoint pen writings and ESDA impression intersections can be more problematic than those involving non-ballpoint pen writing. It is often the case that positive results for ballpoint pen writings will either not be achieved or will be achieved at a reduced level of confidence. The more straightforward situation of non-ballpoint pens will therefore be considered first.

Sequence of ESDA Impressions and Non-ballpoint Pen Inks

In most instances, the basic premise will apply. Soon after writing, the 'dried' non-ballpoint pen ink is capable of 'taking' an ESDA impression, i.e. allowing the impression to be laid down on top of the ink in a detectable fashion. In most instances, non-ballpoint pens do not produce significant grooves in the paper surface partially due to the nature of the tip and partially due to the ink applied. The combination may, in any event, result in the relaxation of the fibers rather than creating a heavy permanent groove in the paper. When an ESDA impression is made over the top of dried non-ballpoint pen ink, generally one can see a continuous black ESDA impression across the visible ink stroke (Figure 1). However, when an ESDA impression exists on a paper and the wet non-ballpoint pen ink is applied across it, the ink will permanently destroy the impression. The result is a clear break in the black ESDA line where it intersects with the ink (Figure 2).

Generally speaking, results of this nature are

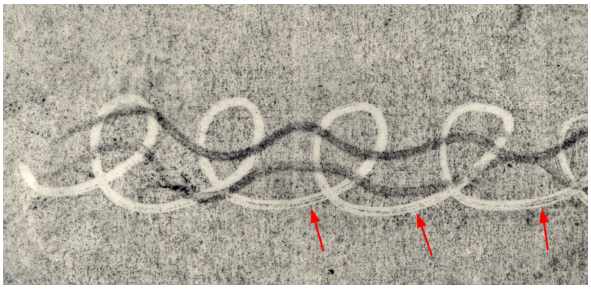

Figure 1a An example of continuous black ESDA impression lines crossing the inkstrokes, seen as a negative image on the lift. The red arrows point to the presence of thin toner lines within the areas of the visible writing line where the pen has failed to lay down ink.

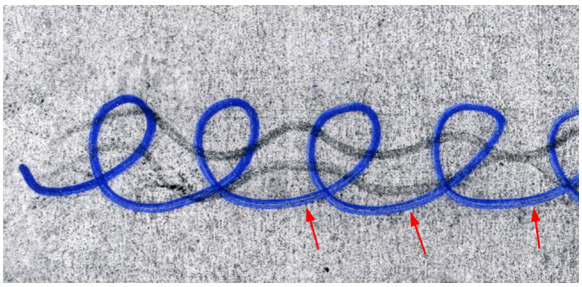

Figure 1b Overlay of the ESDA lift and sheet tested showing the intersection locations of the ESDA impression lines and visible ink lines. The red arrows point to areas within the writing line where there is an absence of ink. These voids, or straie, correspond to the toner lines seen in Figure 1a.

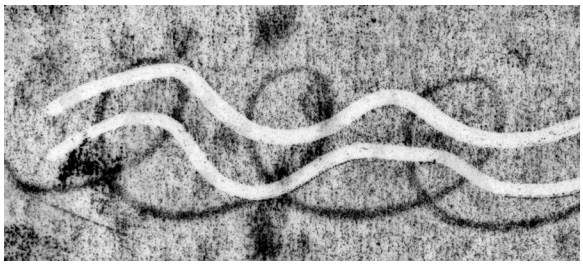

Figure 2 Example in which the ink has permanently destroyed the impression, resulting in breaks in the black ESDA impression lines where the lines intersect.

very clear cut and can very reliably be interpreted. In the case of a continuous ESDA impression running over the ink stroke, the impression has to be on top of the ink otherwise the ink would have destroyed the black ESDA impression line. Where the ESDA impression line is broken, the ink has destroyed the ESDA impression line and therefore has been written after the impression was produced in the paper. The only possible alternative is that the impression was produced over a wet ink. This will be discussed later with respect to how long the ink remains 'wet' and prevents an impression from being applied over the top of it.

Summary of What Sequencing Can Tell Us – Ballpoint Pens

- Conclusive or strong opinions can often be given where non-ballpoint pens are involved in producing the visible ink lines on the document being tested.

Sequence of ESDA Impressions and Ballpoint Pen Ink Writings – Results of ESDA Impressions over Ink Strokes

The position with respect to the intersection of ballpoint pen writings and ESDA impressions is slightly different and more complex. Where the ESDA impression line is seen to be continuous or near continuous across an ink stroke this is positive evidence that the impression was made after the ink stroke (Figure 3), as the ink has not destroyed the ESDA impression line at the intersection point. Effectively, this applies to any encroachment of the ESDA impression into the intersection with the physical impression line. The same is true for a reduction in intensity of toner and/or thickness of the line. It must be appreciated that the ESDA impression does not have to be a continuous unbroken line. It is the

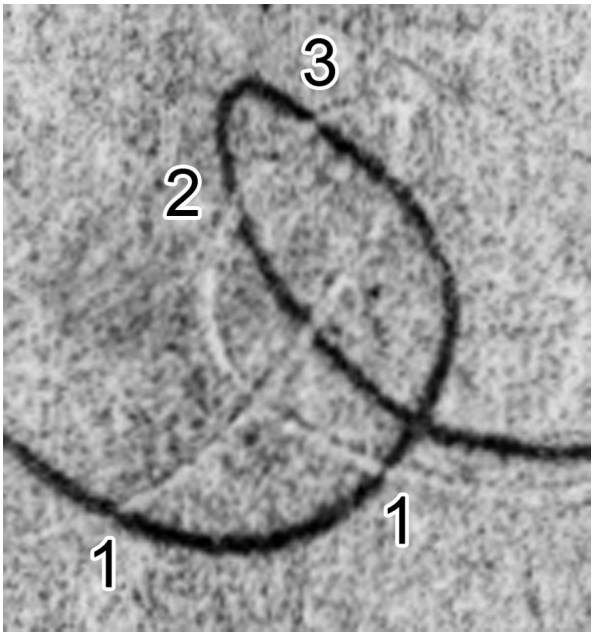

Figure 3 Examples of intersection types that may be seen when indentations overwrite the visible ink line include: 1. Decrease in dark line thickness. 2. Less dense faint line. 3. Slight encroachment into the clear ink line but not a continuous ESDA impression line.

experience of the authors that encroachments and/or a lessening of the impression line are seen as frequently, or even more often, than are solid lines. It must be noted that the preceding holds true only if the visible ink line is continuous and contains no striations etc. at the intersection point.

Relatively heavy pressure applied through the ballpoint pen into the paper often results in a corresponding significant groove or rut. When writing is applied to an overlying sheet, difficulties can be encountered in the lay-down of ESDA impressions over those deep grooves. Without contact between the lower surface of the upper sheet and the bottom of the deep groove, the indentation line will appear broken as no impression can be imparted to the bottom of the groove without contact of the two paper surfaces (see Figure 4).

The condition of the intersection is dependent to a large degree upon the quality and clarity of the detectable ESDA impression lines and the pen pressures involved. With respect to ballpoint pen lines, in practical terms a continuous impression line may not be seen at every intersection. Rather, it is more likely that only a small percentage (possibly 0% – 40%) of instances will reveal the true sequence when moderate writing

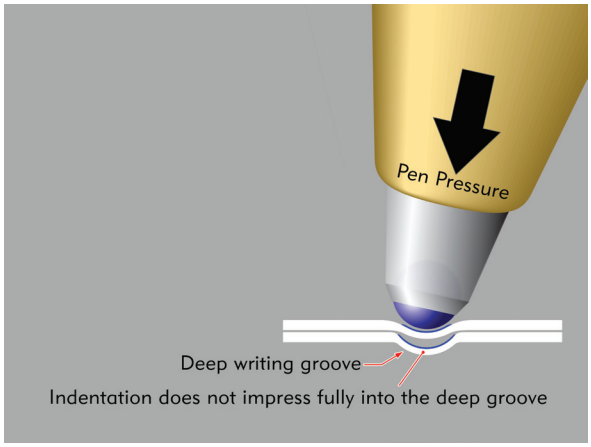

Figure 4a Deep writing grooves present in the underlying sheet may prevent embossed impressions in the upper sheet from contacting the bottom of the paper surface within the groove, resulting in an incomplete ESDA impression at the intersection point.

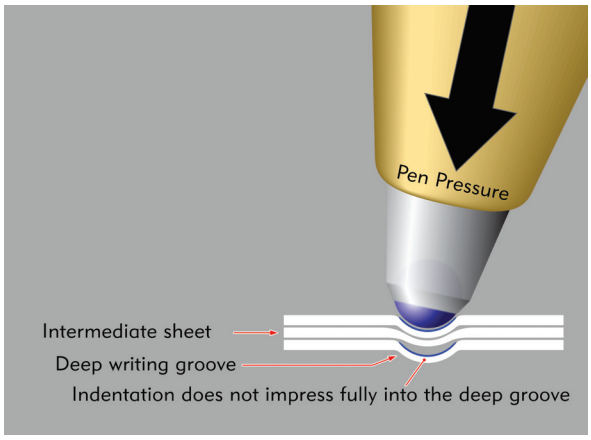

Figure 4b Deep writing grooves present in the underlying sheet, together with an intermediate sheet, are likely to prevent the embossed impressions in the upper sheet from contacting the bottom of the paper surface within the groove, resulting in an incomplete ESDA impression at the intersection point.

pressures are involved (see Figure 5). Even if no ESDA impression lines whatsoever over ink are seen this does not necessarily indicate the ink is over the impression. This is because such a result can also be seen where there are either (1) poor quality ESDA impression lines or (2) the impressions are generally clear but, as stated previously, broken when intersecting with heavily written ink strokes.

These circumstances can potentially give rise to a misleading 'false negative', unless full appreciation of this behaviour is recognised. Given the preceding, it is essential that great caution be exercised.

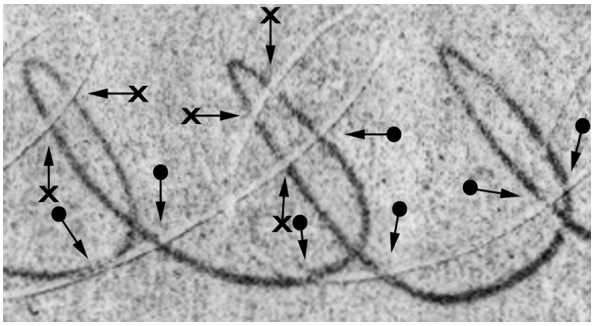

Figure 5 Xs indicate false negatives or inconclusive intersections, while circled arrows point towards unbroken dark lines – a clear indication that the impression is over the inkstroke irrespective of other "false negative" broken impression lines.

What can Cause the ESDA Impression Line to Appear Continuous at the Intersection Point?

One Observation - Two Possible Sequences:

1. The ESDA impression is over the ink – ESDA impression lines are often continuous when produced after the ink stroke has been applied to the paper, or alternatively.
2. The ink is applied over the impression but the ESDA impression line, (or parts of it) are present where striations or skips appear in the ink stroke, these void areas not destroying the underlying ESDA line.

Sequence of ESDA Impressions and Ballpoint Pen Ink Writings – Results of Ball Point Pen Ink over ESDA Impressions

Where an ink stroke is over the ESDA impression line there may well be a sharp cut off of the impression line at the edges of the intersection point, especially where the visible handwriting was made with relatively heavy pen pressure.

Look for instances in which the ESDA impression line is near parallel to and overlaps any visible ink line to see whether there are any long sharp bisections of the ESDA impression (see Figure 6). This is possibly a strong indication of the ink being over the impression especially if combined with other sharp cut offs at intersections. The significance of the cut offs is greatest when the visible ink line creates little physical indentation in the page. This is because the top edges of a physical impression can be relatively sharp to the extent that ESDA impression lines are clearly and fully bisected. However, it is essential that the FDE carefully inspect the intersection points to ensure that the visible ink line is devoid of striations, skips or other voids, for in these areas the impression line will not be broken.

Figure 6 Instances in which the indented impression line is nearly parallel to, and overlaps with, the visible ink line can be particularly telling. In this instance, the ink line sharply bisects the ESDA indentation line.

What Causes a Break in the ESDA Impression Line at the Intersection?

One Observation - Two Possible sequences:

1. The ink is over the ESDA impression – a continuous solid ink stroke has run over the impression thereby destroying the ESDA line at the intersection point, or alternatively
2. The ESDA impression is over an existing heavily written physical impression, but the ESDA impression has "jumped" the deep groove.

Summary of What Sequencing Can Tell Us – Ballpoint Pens

- When positive observations are made of continuous, near continuous impression lines, or where there is some degree of encroachment of the ESDA line on top of the visible ink lines, this may be taken as conclusive evidence that the impressions overwrite the original ink strokes. This presupposes good continuous visible ink lines at the intersection points, with the absence of striations or skips.
- Only one such clearly defined intersection

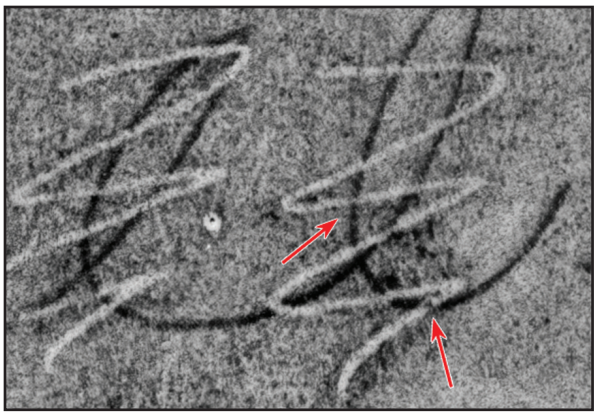

Figure 7a Intersection points of ESDA impressions with ballpoint pen writing.

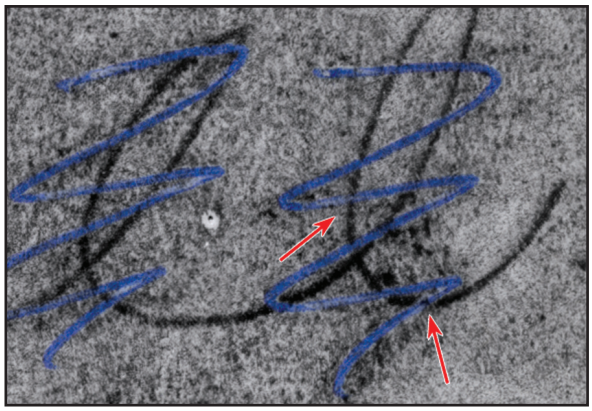

Figure 7b Analysis of the intersection points with the document being tested positioned immediately below the ESDA lift.

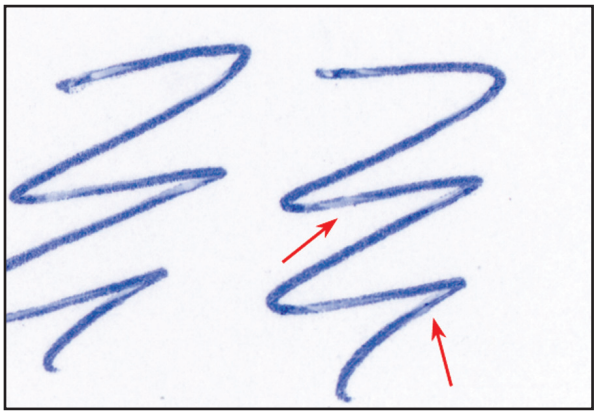

Figure 7c The ink lines present on the page tested. Note the incomplete areas within the ink lines that can have an impact on the sequencing result.

with the ESDA line crossing it is necessary to justify a conclusive finding, for there is no other explanation as to why the continuous ink line does not destroy the ESDA impression line. Expect a number (possibly a large number) of "false negatives" i.e. breaks in the ESDA line at intersections.

- The converse situation of breaks in ESDA impressions does not necessarily indicate that the writing is on top of the impressions.
- Clear bisections of an ESDA impression line combined with sharp cut-off points at other intersections, together with light writing pressure for the visible ink stroke, is evidence which supports the proposition that the ink is over the impression.

From the preceding discussion, it should be apparent that all intersections on a document must be evaluated and all evidence carefully considered.

Sequencing Limitations, Challenges and Considerations

The following are obstacles that hinder or preclude sequencing determinations:

- Poor development of indented impressions
- Poor visible ink line featuring numerous voids, skips or striations.
- The visible writing develops on the ESDA transparency as a black outline rather than a negative or neutral image. For some reason, some ballpen inks will produce such an image of the writing which naturally precludes the sequencing process.
- Indistinct or fuzzy ESDA impressions may render the intersection unsuitable for sequencing.

Practical Points for Applying the Sequencing Technique

The authors strongly recommend that:

- The sheet being tested should be well developed so that both the ESDA impressions and preferably the 'negative image' from the visible writing can be clearly seen. The benefit of seeing the negative image on the ESDA lift is that the FDE can quickly identify intersection points. However, it is not essential that the 'negative image' be resolved as the document being tested will be positioned beneath the ESDA lift during evaluation, allowing the actual ink lines to be viewed.
- The quality of the ink stroke, with respect to the ink applied to the paper at every point of intersection, must always be checked to ensure complete coverage so as to prevent

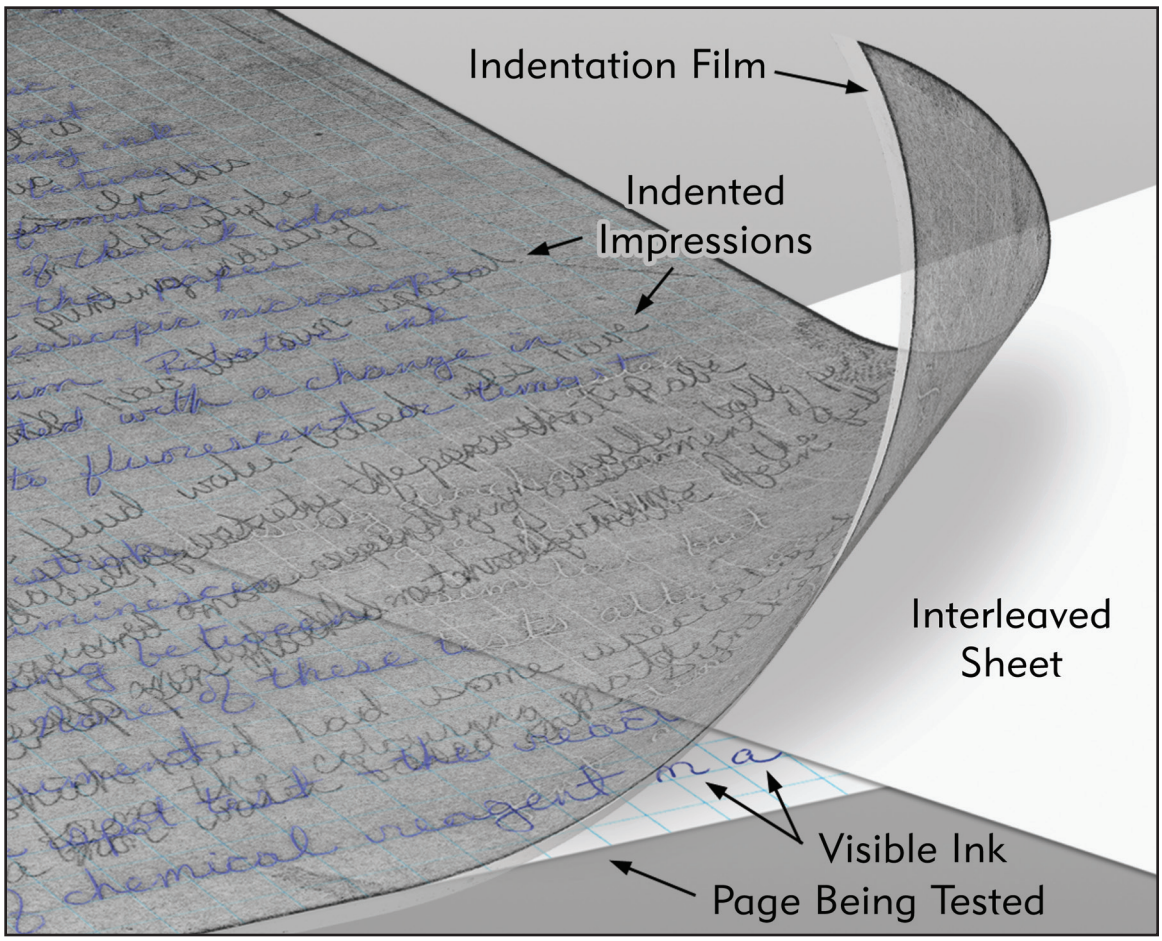

Figure 8 Interleafing a sheet between the ESDA lift and the document being examined assists in evaluating the condition of the ink line at the intersection points.

any false positive observations. It must be appreciated that ESDA toner deposits can be found even within very narrow striations irrespective of whether the impression is on top of, or beneath, a faulty ink line (as illustrated in Figure 1 and Figure 7). Disregarding the condition of the ink stroke at any intersection point is a significant and likely source of error.

- Relatively low magnification of, say, x 7 – x 10 can be used to examine the intersection points. With significantly higher magnifications, it becomes more difficult to 'see the wood for the trees'.
- Having affixed the adhesive sheet over the ESDA film, the ESDA transparency lift is not separated from the underlying sheet that is being tested. The adhesive film can be pressed down well with a tissue or cloth (but not a roller) and keeping it in contact with the paper being tested ensures the perfect registration of the visible writing and the ESDA impression lines. Once the plastic film is stripped from the paper being examined, perfect realignment is difficult for a subsequent examination. Remember, often the encroachment of a small amount of ESDA impression line on an ink stroke can provide positive evidence the impression is on top of the ink. This necessitates the exact registration of ESDA film and the underlying document which is difficult to achieve if the sheets are separated and then re-superimposed. Any inaccurate realignment of ESDA print and the paper under examination can be a source of potential error. The natural electrostatic attraction of the ESDA film to the underlying sheet prior to separation ensures there is not even the most minute movement of the two sheets relative to one another.
- A sheet of white paper can be carefully slid between the ESDA transparency lift and the document under test so as to see the impression lines better (Figure 8). One can

then 'flick' between the impression line at the intersection alone (white paper obscuring the writing on the sheet below) and the impression line at the intersection whilst viewed on top of the ink stroke. However, the FDE should try to keep at least 30% to 50% of the total area of the paper and the overlying ESDA sheet in contact at all times as the electrostatic attraction is then generally adequate to ensure that no slippage of the ESDA transparency lift and the paper under test can happen.

- Either the cloud or cascade method can be used, but a roller is never used to increase contact between the lift and the acetate sheet while they are still in contact with the document being tested.
- The line edges of both the black ESDA impression lines and visible ink strokes at each point of intersection should be carefully studied. Is there a sharp cut off or do the ESDA impression lines encroach on the visible ink line?
- The FDE should consider whether the ESDA impression line is fully interrupted or lessens in its intensity or thickness at the intersection points. Remember, even if the intensity of the ESDA impression line is significantly lessened relative to either side of the intersection point, this is still positive evidence of the impression being on top of the ink stroke – always bearing in mind that a continuous layer of ink will always destroy an ESDA impression line.

The Possibility of ESDA Impressions Overwriting Wet Non-ballpoint Pen Inks

If the ink is wet on the underlying sheet when an impression is made over the top of it, the ESDA impression line will not run over the intersection point but rather will appear broken. This is because the wet ink will destroy the ESDA impression irrespective of their execution sequence. Therefore, caution has to be used in situations with non-ballpoint pen inks if there is a possibility of the impression being made over wet ink. However, in typical casework studies, this is usually an unlikely scenario.

Information on the 'drying times' of inks and their subsequent interaction with ESDA impressions is limited. Original research was undertaken on an experimental basis. When impressions were made 5 minutes after the ink stroke was written, approximately 40% of intersections showed some degree of breaks in the ESDA impression line. The same scenario with a 30-minute interval between writing and the impressions being made did not result in breaks in the ESDA impressions. In this case one assumes the ink had 'dried' sufficiently such that it did not repel the ESDA impressions.

The Possibility of Impressions Overwriting Wet Ballpoint Pen Inks

Timed experiments were completed using 10 inks, the writings being made with moderate pen pressure. With a 5-minute interval between production of these ballpoint pen ink entries and subsequent creation of impressions over them, the ESDA impressions could be detected on top of the visible writing. When the interval was decreased to 2 minutes, only 80% of the inks evaluated showed good ESDA impression lines over the ink.

Whilst the above represent experimental data collected at one point in time, it must be appreciated that the temperature and relative humidity of the environment in which such writings are undertaken may have an effect on the rate at which the inks 'dry'. In a similar vein, the formulation of the inks may also have an effect. It would appear, however, that even with the combined effects of ambient conditions and ink type, it is unlikely that the ink would remain 'wet' over a long period of time (many minutes) thereby impacting sequencing results. More research is needed in this area under significantly different ambient conditions.

Further Sequencing Possibilities

In addition to the sequencing of handwriting impressions, Allen (1997) reported a similar method can be applied to situations where highlighter has been used. Mohammed (1997) also applied the technique to inkjet printing when intersecting with ESDA impressions. Such interpretations can generally be made with a very high level of confidence as neither technique produces significant physical impressions in the paper.

Possible Impressions Overwriting Wet Inkjet Printing

Mohammed (1997) reports that ESDA impressions made over inkjet ink lines made up to 5½ minutes after the inkjet printing included some broken lines at the intersection points but that 2 hours after printing, the ESDA impression lines

were not broken.

Further unpublished research for timed experiments on a limited number of inkjet printers shows continuous ESDA impressions could be obtained when overlapping writings were executed 10 minutes after the inkjet printing.

Circumstances in Which Sequencing Will Not Work

- Poor ESDA impressions are produced
- Visible writing is executed with a pencil
- Intersections of toner based printing or photocopy toner with ESDA impressions
- Documents that have already been tested for fingerprinting

Conflicting Papers

Giles' paper (1993) is a report of a preliminary investigation only and the sequencing procedure assessments were completed by two non-forensic scientists.

Statistics of the test results are given in detail in the Giles article. Conclusions drawn in her paper are:

- It is possible to determine with a high degree of certainty when ballpoint pen writings have been made on top of impressions.
- Only very guarded conclusions can be drawn where impressions appear on top of writing.

These observations are in contradiction with the interpretation and experimental detail outlined above and that of Radley (Radley 1993). From an assessment of the statistics given in Giles' paper, her previously stated conclusions can be shown to be demonstrably incorrect when all issues are addressed. It is the interpretation of the observation statistics that is problematic.

Her statistics and observations do, however, strongly support the findings put forward by Radley (Radley 1993). A letter to Forensic Science International dated 26th October 1994 by Giles concerning her conflicting paper confirms that:

- Assessments of intersections were by non-experts
- It was stated that "Logically white dominant lines could be either the result of ESDA traces being destroyed by the ballpoint pen lines or merely a situation on which the black impression line has failed to develop. If it is correct, and it seems likely to be so, that the false positives obtained when the pen lines cross impressions are aberrations, then Radley's interpretation is correct i.e. a single incident of a black impression line over the white pen line must be interpreted as the impressions being made after the pen lines."

A second article by Nic Daéid et al. (2008) appears to ignore most of the fundamental factors and the underlying principles which are the basis, both practical and theoretical, of the technique previously described.

The authors disagree with a number of the approaches taken by Nic Daéid et al. and the way in which the examinations have been conducted, as follows:

- Nic Daéid et al. indicate that with ballpen writings on a document containing hundreds of intersections with a high percentage of white dominance it would seem illogical not to look at the accumulative results'. This is not agreed as detailed previously in this article as one can have examples of 100% "white dominant" when ESDA impressions are over the ballpen ink writing of heavy pressure.
- 'The same author produced all of the test data in order to minimise any variability due to writing pressure'. This appears illogical as throughout the population as a whole, writing pressures vary enormously and this, correspondingly, has an enormous effect on the result. Indeed, the suitability of the procedure especially where light pressured writings are produced by individuals creating the ESDA impressions or heavy writing pressures are used for the visible entries can cause a high percentage of false negative results, as previously detailed.
- 'In each case one sheet was placed on top of the other and 10 vertical lines were drawn on the paper using a black ballpoint pen. The top sheet was then placed underneath the second sheet and a series of 11 horizontal lines were drawn on the paper such that they intersected the indentations of the first set of lines. This was repeated for 10 pairs of sheets for each condition (writing over intersection and intersection over writing).' No indication is given as to the timing of the initial writing and production of the impressions. From the quotation above, it might appear that the writing and impressions were made

rapidly one after the other. In one of the author's papers (Radley 1993, 1995) there are discussions concerning the irregular effects that may be obtained if impressions are laid down on top of 'wet' ink. No account of this significant factor has been taken by Nic Daéid et al. This issue is also extensively addressed in our previous discussions.

- Throughout their paper there is not a single mention of the effect of ESDA lines intersecting with ink lines that contain striations, skips etc which is a critical point that must always be taken into account to prevent serious errors in the interpretation of intersections. This factor was addressed at length by one of the authors (Radley 1993) and is also discussed above. As an ink line containing striations can attract toner at the point of the striation, i.e. where no ink has been applied to the paper, the disregarding of this consideration in experiments will potentially lead to misleading results. The results may largely be due to the functioning of the pen and whether or not a good ink line is produced or whether, as with many ballpens, striations are present. Consequently, where Nic Daéid et al record (albeit very small numbers) instances of an ink stroke crossing an impression yet the black impression line is still 'dominant', such occurrences must be the result of poor ink deposits on the paper, striations etc as ink will destroy ESDA impressions, whether this be ballpen or non-ballpen writings, provided the ink application is continuous.
- 'The interpretation of the results was difficult on occasions where the dark impression line became noticeably lighter and occasionally slightly broken at the points of intersection. In these circumstances it was more difficult to determine which of the two lines was dominant and such results were classed as unclear'. Again, this maybe the result of an ESDA impression line being laid down over the ink and insufficient pressure is brought into play at the intersection to allow the top sheet to come into contact with the bottom of the existing groove of the ink stroke on the underlying paper (as shown earlier in Figure 3). Alternatively, lightened (or 'slightly broken') ESDA impressions across an ink stroke can also be the result of a fair amount of toner attaching to striations in the middle of the ink strokes. The results of such a striation situation have to be discarded as they do not reveal the true sequence of execution.

The underlying consideration here is whether or not the ESDA impression line is clearly on top of the visible ink. If this is so, then the impression is on top of the ink irrespective of whether or not the ESDA impression is slightly broken or only encroaches at the intersection point – otherwise the ink would have fully destroyed the impression line.

- 'The results have shown that there are a number of circumstances in which the examiner should be cautious about drawing conclusions. This is particularly the case when examining writing on low quality paper where the percentage of expected results and likelihood ratios were lower than in other circumstances. When an aqueous-based ink has been used, the results obtained follow the expected pattern far closer than any other ink type examined'. This is precisely what is expected if one considers the ink coverage on a paper. Low quality paper is often fibrous and does not have a good flat surface. Consequently, a ballpen may graze over the top of the prominent fibers and not deposit ink on the lower 'valleys'. This therefore renders the ink application somewhat erratic and non-continuous across the width of the ink stroke at the intersection points with the ESDA impression lines. This result may be regarded in a similar light as that of portions of uninked paper surface within an ink stroke due to striations. Where an aqueous based ink is applied, there is generally a seepage of the ink into the entire paper surface, i.e. the ink will flow into the 'valleys' and cover the paper in a far more continuous fashion. Nic Daéid et al's practical findings confirm this but the significance of this occurrence does not appear to be appreciated.
- There is no discussion of what represents "dominance". Any encroachment of an ESDA impression line on top of a solid ink line will be due to the impression being made after the ink stroke.

Whilst Nic Daéid et al.'s paper discusses the likelihood ratio from the percentage of observations re: white/black dominance, on a practical basis one can have a situation where, especially with writers of light pressure, there will be few impressions, if any, laid down over heavy or even

moderate visible ink strokes already impressed into the underlying paper surface (see again Figure 3 and 5). Consequently, it would appear that the likelihood ratio based on a statistical observation of white dominance will not be reliable in the above case. The fact is that one good clear impression of the black ESDA line running over the top of a continuously inked stroke will show that the impression was made after the ink stroke. This is irrespective of how many apparent breaks in the ESDA line at intersections may be seen elsewhere in the same passage of writing. The fact of the matter is that a good coverage of ink will destroy ESDA impressions already on a paper.

- One of the conclusions of Nic Daéid et al.'s paper is that 'The likelihood ratio values for white dominance are greater than when considering dark dominance indicating that this is a more reliable predictor of the sequence of the intersection'. This conclusion totally disregards the points detailed above and does not represent any consideration of vital factors and the whole underlying theory of the technique. Therefore this conclusion is wholly unreliable. The appearance of white dominance, which could potentially be seen in 100% of intersection points on a document, is of little relevance, if, for instance, the writing producing the impressions is of light pressure and/or an existing writing on the underlying sheet on which the impression is being made, bears heavy physical impressions in the paper from the visible writing. In such circumstances, even if the impressions have been made after the ink, there may be no continuous or encroaching ESDA impression line on the underlying ink line. In such circumstances, unless there are significant factors as discussed earlier above (re: bisection of lines), such an observation of consistent white dominance is (predictably) unreliable taken on a likelihood basis.
- Whilst Nic Daéid et al. refer to Giles' work, they do not appear to have followed through the statistical evaluation of her results and have merely accepted her conclusions nor do they appear to be aware of her subsequent letter to the journal concerned.

The techniques adopted and some conclusions reached in Nic Daéid et al.'s paper are, consequently, in our opinion, fatally flawed.

Acknowledgement

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Correction: The Effects of Constraining Signatures

Dainis Simsons, Rosalind Spencer, and Sofia Auer

On page 39 of the June issue, Vol. 14, No. 1, in the article titled **The Effects of Constraining Signatures**, Figures 1, 5 and 6 are incorrect. Below are the correct versions. We regret the error.

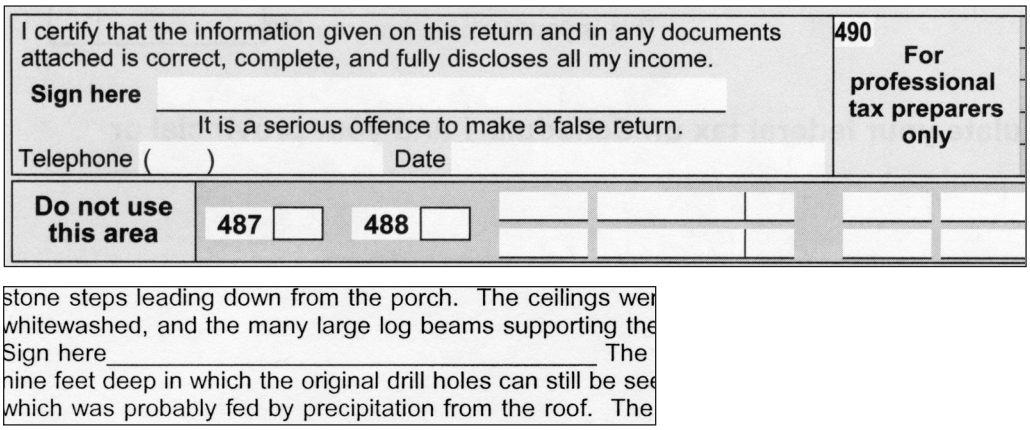

Figure 1 Line within text (portion only) (lower); T1 General 2005 signature box (upper) (neither to scale).

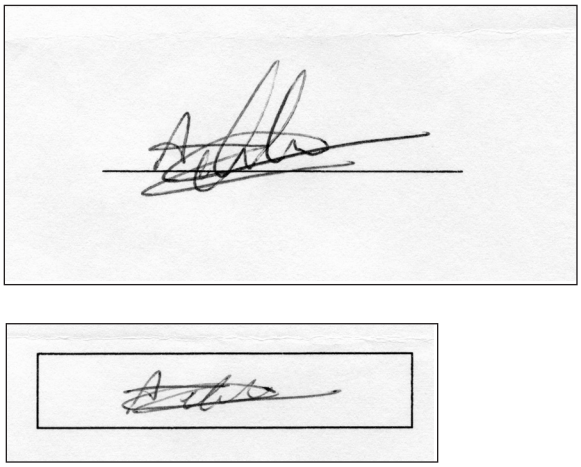

Figure 5 General reduction in size in box (constrained signature shown in lower box) (not to scale).

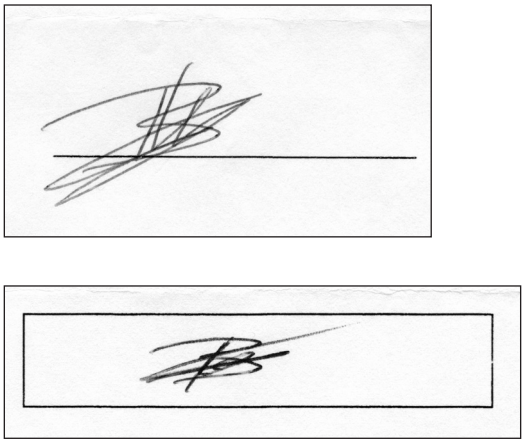

Figure 6 Reduction of ascenders and descenders (constrained signature shown in lower box) (not to scale).