Experiments on Document Copy Degradation
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Whenever accepting a document case, it is important to properly inform potential clients of the ideal materials to provide for examination. When possible, the original documentation should be made available. Depending on the type of case, "original" may have many different meanings. In the case of a signature case, it is desirable to have the document with the "wet ink" signature. The "wet ink" signature is the original document the purported signer took the pen and applied their signature to directly.

All too often potential clients believe a photocopy is more than sufficient to conduct an examination. This belief may due to the client's misunderstanding of the process and science of document examination. I have found most clients believe an examination is based on the pictorial appearance of a signature or document. As document examiners we should strive to educate our clients about the process and science of document examination in order to obtain the best materials available.

It is not always possible to get the original documentation. Documents may be lost or damaged. It is also possible the opposition is in possession of the original documentation. In these cases, it is not always feasible or advisable for the client to request the documents, especially if it means the client must reveal they are hiring a document examiner. Other times original documentation does not and never has existed. If the document involves a copy/pasted signature or a digital signature, a "wet ink" signature or original document does not exist.

Document examiners know that it is important to get original documentation when available, but it is also important to get the *most original* documentation available. Each time a document is copied or scanned some information is lost. This results in reduced quality of the document which I term *photocopy degradation*. Different copying methods result in different rates and types of degradation. I endeavored to find which methods of copying result in the most and fastest degradation.

For this purpose, I obtained a signature from two different individuals and proceeded to test different methods of copying and reproducing to see which methods have what type and greatest effect on document quality. In this paper I discuss photocopy resolution, office photocopying with a Laser Printer, scanning and emailing as a PDF, color versus grayscale copying, and home photocopying with an Inkjet Printer. Please note that each sample provided will always have at least one additional scan in order to produce this article. Thus, when I refer to the "original" signature, it is the signature that has only one scan from the wet ink signature to digital form to put in this article. A first-generation copy will be the first copy from the original signature, plus an additional scan for this article. In order to make it to this article, documents are scanned to a PDF, then cut and copied into a word document, then finally saved again into a PDF. Additionally, the signatures are resized in order to fit on the page and aid readability. Each change is going to have some effect on the final appearance of all signatures in this article. When

describing signatures and generations of photocopies, I will be ignoring those final steps since they are common to all signatures appearing in this article.

Photocopy Resolution

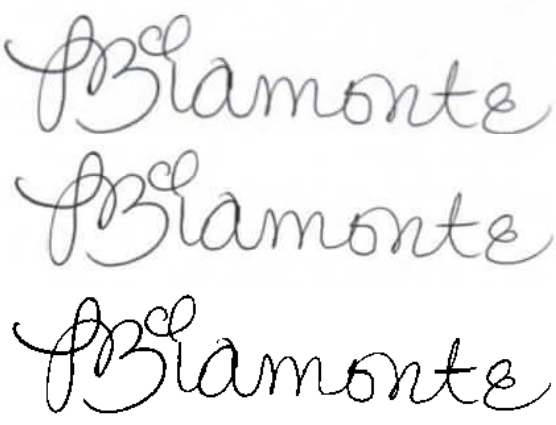
One of the first considerations when discussing the copying process is the resolution. Resolution is important not only for printing but for the scanning process. If receiving a photocopy from a client, it is important the document be scanned at the highest resolution available the client. I normally request clients scan a document at 300 dpi or higher.

Below are three copies from the original signature taken at a resolution of 600 dpi. The top sample was scanned in full color. Important to note with the full color sample is the paper is visible as a slight background discoloration. The lines of the signature are also somewhat fuzzy on their edges (less noticeable when the signatures were resized to fit). The second sample was scanned in grayscale. The grayscale appears very similar to the color scan, though with less background discoloration. The third scan was taken in black and white. While the lines are sharpest and easiest to read, details in the ductus are lost.

Of the three samples, the grayscale scan appears to have retained the greatest amount of detail for use during an examination, although it is very similar to the full color scan.

The black and white scan is still very useable at this resolution. Each scan maintains more than enough detail to conduct an examination. Features such as line quality, method of construction, initial and terminal strokes, and even pressure patterns are still visible. But it is rare for a client to provide scans of documents at such a high resolution.

More commonly documents are scanned at a resolution of 150 dpi or lower. When we compare these same signatures at the lower resolution, we begin to see what details are lost. These signatures were scanned at 150 dpi. Here we find there is very little difference between the color scan on top and the grayscale scan in the middle. Both maintain a significant amount of detail for examination purposes.



The black and white scan shows the most loss of detail, particularly at the initial and terminal strokes. The black and white scan is also starting to lose some detail in the line quality and some signs of pixilation. At this resolution pressure patterns are still visible in all three

scans. Although not ideal, 150 dpi still maintains enough detail from an original signature for use in comparison.

A 75 dpi we begin to have noticeable problems with the signatures. Pixilation is starting to show (less noticeable due to the resizing the signatures to the article), and bits of the ductus are no longer visible in the black and white scan.

The color and grayscale scans have developed a very fuzzy, out of focus appearance. At this resolution the black and white scan is the most easily read. The line quality suffers quite a bit, but pressure patterns are still readily identifiable.

Regardless of color, grayscale, or black and white, all three scans are still useable for an examination at 75 dpi if taken from an original signature.

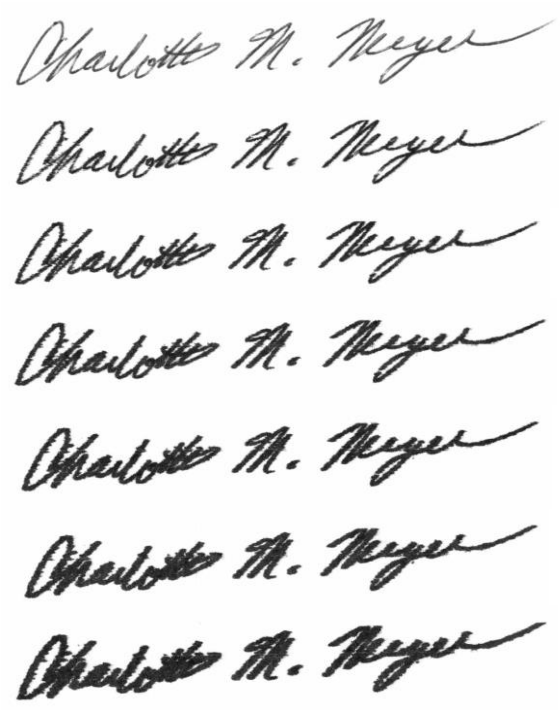
Multi-Generational Photocopies

Laser Jet Printer Results

Here I took the original wet ink signature (top) and photocopied it on a standard office laser printer. I took the printout and photocopied it, took that printout and copied it, and continued this process through six generations. I did not adjust the printer settings from their default, and the scans were taken in grayscale.

Surprisingly, there was virtually no loss of detail from the original signature at top to the sixth-generation photocopy at the bottom. All detail appears to have been retained.

It would be very difficult to determine which signature is from the original scan and which is a sixth-generation photocopy. This indicates a laser printer as being an excellent choice for photocopying documents.



Ink Jet Printer Results

Following this same procedure with a home inkjet printer, we get a vastly different result. The top signature is the original. All subsequent signatures are continuous generation photocopies.

Even from the first generation we start to notice the ink line thickening. Line quality is difficult to judge in the later generation copies. Some of the details in the ductus are more difficult to see. The inkjet also leaves little dots of ink surrounding the main ink trail.

Through six generations, the inkjet printer does not retain the quality of the original signature very well. As we look at later generation copies, the ink trail becomes darker, thicker, and more muddied in appearance. Other details such as tapered starts and finishes become less defined.

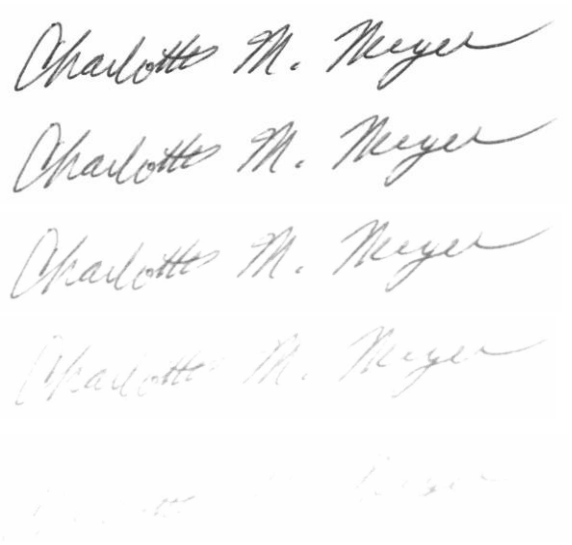
Scan to Email

I decided to see how scanning and emailing a document would affect its quality. I used the same laser jet office printer from before for the first series of tests. I took the original signature, scanned it to a PDF, and used the copier in-built email function to send the PDF to myself. I then printed the PDF using the laser printer function. I took the printout and repeated the process five times.

Scanning and emailing shows significantly faster quality degradation than either low resolution scans or straight photocopying documents. This may be because the transition into a PDF forces a loss of some information in the conversion.

The document loses a great deal of detail after only three scans, and is completely unusable by the fifth. The line quality is non-existent and pressure patterns are assumed by the absence of the line itself. Letter type, style, and construction are unidentifiable in later generations.

Lastly, I repeated this process with an ink jet printer with some modifications. I scanned the documents using a portable Epson scanner and converted the documents to PDF. Then emailed the documents to another computer where they were printed with a standard home ink jet printer. I took the print out and repeated the process.



Here we have the original at the top and four generations of scanning, emailing, and printing. This process has shown by far to have the most rapid and drastic effects on the document. By the third scan the document can no longer be used, and the fourth is barely visible at all (yes, there are five signatures on the right).

What we don't really see in this process is the line thickening we saw earlier when the ink jet printer was used to copy the same document repeatedly. Instead here we see the line getting thinner and less distinct, quite the opposite of what straight photocopying did.

Conclusions

Comparing the different methods of copying and scanning, it becomes readily apparent converting a document to a PDF and emailing it causes the most rapid changes in document quality. To preserve the quality of a signature, the laser jet printer seems to be the best option. The total loss of detail during the photocopying process with a laser jet printer wasn't noticeable even to a sixth-generation copy. If a case requires working from a copy, but the original is available, it becomes advisable to have the client use a laser printer to copy and print.

From these experiments we can see what type of effect each reproduction process has on a document (which may even be important during a case to determine).

1. Laser printers result in the smallest loss of data from the original document if doing a standard photocopying process.
2. The ink jet printer will have a tendency to thicken and darken the lines.
3. Low resolution scans will become pixilated or have a very fuzzy appearance.
4. Scanning and emailing documents will degrade documents the fastest, evidenced in document fading.

In these experiments, only one type of copying process was used each time to isolate the degree and type of degradation. When working a real case, it is likely the documents will encounter one or several of these reproduction processes. This stresses the importance of obtaining the *most original* document available to conduct an examination.