Numeric Approach in Handwriting Comparison

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Abstract. In forensic handwriting examination, the examinator is repeatedly confronted with very similar handwritings. In case of counterfeiting, such imitation is mostly executed as similarly as possible to the model. However, there are writers who by nature have a very similar style to their "model" or can put themselves in the person's shoes exceptionally well. In forensics, this often results in wrong judgements. This circumstance is to be countered by means of a more specific approach than usual. In consequence, in all these cases where highly similar handwritings occur we have to use comparison methods as e.g. systematic scales of quantified on the basis of a highly differentiated quality analysis, followed by a systematic numerical approach. Some appropriate instruments have proven to be very useful and convenient in this context so as to achieve scientifically based assessments. In the following, some related methods will be presented for discussion.

1. Introduction

The need for a systematic registration and collection of data of various kinds is indispensable for scientific methods. In the case of the recording of graphic facts in the daily practice, however, such a method is not yet particularly widespread. In the German-speaking and European countries, comparative handwriting examinations are usually conducted according to the *Best Practice Manual for the Forensic Examination of Handwriting* edited by the European Network of Forensic Science Institutes (ENFSI, 2020): It gives a comprehensive description of best practice in this field. A large part of the manual is devoted to the instructions for the technical examination; however, it is often the case that these do not provide any further insights when we have to deal with handwriting comparison. Then it is often almost exclusively a matter of identifying graphic facts. In addition to some investigations that can still be classified as technical, the manual also recommends identifying and comparing eleven graphic features. However, there is no question of systematic or even numerically scaled recording; nor are eleven features sufficient for a differentiated determination of a handwriting.

Yet, for a systematic determination of graphic features, it makes sense to first classify them according to specific criteria developed for a systematic handwriting analysis, as a basis for further numerical processing. Practical examples will be used to present such numerical methods.

2. Exposition of the problem - example of very similar handwritings: Pablo Picasso (1881-1973) and René Magritte (1898-1967)

As an example of a natural and unintentional similarity, two writings are cited. It is indeed not easy to distinguish between two writings that have so many similar forms.

Here, for example, are highlighted

- In the word *qui*:

Rightward hand connection in *q* /transition to *u* in a stiffened, arcadian form / actual form of the connection as an angle / next connection as a garland / downstroke of the *i* tends to be shorter / *i*-dot set separately

- In *mains / mais, mot*:

arcade shape of *m* / steeper position of the third downstroke in *m* / non-connection and shaping of the *a*, the *i* and the *s* / raising of the last strokes of the *n* (*mains*) or the *m* (*mains, mot*)
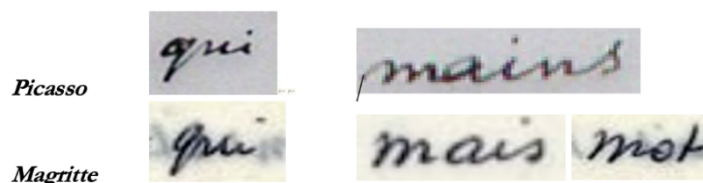

Figure 1. *Examples of very similar characteristics*

So there are found 6 very similar formations with the word qui in only 3 letters, and 12 very similar formations with only 8 or 10 letters. If there would not been further possibilities for comparison available in this case, any expert would probably conclude that it is the same authorship.

Looking at the whole letters, the impression is confirmed as far as both painters are used to mix text and drawings; yet, it might change somehow as also deviations are found. Anyway, the writings have to get analyzed systematically in detail.

3. Numerical-systematic examination methods

For the systematic determination all graphic features were first classified according to the five basic dimensions as: movement, form, space, pressure and stroke; most comprehensive as well as specific characteristics can be prevalently assigned to one of these dimensions. This compilation is not always compulsory, as individual characteristics often contain qualities of several basic dimensions, but it allows a better overview, as it is presented here. For the present differentiation chosen for practical purposes (which can of course be broken down further), there are between 6 and 21 characteristics per dimension, a total of about 62.

Not all of them can be recorded in every manuscript, especially in signatures or short texts the number is limited. For numerical recording, each individual feature is classified on a seven-point scale[1]; subsequently, the congruence can be determined numerically from the assessed values.

Values can be compared simply arithmetically, and, by doing this, we obtain values of congruence or deviation:

Table 1. *Five dimensions: congruence against deviation (non-weighted)*

Congruence Picasso/Matisse	Congruence pos	Congruence neg = deviation
Movement	0	11
Form	5	10
Space	3	16
Pressure	0	5
Stroke	1	5
Total	**9**	**47**

Significance of proportion Congr: Dev → p**~ **1%** (according to X^2 test, value: 6.446; critical value: $\geq$ 6.63)
Significance of proportion Congr: Dev → p*$\leq$ **5%** (according to X^2 test, value: 6.446; critical value: $\geq$ 3.84)

Hence, over all five dimensions, 9 positive and 47 negative congruence points are resulting.

If these values are subjected to the X2 test, the process obtains a significance value of slightly under 1 per cent, or certainly 5 per cent.

3.1. Deviation weighted

Yet, in order to avoid too strong deviations and to weaken the strong potential of a merely arithmetic deviation value, in many cases a deviation weighting is recommended. The definition may again be stronger or weaker, depending on the material available as well as on certain quality criteria.

This is particularly important in difficult cases:
- If the difference between the values of congruence and deviation is no more significant, the result may, but must not be mitigated.
- If the difference between the values of congruence and deviation remains significant, the result is even stronger.

That process was done with writings of Picasso and Magritte as well and the finding was that the mitigated version is no more significant yet just points to a strong tendency. This indicates that further qualitative investigations are compulsory and shows that the expert never is allowed to rely on one only instrument.

Table 2. *Five dimensions: congruence against deviation (weighted)*

Congruence Picasso/Matisse	Congruence pos	Congruence neg (deviation)
Movement	0	5
Form	5	4
Space	3	9.5
Pressure	0	3
Stroke	1	5
Total	**9**	**28**

Significance of proportion Congr : Dev → p< **10%** (according to X^2 test, value: 2.44; critical value: $\geq$ 2.70)

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[1] A seven-point scale might be defined from -3 to +3 for better visual retractability in daily practice, yet, it has to be transformed in a scale counting from 1 to 7 for further numeric and statistical calculation (1 means a very weak appearance, 4 a medium one, and 7 a very strong one).

4. Cluster analysis

In certain cases, not only several manuscripts, but several groups of manuscripts are to be compared. This results in a large amount of numerical data that requires special processing.

A cluster analysis is used to uncover similarity structures between graph-theoretically classified groups that have not been pre-assigned and to re-identify them. In the process, the deviations from each other group are estimated on the basis of the graphological variables as described above. By the assigned values, the determined distance between the groups is given: The greater the distance, the further "away" the groups are from each other.

The basis is again the registration by a seven-point scale as before.

4.1. Cluster analysis - example

In a handwriting comparison case, there were five distinguishable groups of comparative manuscripts available: two postcards with spontaneous cursive writing (V1, V2), with dates preceding the questioned document; furthermore, the suspected person is asked by the police to produce current handwriting samples, which are written particularly carefully (V3-V5). In the further course he prepares a draft in print (Script, V6), he describes the events with handwritten letters to the expert (V7-V9) and submits a note with a short spontaneous note in Script (V10).

Since all these groups of scripts, in a certain way, appeared different from each other, they were divided up as described and each group was systematically classified according to 43 characteristics on a seven-point scale.

The next table shows the exemplary classification of 8 characteristics associated to movement as shown in the table, scaled for 6 groups of handwritings; the results leading to a table with 83 values. Accordingly, the four other dimensions were classified.

Table 3. Example 1 - classification of signs associated to movement

Example Handwriting comparison	X1	V1, V2	V3-V5	V6	V7-V9	V10
Signs associated to movement						
Movement accentuation	5	5	4	4	4	5
Strength of impetus	5	6	4	5	5	5
Homogeneity of flow	2	6	7	6	7	5
Looseness vs. bond	2	5	6	6	6	5
Tempo: Speed of Stroke	6	5	5	5	5	5
Tempo: Speed of Success	5	6	5	6	6	6
Connectedness: degree	3	3	6	1	6	1
Leftward/rightward trend: general	5	6	5	5	5	5

The systematic classification of all 43 characteristics leads to a table of 258 values. In this case, a fairly clear picture emerges: the questioned handwriting X shows a fairly large distance to all the other writings. The comparative manuscripts, however, even if by only small distance to each other, divide again into two groups: the cursive manuscripts and the "script letter" ones (V6, V10). This corresponds very well to the other findings in this case and shows a clear deviation of the characteristics of the questioned handwriting X.
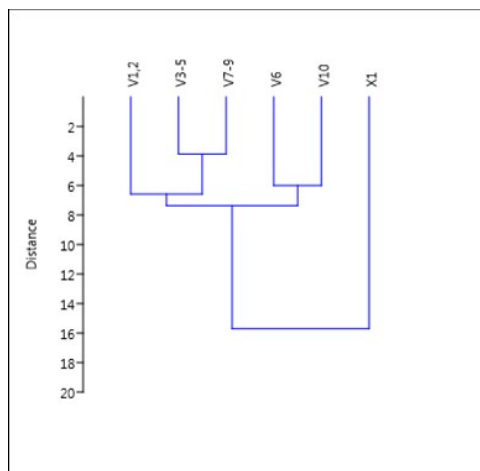

Figure 2. Example 1 - cluster analysis

5. General Discussion

In the comparison of very similar handwritings it is often difficult to obtain a clear result. Of course, a certainty of 100% is never possible *a priori*, the method always remains in the domain of probability. Nevertheless, there are not found authors who suggest a systematic *qua* scientific approach for graphic features even if they do for physical, chemical, other similar investigation. Yet, a systematic numeric registration as well as its mathematic working up allows a better approach to a higher degree of probability.

The numeric tools presented and proposed here should not be considered as solely conclusive evidence in a forensic analysis any more than any other method. Yet, experts do have to apply and to develop as many instruments as possible. Hence, as an extension of the repertorium of methods, these instruments can support the evidence in certain cases.

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