

Pen pressure: the most human trait of handwriting

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Abstract

Pen pressure seems impossible to measure on a scanned page: a ballpoint leaves ink, not force. We show that the ink is enough. We estimate **pressure intensity** as the *ink load per millimetre of stroke*, measured against the paper surrounding each letter and scaled to the physical page. On 13 samples rated by an expert graphologist, the measure ranked pressure almost exactly as the expert did ($\rho = 0.91$), whereas the previous pixel-width method was unrelated to expert judgement ($\rho = -0.28$). In a corpus of 1,758 pages, the measure was highly stable between a person's two pages ($\rho = 0.95$), independent of the other graphometric descriptors (all $|\rho| < 0.30$), and fully separated 12 paradigmatic introverts and extraverts. Yet it did not covary with the introversion–extraversion scale in the general population: it captures a distinct dimension, closer to vital energy. Unexpectedly, the absence of *ink pools* (the deposits a real ballpoint leaves) flagged AI-generated handwriting: all six scan-like synthetic pages were detected, with 1.1 % false alarms when both pages are required. We argue that pressure is the most human and least fakeable trait of handwriting.

Keywords: computational graphometry, pen pressure, integrative graphoanalysis, computer vision, synthetic handwriting, fakeability.

For the non-specialist: the pulse of handwriting

When we write, the hand does not only draw letters: it also presses. We do not decide how hard. Pressure rises when something matters to us and falls when we are tired, and we rarely notice it. That is why, in graphology, pressure is like the blood running through the veins of handwriting: the place where a person's energy, drive and desire show.

The trouble is that a scanned page does not keep the force. It keeps the ink. For years, computational systems tried to guess pressure from how wide the line was. It worked poorly: with a ballpoint, pressing harder barely widens the stroke. What changes is how much ink the pen releases.

Our idea was simple. Instead of measuring width, we measure **how much ink was left on each millimetre of stroke**, comparing the ink with the paper around it. Shadows or greyish paper no longer matter. The result looks like a heat map: blue where the hand barely rested, red where it pressed hard.

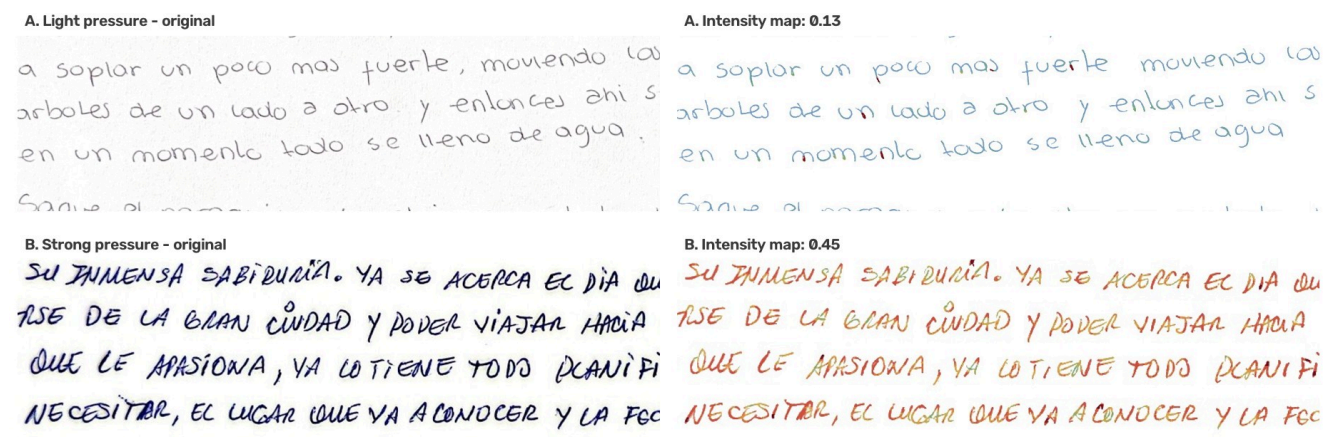


Figure 1. Two real, anonymised samples. A: light pressure (0.13). B: strong pressure (0.45). Blue = light, green = normal, amber = firm, red = strong.

Three things surprised us. First, the measure matched the judgement of a graphologist with twenty years of practice almost exactly. Second, pressure turned out to be a trait of its own: it resembles none of the other traits the system measures, not even how much ink covers the page. Third, it recognised handwriting made by artificial intelligence. A real ballpoint leaves small pools of ink where a letter starts or a curve turns; AI draws an even, "matte" stroke with no pulse. It can imitate the shape of the letters, but not yet the heartbeat of the hand.

1. Introduction and theoretical framework

Pressure is the handwriting trait that classical graphology links most directly to psychic energy, and the one computational graphometry has measured worst. This work aims to close that gap without giving up the theoretical framework.

1.1 Integrative graphoanalysis

GrafoMetrics automates integrative graphoanalysis, a model that organises handwriting into ten hierarchical levels: spatial organisation, stroke dynamics, formal structure, directionality, cohesion, gesture types, symbolic indicators, signature, integrative dominants and psychological inferences. Each level groups parameters that computer vision can detect, quantify, normalise against a population and combine into a profile. The software does not decide: it delivers the measurement and its visual evidence so that the graphologist can apply their own model.

Pressure belongs to the second level, **stroke dynamics**, together with speed and regularity. It is the level of energy and movement, close to Vels's notion of vectors: what handwriting reveals not through its form, but through how it was executed.

1.2 Pressure as an expression of vital energy

For Klages, pressure is part of the interplay between tension and release that gives the stroke its rhythm. Pulver explicitly tied it to libido, understood as psychic energy discharged onto the paper: where pressure increases, drive and desire increase. Vels treated it as an indicator of vitality, will and endurance. In clinical practice, the graphologist reads it as a pulse: the blood circulating through the writing.

This reading has a methodological consequence. Pressure is a largely unconscious motor gesture: writers control the shape of their letters far better than the force with which they trace them. It is therefore, in principle, the hardest trait to fake, for a person and for a machine.

1.3 The problem of measuring it in an image

True pressure can only be recorded with a digitising tablet, which measures the force of the pen tip at every instant. Tablet studies have linked pressure to emotional states such as depression and anxiety (Likforman-Sulem et al., 2017). But in personnel selection, psychological assessment and forensic work, the sample almost always arrives as a handwritten, scanned page.

On a static image, pressure can only be **estimated** from its trace: the deposited ink. The relation between writing and ballpoint ink deposition has been described in forensic document examination (Franke and Rose, 2004). The goal of this work is to build that estimate so that it is comparable across people, stable within the same person and faithful to the graphologist's judgement.

2. Method

2.1 Samples

Sample	Size	Use
Calibration against expert judgement	16 samples (13 with valid colour)	Agreement with the graphologist
Normative corpus	1,758 pages from 908 people (page 1 and page 2)	Norms, stability, independence, false alarms
Paradigmatic cases	12 people in the corpus (7 extraverts, 5 introverts)	Introversion-extraversion
Synthetic handwriting	9 AI-generated pages	Detection of non-human writing

Samples followed the usual GrafoMetrics protocol: letter-size paper, free text about a person in the rain, blue or black ballpoint; most were scanned at 150 dpi and some photographed with a phone. A graphologist with twenty years of practice rated the pressure of the calibration sample on six levels, from very light to extreme, and classified the paradigmatic cases from direct clinical knowledge. All participants consented to the scientific use of their handwriting; no names appear in this work and images are shown as fragments without identifying information. Eight of the nine synthetic pages were generated with ChatGPT, varying ink, letterform, pressure and capture; the ninth arrived in a real assessment as if it were handwritten.

2.2 Measurement principles

We do not publish the algorithm, but we do publish the principles it rests on, so that they can be replicated with another implementation:

1. **Ink is measured against its own paper.** The colour of the paper around each region is estimated first, and stroke darkness is expressed relative to it. Shadows, greyish paper and photo exposure are no longer mistaken for pressure.
2. **Ink colour matters.** Each colour channel is treated separately, so a blue ink is not read as lighter than a black one merely because of its hue. Ink colour is recorded for every sample.
3. **The scale is the page, not the letter.** Measures are expressed in physical millimetres from the known width of the page. They are not normalised by letter size, because pressure and size are independent traits: someone can write small and hard.
4. **Intensity = ink load per millimetre of stroke.** The deposited ink is summed and divided by the length of the stroke path. The result combines how dark and how wide the stroke is into one number.
5. **Quality control before numbers.** If the image arrived converted to pure black and white, colour information is lost and pressure is reported as unreliable, rather than inventing a value.
6. **Ink pools, relative to the writer.** Stretches of 2 mm with far more ink than the median of that same handwriting are marked: the deposits where the hand stops, starts or turns.
7. **Visual evidence.** Each measurement comes with a heat map that draws exactly what entered the calculation.

2.3 Analysis

Agreement with the expert and correlations used Spearman's ρ . Group separation used the area under the curve (AUC, Mann-Whitney test), where 1 means perfect separation and 0.5 chance. Norms are Hazen percentiles computed per page, using only samples with valid colour. The contribution to the GrafoMetrics introversion-extraversion scale was assessed with the item-rest correlation and Cronbach's alpha, using an exact replica of the scale shown in the report.

3. Problems that had to be solved

Each principle above grew out of a concrete failure of the previous method, which estimated pressure from stroke width in pixels.

Problem	What happened	How it was solved
A pixel is too coarse	At 150 dpi, one pixel is as wide as a ballpoint line: 9 of 16 samples gave exactly the same width	Measure ink load, which resolves differences smaller than a pixel
Pressure does not widen the stroke	With a ballpoint, pressing harder darkens the line but barely widens it: width alone was unrelated to the expert ($\rho = -0.24$)	Combine darkness and width into one load
Background and shadows	On photos with greyish paper, the previous method mistook background for ink and gave absurd values	Measure each stroke against the paper around it
Pure black-and-white images	Some scanning apps remove the greys; 8.4 % of corpus pages arrived that way	Detect it and declare pressure unreliable
Ink colour	A pale blue and a deep blue read differently at the same pressure	Treat each channel separately and record the colour
Resolution and paper size	Scanners at different resolutions; letter, A4 and legal paper	Physical scale from the page width
Letter crossings	Where two strokes cross, ink doubles and looked like a pool	Exclude crossings when searching for ink pools

One limit remains: extreme pressure, the kind that grooves the paper, is not fully reflected in the ink. In the most extreme case of the sample, the expert rated pressure as the strongest and the measure placed it as firm. Paper relief is invisible on a flat scan.

4. Results

4.1 Agreement with expert judgement

Ink load per millimetre of stroke was the only measure that ranked the samples as the graphologist did. On the same 12 samples with valid colour, at original resolution:

Measure	ρ with expert	p
Ink load per mm of stroke (intensity)	+0.82	0.001
Darkness of the stroke core	+0.76	0.004
Mean ink grey (previous method)	+0.65	0.023
Stroke width in mm	-0.24	0.44
Stroke width in pixels (previous method)	-0.28	0.38

At the system's working resolution, with one additional case rated later (13 samples), agreement was $\rho = +0.91$ ($p < 0.001$).

4.2 Population norms

The distribution was practically identical on page 1 and page 2. Interpretive bands were set at population percentiles and matched the classical graphological categories.

Page	n	P10	P25	P50	P75	P90
Page 1	825	0.16	0.21	0.27	0.37	0.45
Page 2	785	0.16	0.21	0.27	0.36	0.44

Band	Range (ink load per mm)	Population
Light	below 0.21	lowest 25 %
Normal	0.21 to 0.36	middle half
Firm	0.36 to 0.45	between P75 and P90
Strong	0.45 or more	highest 10 %

4.3 Stability and independence

Intensity was highly stable within the same person: between page 1 and page 2, $\rho = 0.95$ ($n = 763$). Part of this stability comes from both pages sharing pen and scanner, so it is not equivalent to test-retest reliability on different days.

Against the system's roughly 120 descriptors (1,564 pages), intensity overlapped only with the two previous pressure measures, which try to measure the same thing. With everything else, the relation was weak or nil.

Descriptor	ρ with intensity
Mean ink grey (previous pressure)	+0.78
Previous pressure index	+0.64
Fractal dimension of the text	+0.26
Image resolution (mm per pixel)	+0.26
Black over white (ink coverage)	+0.23
All other descriptors	between -0.23 and $+0.21$

The relation with resolution is a capture artefact, not a trait of the person: it is weak but must be monitored.

4.4 Introversion and extraversion

Among the 12 paradigmatic cases in the corpus, every extravert wrote with more pressure than every introvert ($AUC = 1.00$; $p = 0.003$). Introverts ranged from 0.13 to 0.28; extraverts, from 0.28 to 0.46. The previous pressure index did not separate them ($AUC = 0.66$; $p = 0.27$).

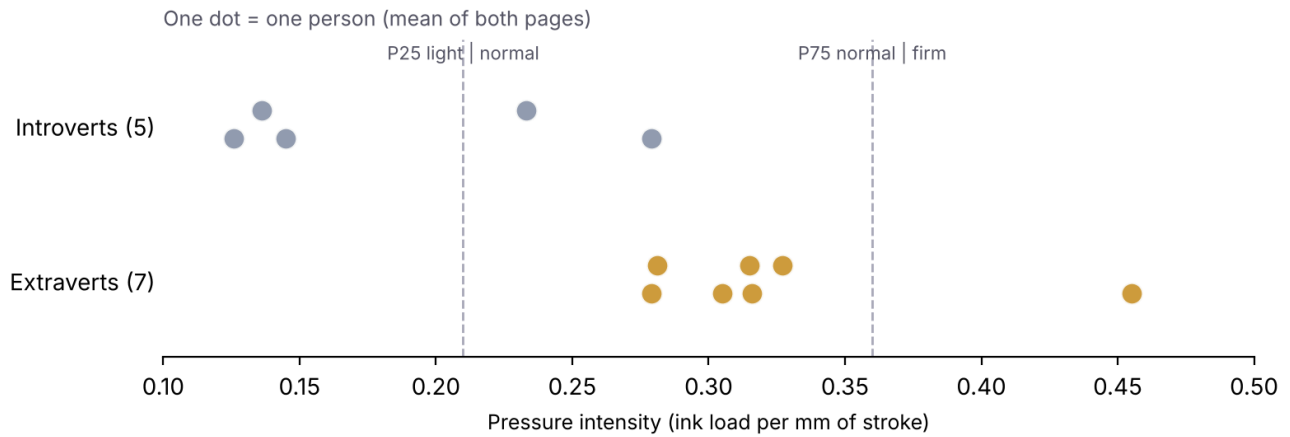


Figure 4. The 12 paradigmatic cases in the corpus with valid colour. Every extravert wrote with more pressure than every introvert, by a narrow margin.

The separation is perfect, but the boundary is narrow: the introvert with the most pressure and the extravert with the least were practically tied (0.279). With 12 cases, this is a strong signal, not proof.

In the general population, however, intensity did not covary with the other signs of the GrafoMetrics introversion–extraversion scale, and adding it made the scale less consistent.

Test	Result
Correlation of intensity with the rest of the scale (n = 821)	$\rho = -0.01$
Scale alpha without pressure	0.66
Alpha with intensity as an item	0.62
Separation of the paradigms by the scale, with or without pressure	AUC 0.99 and 0.98

Pressure intensity is therefore not one more sign of introversion–extraversion: it is a dimension of its own. That it separates the paradigmatic cases so well suggests that clinical judgement of introversion–extraversion also weighs a person's energy, which the scale does not capture by any other route.

5. AI-generated handwriting

AI reproduces the shape of letters, but not the pulse of the hand. The finding began with a real case: a page submitted as handwritten in an assessment passed every descriptor of form and space, and the only anomaly was its pressure, "matte" to the graphologist's eye.

5.1 What gives synthetic handwriting away

A real ballpoint does not lay down ink evenly. When a stroke starts, turns in a curve or stops, the ball releases more ink and leaves **pools**. AI draws an even stroke from start to finish, with a micro-texture in the core of the line that does not resemble ink on paper. We disclose this part of the method in full, because its value lies in transparency: the criterion is the combination of **almost no ink pools** (under 0.15 % of stroke stretches) and **a stroke-core texture typical of a synthetic image**.

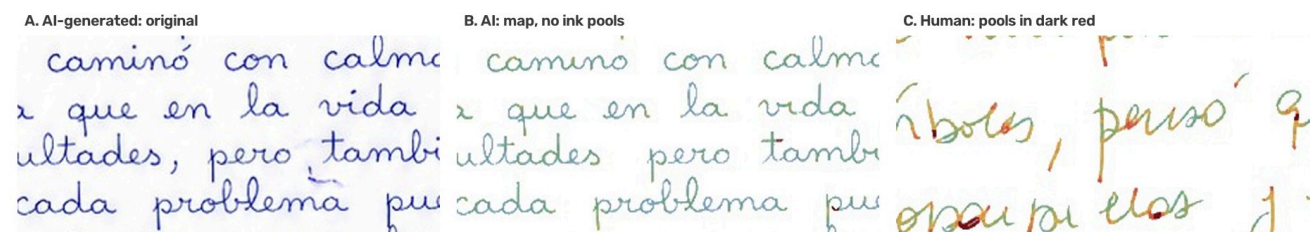


Figure 2. Enlarged detail. A: AI-generated page. B: its intensity map, even and without pools. C: an anonymised human sample, with ink pools in dark red.

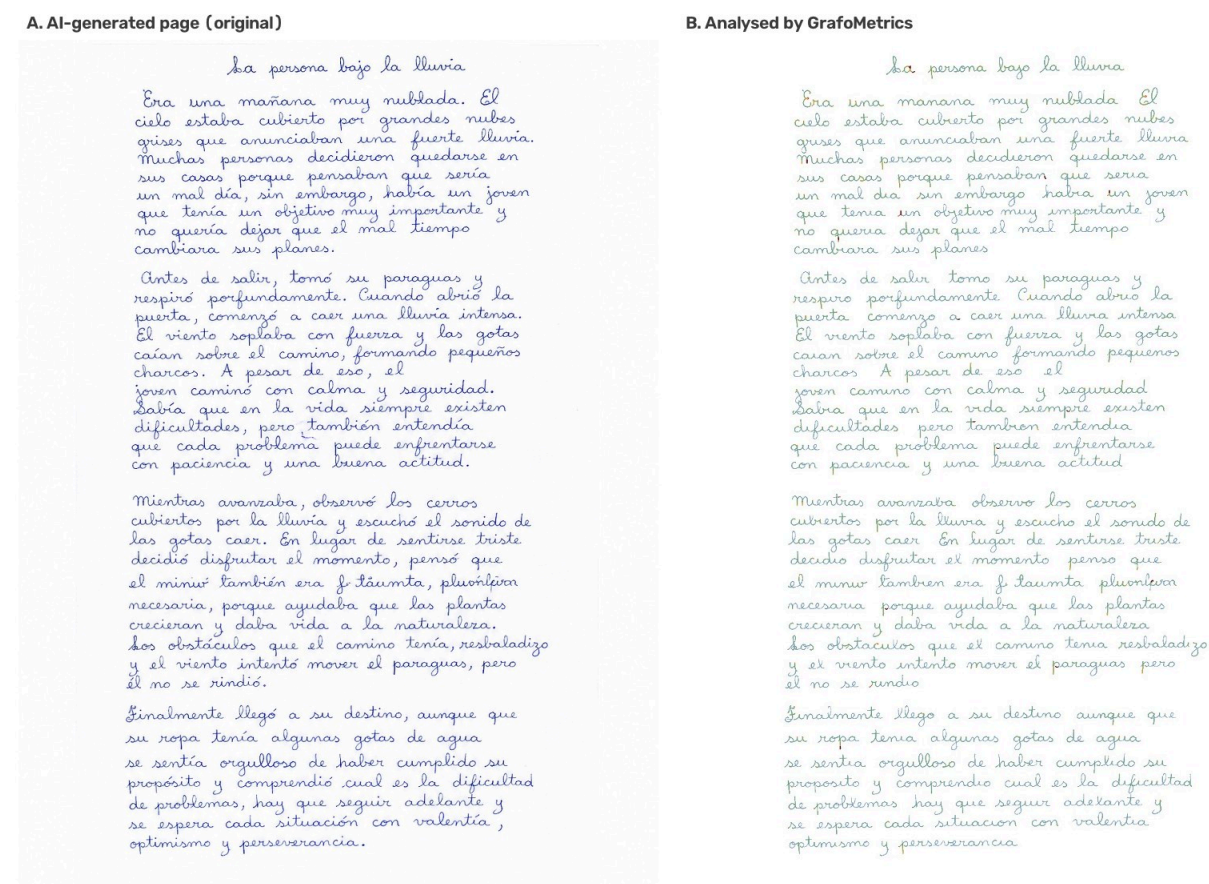


Figure 3. Full AI-generated page (A) and its analysis (B). Published in full because it contains no data about any person.

5.2 Results

Group	Pages	Ink pools (% of stretches)	Flagged
AI, scan-like	6	0.00 to 0.10	6 of 6
AI, phone photo with table and shadow	2	5.4 and 9.9	0 of 2
AI with crossed-out words	1	0.19	0 of 1
Human, calibration sample	15	0.24 to 3.39	0 of 15
Human, corpus (single pages)	1,758	—	45 (2.6 %)
Human, corpus (both pages of the same person)	843 people	—	9 (1.1 %)

The flag caught every scan-like synthetic page, and also recognised the synthetic page hidden in the corpus. It failed in two situations: phone photos with a visible table and shadow, where scene noise mimics pools, and the page with crossings-out, where the crossings-out count as ink build-up.

False alarms on human handwriting were reviewed by hand: they were scans heavily processed by apps, with hard edges and flattened ink, which mimic the synthetic texture. The flag therefore requires both pages, is shown only to the analyst and never to the client, and is presented as a prompt for manual review, not as a verdict.

6. Discussion

6.1 The most human trait of handwriting

The results support the classical intuition that pressure is a trait apart. It is not confounded with size, spacing, slant, cohesion or ink coverage; it is stable within the person; and it separates cases that a clinician distinguishes by their energy. Within integrative graphoanalysis, this is what is expected of an indicator of vital energy: a dimension of stroke dynamics, not of form or space.

They also support the idea that pressure is hard to imitate. A person can polish the shape of their letters to make a good impression, but controls poorly how hard they write. A machine, for now, imitates form without pulse. This strengthens a central argument for handwriting analysis in psychological assessment: it captures non-verbal language, and its most unconscious part, which self-report questionnaires cannot record.

6.2 What these data do not show

- **That pressure measures libido.** That is the theoretical interpretation of the framework. What was shown is that the measure reproduces expert judgement, is stable and independent, and separates clinical cases. Its relation to constructs measured by other tests must be studied with validated inventories.
- **That it cannot be faked.** The AI flag worked with one generator and one kind of capture. Generators improve, and image processing can erase the pools of human handwriting.
- **That it distinguishes introversion from extraversion in the population.** It separated 12 expert-selected cases, but did not covary with the scale in 821 people.
- **A blind criterion.** The expert who rated pressure and classified the cases knows the system. Replication with raters unfamiliar with it is needed.

6.3 Future work

1. Crop the page before measuring phone photos, so that the table and shadows do not mimic ink pools.
2. Measure crossings-out as a descriptor of their own and exclude them from the pool count.
3. Separate norms by ink colour and control for capture resolution.
4. Validate the AI flag with dozens of images from different generators.
5. Relate intensity to personality inventories and clinical criteria, with hypotheses registered before looking at the data.

6. Study extreme pressure with raking light, which reveals the groove in the paper.

7. Conclusions

Pen pressure can be estimated from a scanned page if one measures the ink rather than the width: ink load per millimetre of stroke, against the paper itself and in physical millimetres. Measured this way, it reproduces expert judgement ($\rho = 0.91$), is stable within the person ($\rho = 0.95$), is independent of the rest of the handwriting and forms a dimension of its own, distinct from introversion-extraversion. Its finest trace, the ink pools, currently tells the human hand from a synthetic image. The algorithm can and should improve; the principle, however, appears sound: pressure is where handwriting shows its pulse, and that is why it is its most human and least fakeable trait.

Ethical considerations

Everyone whose handwriting was analysed consented to the scientific use of their samples. No names appear in the article, fragments were chosen without identifying information, and the paradigmatic cases were replaced with codes. The synthetic-handwriting flag is used as an internal audit tool, visible only to the analyst, and never as the basis of a decision about a person without human review.

References

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