
Handwriting Analysis In Forensic Document Examination

Writing is constantly involved in our lives. Ever since we were taught to write in kindergarten, we continuously alter our handwriting until our motor skills were fully developed (Koppenhaver, 2007). That was when writing became a sub-conscious act, and we divert our attention to the content we intend to write. Eventually, a writer's handwriting will attain its own unique features, and only us, who were the very owners of our handwriting, can emulate these unique features. I remember vividly that teachers used to display model essays from our classmates anonymously and apart from reading and appreciating the essay content, we tried to guess which classmate did the essay belong to. This was done by analyzing the handwriting in the essay and identifying whose handwriting it might be. It is somewhat similar to forensic document examination, except with more rigor and seriousness, and had to withstand the scrutiny in court when forensic document evidence is being called upon. However, forensic document examination not only encompasses handwriting analysis.

The Howland will forgery trial involved tracing signatures of Sylvia Ann Howland in her will. Dr Benjamin Peirce, a mathematician from Harvard, testified that the probability of identical strokes made in two separate signatures was a whopping one in 530 (which is one in 9.31×10^{20}). He had assumed that the strokes were made independently and testified that the binomial model can be used to find the probability. Yet, under the binomial model, the probability of a match should be the same at each of the 30 positions in Howland's signature. This assumption was not possible since certain strokes would have a higher probability of matching than others, especially those made earlier in the signature. Another assumption made was independence of the strokes made, but this was not true since some strokes could affect how other strokes would turn out in the signature. Considering that the assumption of independence did not hold true, it would greatly increase the probability of 30 matches when comparing two signatures (Meier & Zabell, 1980).

In addition, Dr Benjamin Peirce failed to account for any correlation between signatures made close in time (Meier & Zabell, 1980). It was possible for signatures made earlier in life to differ from those made later in life, and also possible for signatures made in a single sitting to be more similar than those made with some time apart. Time period was, in fact, a factor affecting intra-variability of handwriting. A study done by Walton (1997) found that aging produces greater fluctuations in an individual's health, hence producing high intra-variability in the quality of writing of an individual. Writing depends on coordinated function by the brain with the muscles and visual systems, which is essentially a motor performance coupled with perception. This performance deteriorates as one ages, although the extent may vary from individual to individual. Hence this may cause a health variation in the elderly population, such that not everyone in the elderly population ages at the same rate. Not everyone's health in the elderly population deteriorates at the same rate either. This will produce high inter-variability between individuals, which is an essential principle of handwriting analysis. However, high intra-variability can occur should an elderly's health fluctuate due to his/her health condition.

A large number of known documents and signatures may be required when examining signatures or handwritings written by an elderly. Another factor Walton looked into was the effect of neurological disease on the handwriting quality of the elderly. A neurologically-

deteriorated signature or handwriting may be mistaken or confused with forged defects. Yet Walton mentioned that with close inspection, a neurologically-deteriorated signature can be distinguished from that of forged one. A lesson learnt is to be cautious when examining questioned handwriting samples from the elderly, especially if they are suffering from any neurological disease. A study done by Anil and Dhara (2014) looked at how different writing instruments affect the quality of handwriting. They used a Handwriting Evaluation Tool to measure handwriting quality. It was a three-point rating scale on the basis of eight components of good handwriting. The eight components include linearity, size of letters, space between letters, space between words, space between lines, formation of letters, neatness and legibility. 3 points is given when the component was thought to be maintained, 2 points for maintained up to some extent and 1 point for not maintained. However, the issue is that it can be quite subjective. To what extent do you judge whether a certain component was maintained? If there was a slight difference between the samples collected and the participant's handwriting, would that constitute to "maintained up to some extent" or "not maintained"? When would "not maintained" be assigned to the handwriting? Such subjective interpretations can differ between individuals.

The issue of subjectivity was not limited to the observation of handwriting quality for research purposes (for example, the abovementioned study done by Anil and Dhara). In a study done by Miller (1984), participants who were given additional inculpatory evidence against the suspect believed that the suspect was guilty upon examining the forged signatures and handwriting samples from the suspect. This was not observed in participants who were just given the signatures and handwriting samples without any additional evidence against the suspect. In addition, Kukucka and Kassin (2012) discovered that given the knowledge of a recanted confession, it can affect the analysis of handwriting evidence negatively. Such cognitive bias can affect the interpretation of handwriting evidence, even if the one examining is an experienced forensic document examiner. This may lead to erroneous conviction of the suspect if handwriting evidence was admitted in court and is given a substantial amount of weight.

Figure 1: Schematic diagram of handwriting identification and verification using automated tools (Adak et. al. , 2018). Handwriting analysis is hence highly subjective in nature. It can be affected when context is given, such as expectation and suggestion (Michael, 2013).

To combat the issue of subjectivity, there are automated tools such as CEDAR-FOX that can aid the forensic document examiner with statistical examination of handwriting characteristics. CEDAR-FOX is a software system for forensic comparison of handwriting, which was developed at the Center of Excellence for Document Analysis and Recognition (CEDAR). It can help forensic document examiners analyze handwriting fast and reliably in a systematic manner, and is also simple to use. CEDAR-FOX can be used to verify if two handwriting samples were by the same writer, or finding the closest match in a database of handwriting samples. This can be illustrated by Fig. 1, where identification can be done by inputting a questioned sample (Text-i) into the software and the output would be the writer (Writer-i) likely to have written the sample with a certain degree of accuracy. As for verification, the questioned samples (Text-i and Text-j) inputted into the system can give an output of whether these two samples were written by the same writer or not. Text-j can be from the database of known authors (Adak et. al. , 2018). Its final goal is to compare two samples of writing to calculate the log likelihood ratio (LLR) of the prosecutor's and defense's hypothesis (Ball & Gregory, 2011). LLR is used in determining document similarity, with a positive LLR value indicating that the two samples were likely to be written by the same writer and a negative LLR value indicating that they were likely to be written by different writers (Ball & Gregory, 2011). Yet, there can be statistical errors associated with

automated tools. This is why the individual operating CEDAR-FOX should also be a professionally trained forensic document examiner for troubleshooting. In conclusion, handwriting analysis is highly subjective in nature and there can be statistical errors incurred when analyzing the evidence. Even forensic document examiners like Dr Benjamin Peirce would fumble with the statistics employed for handwriting analysis.

However, through the Howland will forgery trial, we can see that there is an attempt in involving statistics such that handwriting evidence can be more reliable and quantifiable. The forensic document examiner has to exercise caution when analyzing the evidence and assigning a certain weight to it, for not only there can be errors in the statistical methodology, there can be intrinsic errors such as cognitive bias. This is why in the field of forensic document examination, there is an attempt to rely on automated tools such as CEDAR-FOX to reduce any form of biasness from the examiners. In addition, given a huge quantity of samples, automated tools can also ease the process of handwriting analysis. Despite mentioning many drawbacks in handwriting analysis, we can be optimistic that people are developing ways and tools to make handwriting analysis more scientific and objective.

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