

Comparison between Digital and Paper Handwriting—A Contribution to Graphoscopic Analysis [†]

Vlad Tatarescu ^{1,2}, Daniela Eusébio ^{1,3}, Mariana M. Louro ⁴ and Alexandra Bernardo ^{1,3,*} 

¹ Laboratório de Ciências Forenses e Psicológicas Egas Moniz, 2829-511 Almada, Portugal; vlad.tatarescu@gmail.com (V.T.); danielaeusebio99@icloud.com (D.E.)

² Mestrado em Tecnologias Laboratoriais em Ciências Forenses, Egas Moniz School of Health and Science, 2829-511 Almada, Portugal

³ Egas Moniz Center for Interdisciplinary Research (CiiEM), Egas Moniz School of Health & Science, 2829-511 Almada, Portugal

⁴ Licenciatura em Ciências Forenses e Criminais, Instituto Universitário Egas Moniz, 2829-511 Almada, Portugal; marianalouro1@gmail.com

* Correspondence: abernardo@egasmoniz.edu.pt

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Abstract: The growing development of new technologies and the evolution of communication devices has led the world's population to gradually replace traditional writing on paper and pen with digital handwriting. This shift in writing instruments and media presents new challenges for calligraphy specialists. The aim of this study is to compare digital handwriting and traditional writing on paper and to explore the possible influence of different supports on the analysis of handwriting. This study's design consists of the analysis and comparison, by three calibrated forensic experts, of the handwriting of 10 participants, 4 of whom provided anonymous samples for authorship identification purposes. Preliminary results of the comparative analysis in both media revealed some differences in letter size, spacing, dots, ovals, and initial and terminal strokes, and similarities in graphic impulses, inclination, commas, punctuation, accentuation, calligraphic case, speed, and letter shapes. Concerning authorship identification, a 75% success rate was achieved.

Keywords: graphoscopy; forensic handwriting analysis; questioned documents



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1. Introduction

The current technological era promotes the rapid transmission of information worldwide; however, it raises security issues that require the adaptation of traditional security elements (such as signatures and handwriting itself) to new digital writing instruments. In this sense, several studies have explored the eventual equivalence between an individual's signature and handwriting in both supports (paper and digital), with the aim of developing tools and methodologies that assist in graphoscopic analysis. In general, differences have been described, for example, in terms of speed (faster in the digital support), size (larger in the digital support) and pressure (lower in the digital support) [1,2]. In addition to these differences, significant differences between handwriting/signatures have also been reported when written on different software and hardware resources, which makes standardization difficult when it comes to digital samples, especially when the individual writes/signs in different positions [3–5]. Thus, the present work aims to contribute to the description of the common and particular characteristics of handwriting in each medium (paper and digital).

2. Materials and Methods

This pilot study adopts a design, presented in Figure 1, involving 10 forensic students as volunteers, between the ages of 18 and 20. The participants provided handwriting

samples, including four anonymous samples for authorship identification (2 positive controls and 2 negative controls). All participants willingly agreed to participate in the study and provided their written informed consent. To ensure anonymity, participants were coded with randomly generated numbers.

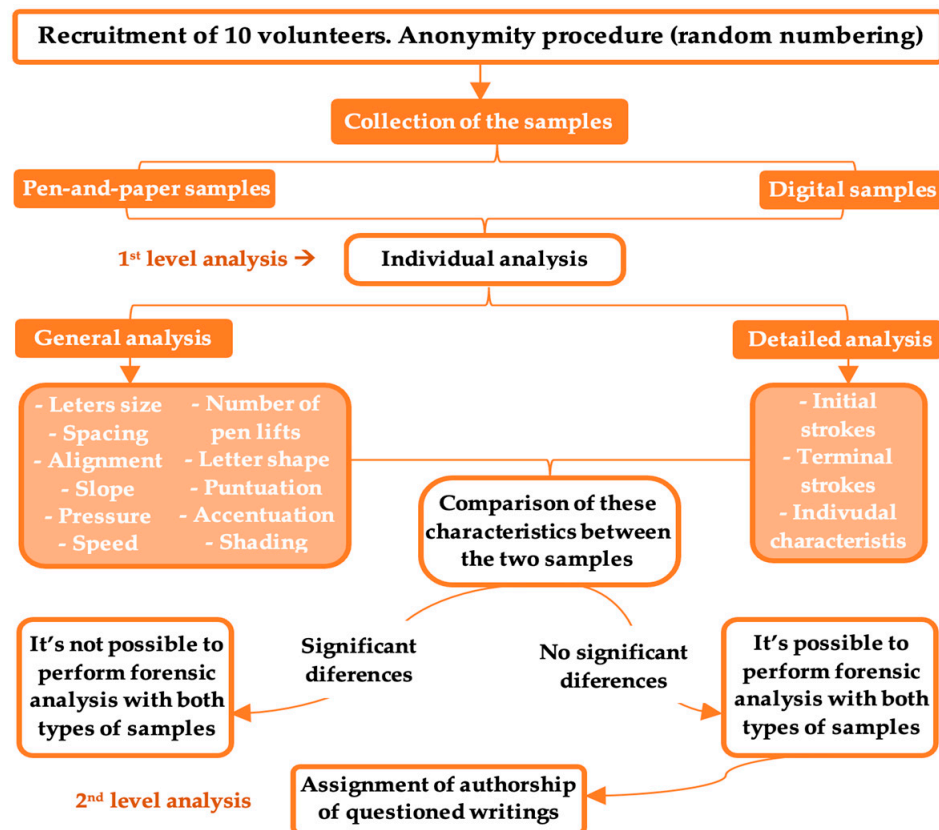








Figure 1. Pilot study design.

Participants were asked to write a text three times (once in uppercase and twice in lowercase) on a piece of paper, and to repeat the process using a digital medium, namely an 8th generation iPad® and an Apple Pencil 1st gen. Blue ink pens and individual sheets of white A4 paper were used, in accordance with the Judiciary Police guidelines (LPC-FEM-MD012, LPC-FEM-MD016 and LPC-FEM-MD017).

Forensic handwriting analysis was performed at two levels by three independent calibrated experts. The first level involved an analysis of the handwriting and comparison of the general and detailed characteristics between the two supports for 8 participants, and the second level involved the graphoscopic analysis on both supports with the aim of assigning the graphic identity of 4 anonymous samples.

3. Results

The comparison of the handwriting from eight participants revealed notable differences between the pen-and-paper and digital media. Several recurring differences were observed, including discrepancies in the opening of ovals, periods, spacing, and letter size. The detailed analysis highlighted disparities, particularly in the initial and terminal strokes. It should be noted that no significant changes in digital writing pressure were detected, as indicated by the figures presented in Figure 2.

Analyzed Characteristics	Feature on Paper	Feature on Digital Support
Ovals opening	 Figure 1 - Oval opening of the lower case letter "a" in the paper handwriting	 Figure 2 - Oval opening of the lower case letter "a" in the digital handwriting
Periods	 Figure 3 - Periods in the paper handwriting	 Figure 4 - Periods in the digital handwriting
Spacing	 Figure 5 - Spacing in the paper handwriting	 Figure 6 - Spacing in the digital handwriting


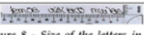




Analyzed Characteristics (continuation)	Feature on Paper (continuation)	Feature on Digital Support (continuation)
Size of the Letters	 Figure 7 - Size of the letters in the paper handwriting	 Figure 8 - Size of the letters in the digital handwriting
Pen Pressure	 Figure 9 - Pen pressure in the paper handwriting	 Figure 10 - Pen pressure in the digital handwriting
Shading	 Figure 11 - Shading in the paper handwriting	 Figure 12 - Shading in the digital handwriting

Figure 2. Handwritings differences observed between paper and digital supports.

For instance, when examining the opening of ovals, a distinct contrast was observed between paper writing and digital support. In paper writing, the oval exhibited an open shape at the top right, while in digital writing, it appeared closed at the top right. Similarly, in the case of periods, the shape differed between paper writing (dot shape) and digital writing (straight line). Furthermore, the comparison indicated that the spacing and letter size in paper handwriting were generally smaller than those in the digital medium. This finding aligns with the observations made by other authors [3]. In terms of the initial and terminal strokes, there were a few discernible distinctions. The terminal stroke of certain letters and the initial stroke of dashes exhibited variations between paper handwriting (straight line) and digital writing (hook-shaped). On the other hand, it was possible to establish a similarity relationship between certain graphical and dynamic characteristics of the writings performed on paper and the digital support. Thus, similarities were observed in graphic impulses, inclination, commas, punctuation, accentuation, calligraphic case, baseline, speed, and letter shapes. An example of these similarities can be observed in Figure 3.

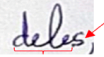

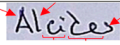

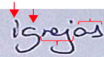

General Appearance Characteristics - Graphic Impulses	Graphical Impulses - Paper support	Graphical Impulse - Digital support (tablet)
In both scripts, the word "their" is realized in two graphic impulses.	 Figure 13 - Graphical impulses of the word "their" in writing n°04 on paper.	 Figure 14 - Graphical impulses of the word "deles" in writing n°04 in digital support.
In both writings, the word "Alcides" is realized in five graphic impulses.	 Figure 15 - Number of graphic impulses on the word "Alcides" in writing n°18 on paper.	 Figure 16 - Number of graphic impulses in the word "Alcides" in writing n°18 in digital support.
In both writings the word "churches" is realized in four graphic impulses.	 Figure 17 - Graphical impulses of the word "church" in writing n°35 on paper.	 Figure 18 - Graphical impulses of the word "church" written in writing n°35 in digital support.

Figure 3. Comparison of characteristics of writing performed on paper and digital supports.

Regarding the second level of graphoscopic analysis, namely the assignment of authorship of questioned writings, it was possible to attribute an identity to one out of four anonymous handwriting samples and conclude that two anonymous samples did not match any of the eight samples previous analyzed. The obtained results suggest that it is possible to compare texts in both formats, as similarities were identified in 16 parameters (inclination, commas, periods, question marks, accentuation, calligraphic style, opening of ovals in lowercase letters "a", "g", "p", and "q", speed, letter size, letter shape, lowercase letter "d", lowercase letter "f", uppercase letter "E") between the anonymous writing and its corresponding paper and digital formats. Consequently, it is possible to attribute samples 18 and 67 to the same author. Figure 4 provides two examples of similarities between the two writings concerning appearance characteristics.

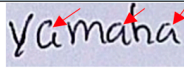
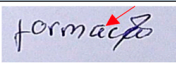
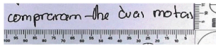

	Analysed characteristics	Anonymus sample n° 18	Anonymus sample n° 67
Paper support	Oval opening Lower-case "a" In both scripts, the letter oval is mostly open in the upper right area.	 <i>Figure 19 - Opening of the lower case oval of letter "a" in writing n°18 on paper.</i>	 <i>Figure 20 - Opening of the lower case oval of letter "a" in writing n° 67 on paper.</i>
Digital support	Letter Size In both scripts, the size of the letters is approximately 5 mm.	 <i>Figure 21 - Size of the letters of writing n° 18 in digital support.</i>	 <i>Figure 22 - Size of the letters of writing n° 67 in digital support.</i>

Figure 4. Comparison between paper and digital handwriting samples.

4. Conclusions

This pilot study indicates the feasibility of comparing handwriting in both supports and evaluates handwriting authorship with a 75% success rate. However, it is crucial to emphasize that a validated methodology is essential in supporting the comparison between the supports and in the attribution of handwriting authorship.

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Conflicts of Interest: The authors declare no conflict of interest.

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