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The Use of Simple Dimensional Measurements in the Analysis of Simulated Signatures: A Preliminary Study

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The ability of participants to simulate the width, height, and width: height ratio of simple and complex target signatures has been explored. The natural variation of the target signatures was evaluated over 29 and 28 signatures for the simple and complex signatures respectively. A group of 20 participants were provided 12 simulations of each signature on lined and plain paper. Paired t-tests show that the complex signature was more consistently reproduced than the simple signature. Single factor Analysis of Variance (ANOVA) followed by post hoc Tukey Honestly Significant Difference (HSD) tests showed that the complex signature was more easily simulated.

Introduction

The analysis of signatures is one of the main areas of interest for forensic document examiners. Generally the analysis consists of the examination of genuine signatures to assess the extent of natural variation and whether the features of a questioned signature fall within or outside this range. Such analysis is difficult to quantify and has been prone to the accusation of subjectivity. This has led to studies specifically aimed at assessing the individuality of handwriting (Srihari et al 2002, Li et al 2005) and there have been many studies into statistical analysis of handwriting. The frequency of occurrence of combinations of handwriting characteristics has been examined (Muehlberger 1977), letter and word spacing (Ling 2002) have been used in an attempt to identify common authorship of documents written after a 2 year interval, discrimination between different writers has been evaluated by analysis of letter shapes (Marquis et al 2005) and disguised slope of handwriting has been studied by pattern recognition methods (Brink et al 2011). The application of Bayesian methods for the assessment of the strength of handwriting evidence has been recently reported (Davis et al 2011), (Hepler et al 2012). Statistical evaluation of signatures by simple measurable parameters such as signature length, and height and width of particular features has been used to assess the natural variation in a collection of signatures (Matuszewski and Maciaszek 2008) , (Maciaszek 2011). Similarly, analysis of Arabic signatures has been used in an attempt to identify demographic variables (Al Haddad et al 2009) and how these can be related to the success of forging signatures (Al-Musa Alkahtani and Platt 2009, 2010, 2011), whilst analysis of Polish handwriting characteristics have also been statistically analysed (Turnbull et at 2010). In this paper we present preliminary findings in the use of height, width, and width: height ratio as a means of indication of forged signatures. Whilst it is not anticipated that this will provide an alternative to the experience and judgement of "traditional" document analysis it may provide a useful additional means of analysis. In particular, in cases where the parameters fall outside the range of natural variation this can provide a simple means of satisfying the Daubert criteria.

Experimental

Samples of the target signatures were produced in normal course of business (AP 29 signatures) or over several days specifically for the study (RB 28 signatures). The length and width of each signature was measured to the nearest mm. Given the natural variation in the signatures, greater precision in measurement was unwarranted. The standard deviation was taken as a measure of the natural variation in the samples.

Participants studied a sample of the signatures for 30 minutes. They produced simulated signatures from memory without sight of the originals, 12 on lined and 12 on plain paper.

The differences in width, height, and width: height ratio between lined and plain paper were analysed for each participant by paired t-test assuming unequal variance.

One way between groups analysis of variance was conducted to explore the success of the participants in simulating the target signatures on lined and plain paper. Statistical significance was set at a $p < 0.05$ level. Effect size was calculated using Cohen's eta squared statistic with values above 0.14 indicating a large effect, (Cohen 1988). Statistically significant differences between the participants were located by post hoc Tukey HSD tests.

Results and discussion

The signatures are shown in Figure 1 and can be classified as "simple" i.e. legible (AP signature) and "complex" i.e. not readily legible (RB signature).

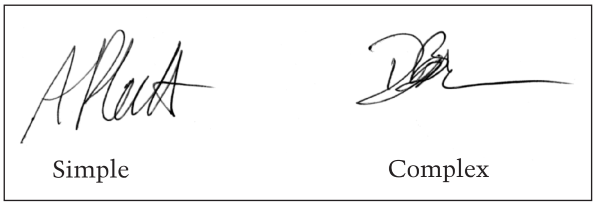

Figure 1. The target signatures

The descriptive statistics for the simulations are shown in Table 1 with the standard deviations being taken as a measure of the natural variation.

Success in the simulation of simple and complex signatures

The success with which the participants were able to simulate the dimensions of the target signatures was analysed by carrying out single factor ANOVA tests for each participant's simula-

	Simple Signature[1]						Complex Signature[2]					
	Width		Height		Ratio		Width		Height		Ratio	
	2.7(0.3)		1.4(0.2)		2.0(0.2)		2.5(0.3)		1.2(0.1)		2.2(0.2)	
Participant	Lined Paper[3]			Plain paper[3]			Lined Paper[3]			Plain paper[3]		
	Width	Height	Ratio	Width	Height	Ratio	Width	Height	Ratio	Width	Height	Ratio
1	2.7(0.3)	1.2(0.1)	2.2(0.2)	2.5(0.4)	1.0(0.1)	2.6(0.4)	2.2(0.3)	1.1(0.1)	2.0(0.3)	2.5(0.3)	1.2(0.1)	2.2(0.3)
2	2.5(0.4)	1.0(0.3)	2.6(0.6)	2.8(0.4)	1.0(0.1)	2.7(0.3)	2.2(0.2)	0.9(0.2)	2.5(0.4)	2.2(0.3)	0.8(0.8)	2.7(0.4)
3	3.3(0.3)	1.2(0.2)	2.7(0.4)	3.8(0.3)	1.4(0.2)	2.8(0.2)	3.5(0.3)	1.1(0.2)	3.2(0.6)	3.3(0.3)	1.3(0.2)	2.5(0.2)
4	3.2(0.4)	1.2(0.1)	2.7(0.4)	3.3(0.3)	1.2(0.1)	2.9(0.5)	2.7(0.4)	1.4(0.1)	2.0(0.3)	3.3(0.4)	1.2(0.1)	2.7(0.2)
5	3.1(0.5)	1.2(0.1)	2.7(0.4)	3.1(0.5)	1.0(0.1)	3.0(0.5)	2.6(0.4)	1.1(0.1)	2.5(0.4)	2.6(0.3)	1.0(0.1)	2.5(0.2)
6	2.3(0.2)	1.1(0.1)	2.2(0.3)	3.3(0.6)	1.1(0.1)	2.9(0.4)	2.3(0.3)	1.1(0.1)	2.2(0.4)	2.1(0.6)	1.1(0.1)	1.9(0.4)
7	2.0(0.2)	0.9(0.1)	2.3(0.3)	1.9(0.2)	0.8(0.1)	2.4(0.4)	1.9(0.2)	0.8(0.1)	2.3(0.5)	1.9(0.2)	0.9(0.1)	2.3(0.4)
8	2.7(0.4)	1.0(0.1)	2.7(0.3)	2.6(0.2)	0.8(0.1)	3.4(0.5)	2.1(0.4)	1.1(0.2)	2.1(0.5)	2.1(0.3)	1.0(0.2)	2.2(0.4)
9	3.0(0.3)	1.1(0.1)	2.7(0.3)	2.7(0.3)	0.9(0.1)	3.0(0.4)	2.8(0.2)	1.1(0.1)	2.6(0.3)	3.1(0.4)	1.1(0.1)	3.0(0.6)
10	2.7(0.2)	0.9(0.1)	3.0(0.4)	2.9(0.3)	0.9(0.1)	3.3(0.3)	2.1(0.4)	1.0(0.1)	2.2(0.4)	3.3(0.5)	0.9(0.1)	3.6(0.7)
11	3.1(0.4)	1.6(0.2)	2.0(0.4)	2.8(0.4)	1.4(0.1)	2.0(0.3)	2.3(0.3)	1.3(0.1)	1.9(0.3)	2.4(0.3)	1.2(0.1)	2.0(0.3)
12	2.5(0.5)	1.4(0.2)	1.8(0.4)	1.7(0.2)	1.0(0.1)	1.7(0.3)	2.0(0.3)	1.2(0.2)	1.6(0.3)	1.8(0.4)	1.1(0.1)	1.7(0.4)
13	2.1(0.1)	1.1(0.1)	2.0(0.2)	2.3(0.4)	1.3(0.2)	1.7(0.2)	2.0(0.4)	1.0(0.1)	2.0(0.4)	2.2(0.3)	1.1(0.1)	2.0(0.3)
14	2.1(0.3)	1.0(0.2)	2.2(0.4)	2.9(0.5)	1.2(0.1)	2.4(0.5)	2.2(0.2)	1.3(0.2)	1.7(0.3)	2.1(0.4)	1.3(0.2)	1.6(0.3)
15	1.5(0.2)	0.6(0.1)	2.5(0.5)	1.6(0.1)	0.5(0.1)	3.1(0.5)	1.3(0.2)	0.7(0.1)	2.1(0.4)	1.1(0.1)	0.6(0.1)	1.7(0.3)
16	3.4(0.2)	1.8(0.1)	1.9(0.2)	3.8(0.4)	1.9(0.3)	2.0(0.4)	2.6(0.2)	1.4(0.2)	1.9(0.4)	2.6(0.4)	1.3(0.1)	2.1(0.5)
17	3.9(0.5)	1.2(0.1)	3.3(0.6)	3.9(0.2)	1.4(0.1)	2.8(0.4)	2.4(0.3)	1.1(0.1)	2.2(0.4)	2.4(0.4)	1.1(0.2)	2.3(0.6)
18	2.8(0.3)	1.7(0.1)	1.6(0.1)	2.5(0.6)	1.4(0.2)	1.8(0.4)	2.3(0.2)	1.1(0.1)	2.1(0.2)	2.3(0.4)	1.0(0.1)	2.4(0.5)
19	2.6(0.3)	1.2(0.2)	2.2(0.4)	2.7(0.2)	1.2(0.1)	2.2(0.2)	2.8(0.3)	1.3(0.2)	2.1(0.4)	3.1(0.2)	1.2(0.1)	2.5(0.3)
20	2.5(0.3)	1.3(0.2)	2.0(0.2)	2.8(0.2)	1.4(0.1)	2.0(0.3)	2.2(0.3)	1.1(0.1)	2.0(0.4)	2.8(0.5)	1.1(0.1)	2.5(0.3)

Table 1. Descriptive Statistics: mean (standard deviation) / cm, for the target signatures and the simulations
1. Averages over 29 target signatures. 2. Averages over 28 target signatures. 3. Averages over 12 simulated signatures.

	Simple Signature				Complex Signature			
	Lined†	h^2‡	Plane	h^2	Lined	h^2	Plane	h^2
Width	55	0.74	50	0.72	50	0.71	55	0.68
Height	40	0.81	35	0.74	70	0.63	65	0.60
Width: Height ratio	40	0.70	55	0.78	85	0.55	90	0.43

Table 2. The percentage success rate in simulation of the width, height, and width: height ratio simple and complex target signatures.

† The percentage of success

‡Effect size, vales >0.14 indicate a large effect size.

tions against the target signatures. Tukey HSD post hoc tests were used to locate these differences and the success rate over all participants (expressed as a percentage) for each of the parameters is shown in Table 2, together with the effect size (η^2).

The results indicated that in all comparisons significant differences occurred between the simulations made by some of the participants and the dimensions of the target signatures. The magnitude of the effect size is, in all cases, considerably higher than the 0.14 threshold considered to represent a large effect (Cohen 1988) and indicates that not only are the differences significant but that they are of practical importance. As can be seen from the percentage success rates, the participants generally found it easier to simulate the "complex" signature for the height and ratio, with little difference in ease of simulation of width. The use of lined or plain paper appears to have relatively little effect on these aspects of the simulations.

In the attempted simulation of the legible signature, elements such as form are likely to be easier to simulate compared to the more stylised complex signature. Thus with the more legible signature, it is possible that the author's own handwriting characteristics became more important, leading to a poorer simulation of the proportions of the target signatures.

The success of the individual participants in reproducing all three aspects is of interest as this represents the successful simulation of the signatures as judged by the criteria used in this study. The participants displayed a slightly greater proficiency in overall success in simulating the more complex signature with 35% passing all three criteria as opposed to 27.5% for the simpler signature.

Differences between lined and plain paper

From these results it is also possible to explore whether there was any difference in the quality of simulations between lined or plain paper. Paired samples t-tests were conducted to evaluate the impact of lined versus plain paper on width, height, and width: height ratio and the consistency of the simulations over all, the participants is shown in Table 3. Where significant differences between the two sets of dimensions occurred, the effect size, η^2, was calculated by $\eta^2 = t^2/(t^2 + N -1)$ (Cohen 1988) where t is the test statistic and N the number of attempted simulations (N = 12 in this study). The values of η^2 which range from 0.21 to 0.81 are again significantly greater than the 0.14 threshold and thus represent a large effect size in all cases.

	Simple Signature	Complex Signature
Width	55	65
Height	30	70
Width: Height Ratio	55	70

Table 3. The Percentage consistency in simulating dimensions in the target signatures on lined vs. plain paper.

It is clearly seen that the more complex signature was reproduced more consistently than the simple signature with samples from approximately 70% of participants having indistinguishable dimensions between lined and plain paper. Intuitively it might be expected that the simple signature may have been easier to simulate reproducibly and the reason that this is not observed here is probably the same as discussed above for the success in simulating the target signatures. Thus with the illegible signature, participants were less able to make a conscious effort to reproduce the form of the letters and instead tended to focus more on the overall proportions. It is also apparent that relative ease of simulation of each parameter varied between the two target signatures. For instance, height achieved the lowest score for the simple signature and the highest for the complex signature.

Conclusion

The study indicates that natural variation is best assessed by observing differences in form and letter design rather than size, for the complex signature. However based on the simple measurements made here, the opposite appears to be the case for simple signature, where in the absence of intricate form details, the size and proportion of the signature become its most discriminating features. Importance of using standard methods of analysing the form and line quality of a questioned signature against a specimen signature was also highlighted, as two participants, had simulated width, height and proportion accurately for both signatures. However upon cursory inspection, it was evident that they had not convincingly reproduced the form of the signature. There are numerous factors such as line quality and form that affect the individuality of handwriting and signatures and the combination of these has to be taken into account to form a firm conclusion.

It is clear that simple measurements such as those described above cannot provide conclusive information on whether a questioned signature is genuine or not. For instance a traced signature would pass as authentic when judged against the criteria discussed here. However in some instances, the natural variation of the set of genuine signatures may be useful in providing an objective basis on which a document examiner could conclude that a signature was not genuine.

The analysis presented here might, in some instances, be used as a simple means of demonstrating differences between genuine and questioned signatures in a manner which could help meet the Daubert criteria for reliability of expert evidence.

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