THE FREQUENCY OF THE OCCURRENCE OF HANDWRITING PERFORMANCE FEATURES USED TO PREDICT WHETHER QUESTIONED SIGNATURES ARE SIMULATED

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Abstract: *Forensic Document Examiners (FDEs) examine the physical morphology and performance attributes of a line trace when comparing questioned to specimen handwriting samples for the purpose of determining authorship. Along with spatial features, the elements of execution of the handwriting are thought to provide information as to whether or not a questioned sample is the product of a disguise or simulation process. Line features such as tremor, pen-lifts, blunt beginning and terminating strokes, indicators of relative speed, splicing and touch ups, are subjectively assessed and used in comparisons by FDEs and can contribute to the formation of an opinion as to the validity of a questioned sample of handwriting or signatures. In spite of the routine use of features such as these, there is little information available regarding the relative frequency of occurrence of these features in populations of disguised and simulated samples when compared to a large population of a single individual's signature. This study describes a survey of the occurrence of these features in 46 disguised signatures, 620 simulated signatures (produced by 31 different amateur forgers) and 177 genuine signatures. It was found that the presence of splices and touch-ups were particularly good predictors of the simulation process and that all line quality parameters were potentially useful contributors in the determination of the authenticity of questioned signatures.*

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1. Introduction

FDEs express opinions regarding the authorship of questioned signatures based on subjective comparative techniques that have been described in a large number of publications (Osborn, 1929; Harrison, 1958;Conway, 1959; Hilton, 1982; Ellen, 1989; Huber & Headrick, 1999; Found & Rogers, 1999). In essence, the process is one of comparing all of the features of a questioned signature to the range of variation in the features displayed in a population of specimen signatures. These comparison features can generally be distilled into 'spatio-temporal' and 'execution' characteristics. Spatio-temporal features are those that participate in how the signature 'looks'. How the components were formed in time, the size and relative proportions of characters (or components if we are considering a form which has no or only a few allographic forms), the width of forms and strokes, will all contribute to the spatial character of a signature. Execution characteristics include the direction in which the strokes are formed, the speed of execution, the relative pen pressure within and between strokes, and the presence of 'flying' starts and finishes, etc.

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The underlying assumption made by FDE's is that, given a complex signature, an individual attempting to forge it will invariably fail to successfully capture all of the spatio-temporal and/or execution characteristics. This failure will be evident in spatial and/or execution features that can be observed (either visually or with the assistance of a microscope). A number of studies have investigated the types of features that can assist FDEs in their determinations regarding the validity of questioned signatures. Leung, Cheng and Poon (1993) provided evidence that forgers concentrated on eye-catching spatial features within the writing they were simulating, at the expense of writing dynamics. Van Gemmert and Van Galen (1996) reported that although subjects were able to match the writing lengths and writing slants of the models they were copying, their writing did slow down significantly and the fluency of their performance was disrupted. Further evidence of the validity of using spatial and execution characteristics as predictors of the simulation process comes from expertise studies. (Kam, Wetstein & Conn, 1994; Kam, Fielding & Conn, 1997; Found, Sita & Rogers, 1999; Kam, Gum madidala, Fielding & Conn, 2001; Sita, Found & Rogers, 2002) and skill characterisation trials (Found & Rogers, 2002; Found, Rogers & Herkt, 2001). In all expertise validation studies to date there has been the finding that expertise of FDEs is both real and demonstrable. Since FDEs claim that the basis of their ability to discriminate genuine and simulated signatures revolves around interpreting the significance of spatial and execution features (or the similarity or dissimilarity of these features in relation to a population of specimen signatures), then it would appear that there is some basis for validly relying on these features.

The research described here is intended to further the work of Herkt (1986) who documented the methods of forgery used by 72 writers and determined the most common faults in their forgery attempts. Each of these writers forged the signatures of different individuals (two forgery attempts per writer). Herkt, in terms of non-spatial characteristics, found that 37% of the forgeries displayed 'shakiness, breaks and patching', and 43% contained noticeably 'heavier or lighter pressure habits'. This author concluded that the best forgeries (which constituted 74% of the attempts) were made 'freehand' as opposed to 'traced'. The aim of this study was to determine the frequency of occurrence of a selection of non spatio-temporal line features in order to assess their usefulness to discriminate between genuine, disguised, and simulated signatures. The experimental design described by Herkt was modified to limit variables associated with the number of different individuals' forged signatures (from 72 to one), the type of forgery produced (in this case only freehand forgeries were requested), and to reduce and define the features being studied.

2. Methods and Materials

All signatures used in this study were written using the same make and model of ballpoint pen and the same writing paper stock.

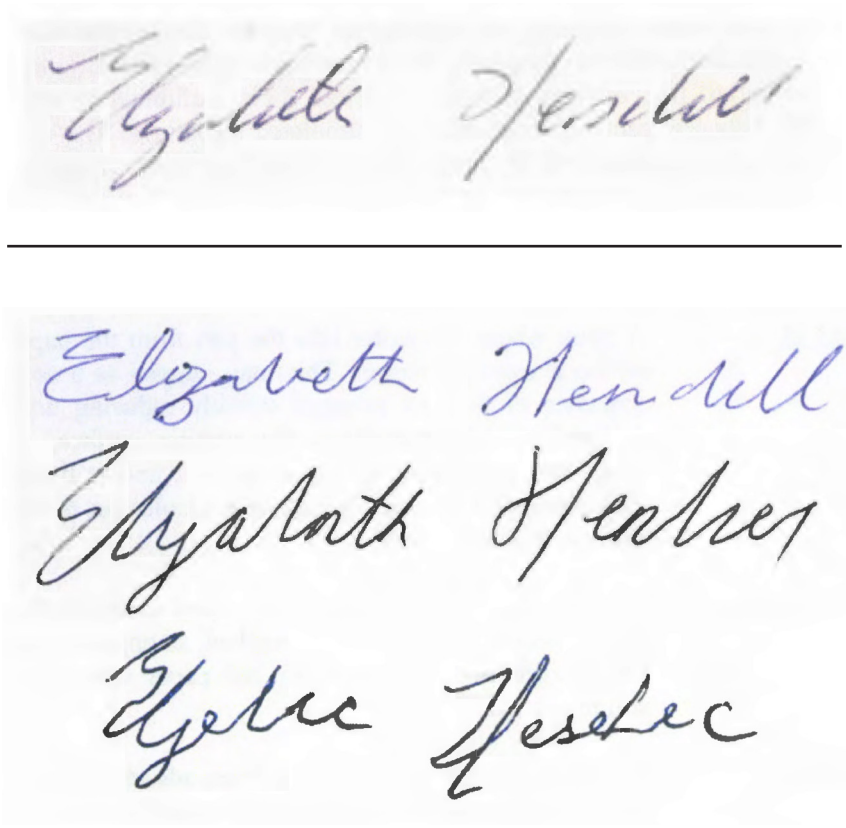
2.1 Collection of the genuine and disguised signatures

The genuine signature writer was a female in her thirties. Over a three-month period this writer was requested to:

- Perform approximately 12 repetitions of her signature (3 to a page) on as many days as was convenient.
- On the days where she performed the normal signatures she was requested to produce a small number of disguised signatures. The definition of disguise was given to the writer as meaning that it is to be written with a view to denying that it was her signature. The writer was informed that the signature must pass a fictitious 'transaction point' and therefore did have to retain some similarity to her normal signature.

In all, 177 genuine and 46 disguised signatures produced by the genuine writer were used for analysis.

In addition to the above, the writer was requested to provide 31 sheets of paper, each bearing three normal signatures that could be used by the forgers as models. The execution of these signatures was random over the genuine signature collection period. Each of the 31 forgers received one of these sheets.



For reference, a reproduction of one of the specimen signatures is provided in Figure 1.

2.2 Collection of the simulated (forged) signatures

Thirty-one individual volunteers, all working at the same industrial site, were used as forgers. Each individual was supplied with a kit containing a ballpoint pen, all writing paper that would be required to per form the simulation tasks, and a document bearing three original genuine signatures.

Simulators were instructed that they could use any or all of the three genuine signatures as models for their forgeries. Subjects were also instructed that their simulations must be freehand and could not be tracings. Simulators were required, in one sitting, to forge the genuine signatures 20 times. Examples of forgeries produced by three different simulators are provided in Figure 2.

At the end of the genuine, disguise and forgery collection phase, all signatures were compiled into a single booklet for analysis.

3. Definitions of features analysed

For the purpose of this paper, the following definitions of line quality parameters (execution features) were applied:

3.1 Tremor

Minor deviations in the line trace from its general overall direction. These are observable as a generally 'shaky' appearance of the line. In this study, signatures were either categorised as bearing tremor or not bearing tremor.

3.2 Relative Speed

Whether the questioned signature had, in the opinion of the examiner, been executed at a 'faster', 'slower' or 'similar' speed to that used to execute the genuine signatures. This judgement was based on a combination of features such as shading, tremor and pen pressure.

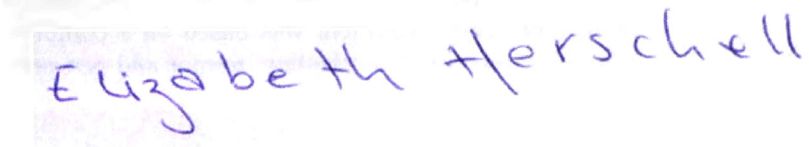


FIGURE 3. An example of a disguised signature.

3.3 Splice

Where a line trace is broken by a pen lift and the pen is then replaced over the line to re-start the formation.

3.4 Pen Lift

A point where the writer lifts the pen from the paper within a word formation. This may happen as a consequence of the pen pressure steadily reducing until the pen no longer touches the writing surface, or where the pen comes to an abrupt halt and is lifted. Splice points were not counted in the collation of the data for this parameter.

3.5 Blunt Endings

'Blunt endings' are formed by the pen slowing to a stop when the end of a line is reached, as opposed to a gradual lifting of the pen from the paper when it is still in motion.

3.6 Touch-up

An extra line (or lines) that has been added to a portion of a signature in an attempt to modify its appearance. 'Touch ups' have been traditionally associated with attempts by a forger to try to make the finished product look more like the signature that is being copied.

A 15-year qualified FDE was used to count each of the parameters described above for the genuine, disguised and simulated signatures.

Early in the examination of the signatures, it was found that the disguise strategy adopted by the specimen writer resulted in signatures that were dissimilar in construction to the normal signature for this individual (see Figure 3). This rendered the disguise group unsuitable for the analysis phase as the signature was now not comparable to the genuine or simulated signatures. It is noted that the specimen writer adopted this strategy in spite of being informed that 'the signature must pass a fictitious 'transaction point' and, therefore, did have to retain some similarity to the normal signature'. The form of disguise noted here is not, however, unexpected, as a discussion of this form of disguise appears in Wendt (2000).

4. Results

Each of the 177 genuine and 620 simulated signatures were inspected for pen lifts, splices, blunt endings, touch ups, and the presence of tremor. Table 1 shows the percentage of genuine and simulated signatures displaying each of these feature types.

As can be observed from Table 1, the genuine group did not exhibit any signatures displaying splicing or touch ups. Pen lifts, blunt endings and tremor were all features that were present to some extent within the genuine signature group. These three features, therefore, reflect aspects of natural feature variation within the questioned signature. However, these features were more likely to occur in simulated signatures. As can be observed by comparing the second and third columns of Table 1, for each feature type the percentage of signatures displaying the feature is substantially larger for the simulated signatures than for the genuine signature group. The percentage of signatures displaying tremor was 6.5 times greater for the simulations than for the genuine group. The percentage of signatures displaying pen lifts was 2.9 times greater for the simulations than for the genuine group. The percentage of signatures displaying blunt endings was 4.3 times greater for the simulations than for the genuine group. In addition, if a genuine signature displayed a pen lift or blunt ending it occurred only once, whereas a simulated signature may have displayed more than one such

TABLE 1. Percentage of signatures displaying each of the five feature types generated by the genuine writer and by the forgers.

Feature type	Genuine signatures	Simulated signatures
Pen lifts	18.1	51.6
Blunt endings	16.9	72.7
Tremor	9.6	61.9
Splices	0.0	98.5
Touch ups	0.0	19.0

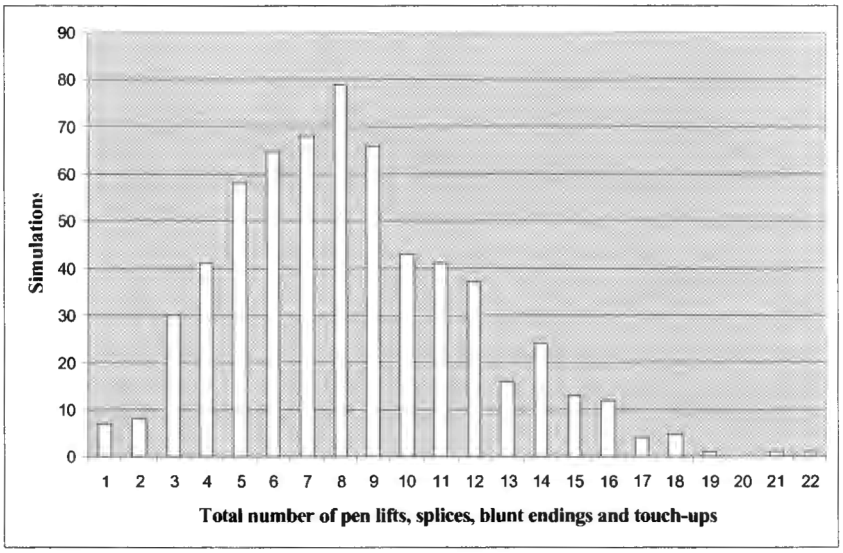


FIGURE 4. The number of simulated signatures versus the total number of pen lifts, splices, blunt endings and touch-ups detected.

feature. There was a total of 822 pen lifts observed for the 320 simulated signatures displaying this feature, and 999 blunt endings were observed in the 451 simulated signatures displaying this feature.

Unlike the genuine signature group, simulated signatures displayed substantial numbers of splices and touch ups. Six hundred and eleven simulated signatures displayed a total of 3185 splices and 117 simulated signatures displayed a total of 118 touch ups. As can be observed from Table 1, there is a very high percentage of simulated signatures in comparison to the genuine signatures displaying these features (98.5 versus 0 for splices, and 19 versus 0 for touch ups). Since none of the 177 genuine signatures displayed splices or touch ups, these features appear to be particularly good predictors of the identity of the questioned signature. The percentage differences for the other features used suggest that they can also contribute to the discrimination process. This is particularly the case when a number of the different features are observed in a questioned signature.

Figure 4 shows an analysis of the simulated signatures according to the total number of pen lifts, splices, blunt endings and touch-ups detected. An approximately normal distribution is observed with few simulations exhibiting very low and very high numbers of these features, and most exhibiting five to nine predictor features. It is the case that the position of this curve, relative to the x-axis would be expected to move according to the relative complexity of the signature being simulated.

A determination of relative speed was made for each of the genuine and simulated signatures. As expected, all 177 genuine signatures showed

TABLE 2. Relative speed distributions for the simulated signature group.

Simulations	Number of signatures	% of signatures
Slower	411	66.3
Similar	182	29.4
Faster	27	4.4

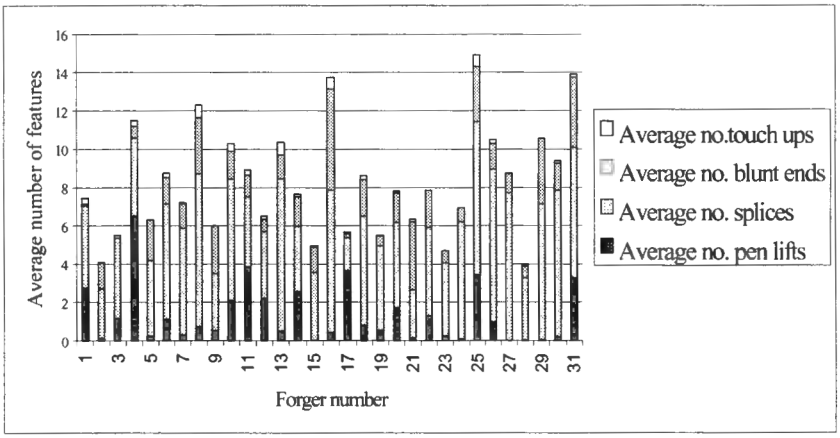


FIGURE 5. The average number of touch ups, blunt endings, splices and pen lifts for each of the 31 forgers used in this study.

performance speeds similar to each other. Table 2 shows the relative speed distribution for the simulated signatures. The majority of simulated signatures exhibited features that indicated that they were written more slowly than the genuine signatures (66.3%). A small number of these signatures were written more quickly than the genuine signatures (4.4%) and around thirty percent were written at a similar speed.

The results presented thus far have treated the 620 simulations as a group. If the average number of execution features is calculated for each of the forgers independently, then the data profiles provide a means to assess the extent of inter-forger variation in terms of the frequency of the presence of those execution characteristics under study. Figure 5 provides a plot of the average number of touch ups, blunt endings, splices and pen lifts for each of the 31 forgers used in this study. As can be observed by the height of the bars and the inter-forger differences in terms of the relative proportions of each of the execution characteristics from which the bars are comprised, there is a wide range of variation between the ability of the forgers to execute the signatures.

5. Limitations

This study was limited to execution features alone which should not in any way de-value the role that spatial properties have in the routine casework comparison of questioned to specimen signatures. Since a single FDE was the instrument used to measure the execution features, it is possible that there may be variation within this individual in terms of his ability to categorize the features under study (particularly when such a large number of signatures and features were being counted or considered). It is not thought, however, that inconsistencies in FDE feature detection would be a major contributor to the results, particularly given the magnitude of the difference in features between the genuine and simulated groups. In addition, this study did not provide any information as to the challenging question of what the relative participation of execution features could be to discriminate between forged and auto-simulated questioned signatures. Investigations on this question are reliant on finding a specimen writer who uses

auto-simulation as a method of disguise. This was not the case with the current writer under study.

6. Conclusion

Basic empirical studies, of the type described here, add to the body of knowledge regarding the relative importance of elements of execution in the comparison of questioned to specimen signatures. Even in the absence of the spatio-temporal information, the large difference in the frequency of occurrence of splicing and touch up features provides support for the proposition that, of the features under study, these are the best predictors of whether or not a signature is the product of a simulation process, providing disguise is not a relevant proposition. The observation that a questioned signature was written more slowly and, in a small number of cases more quickly than the specimen signature, is significant in formation for the FDE. The extent of difference in the occurrence of tremor, blunt endings and pen lifts between genuine and simulated signatures also provides support that these features are valid to use by FDEs when forming opinions regarding the authenticity of questioned signature formations.

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