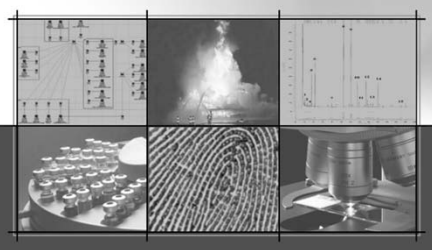
Raymond Marquis,
Silvia Bozza, Matthieu Schmittbuhl, Franco Taroni, Alexandre Thiéry

Handwriting evidence evaluation based on the shape of characters



MSSFHA, Gaithersburg, MD

4-5 June 2013

R. A. Reiss

FNSNF
Swiss National Science Foundation

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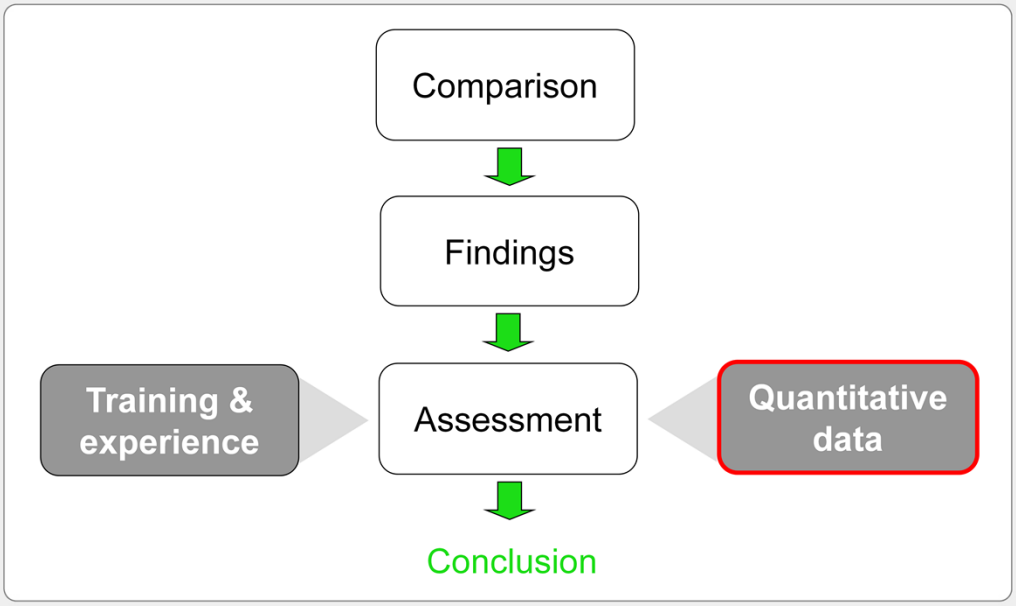
Research goal



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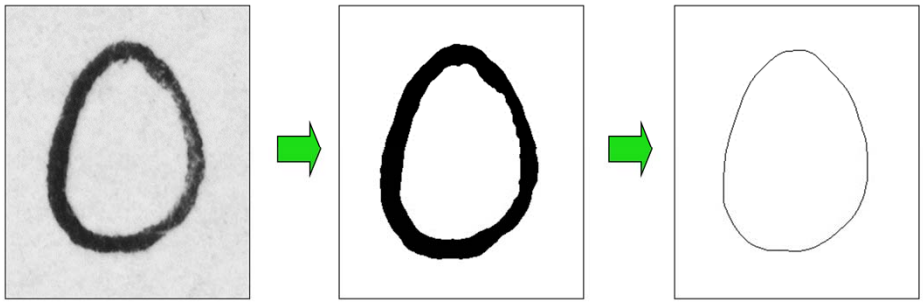
Analysis of shape



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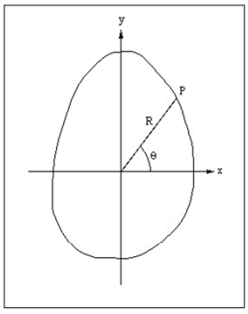
Fourier descriptors



Fourier series

Each curve is described by a series of harmonics

$$R(\theta) = R_0 + \sum_{n=1}^{N}[a_n \cos(n\theta)] + \sum_{n=1}^{N}[b_n \sin(n\theta)]$$

Each harmonic is described by two parameters

$$A_n = \sqrt{(a_n^2 + b_n^2)}$$ amplitude

$$P_n = arctg\frac{a_n}{b_n}$$ phase

Fourier descriptors

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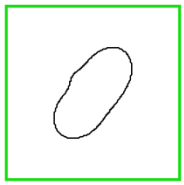
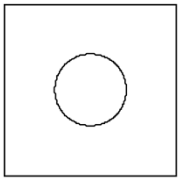
Fourier descriptors



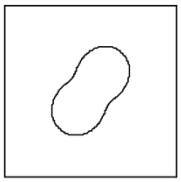
Original contour



Harmonic 1

($Ampl_1$, $Phase_1$)

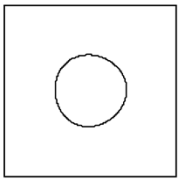
1 leaf



Harmonic 2

($Ampl_2$, $Phase_2$)

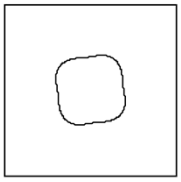
2 leaves



Harmonic 3

($Ampl_3$, $Phase_3$)

3 leaves



Harmonic 4

($Ampl_4$, $Phase_4$)

4 leaves

...

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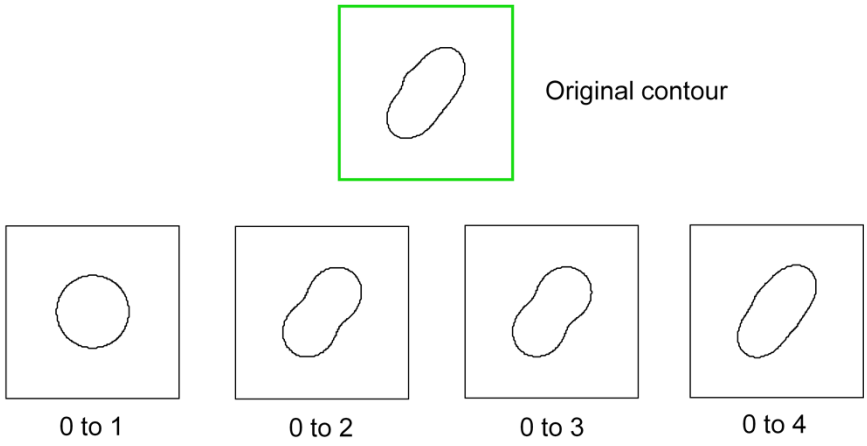
Fourier descriptors



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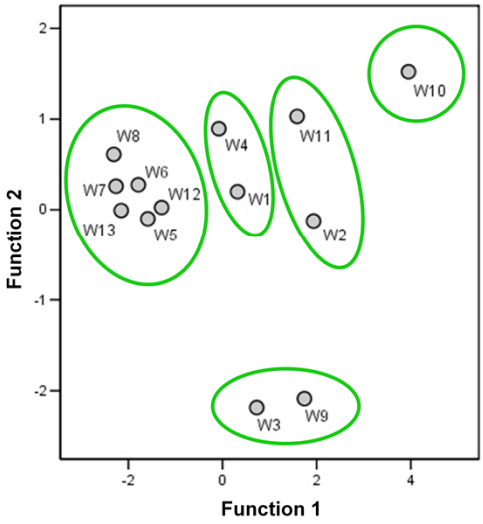
Database

> Sampling

- 13 writers
- 4 letters : *a*, *d*, *o*, *q*
- 2325 loops



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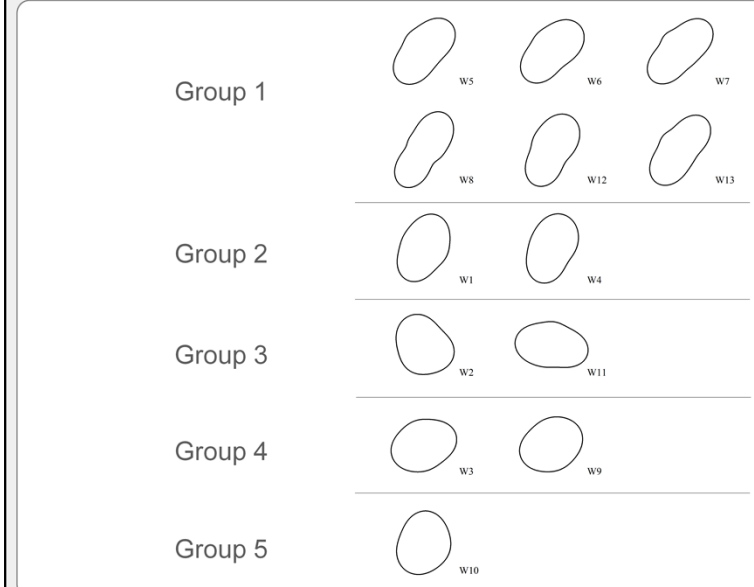
Database



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Assessment model

> Methodology based on a model of Aitken and Lucy (2004)

> Consideration of the correlation between variables

> Consideration of the dependence of the within-writer variability on the writer

> Two-level model

LR: evaluative framework

Handwritten threatening text

Suspect

$$LR = \frac{P(E|H_1)}{P(E|H_2)} = \frac{P(findings|\ the\ suspect\ wrote\ the\ questioned\ text)}{P(findings|\ the\ suspect\ did\ not\ write\ the\ questioned\ text)}$$

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LR: evaluative framework

$E = y_1, y_2 \qquad y_i \sim N(\theta_i, W_i)$

y_1: characters of the threatening text

y_2: characters of the reference material

$$LR = \frac{f(y_1, y_2 | H_1)}{f(y_1, y_2 | H_2)}$$

> the LR value depends on the draw of characters

> multiple draws of a given number of characters

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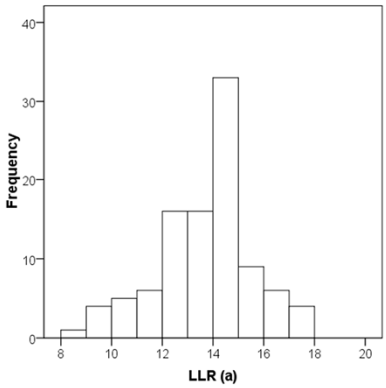
LR: evaluative framework

> Let H_1 be true

The reference material comes from the writer of the questioned text



Quest.

Ref.

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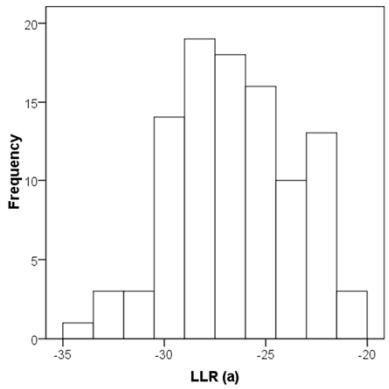
LR: evaluative framework

> Let H_2 be true

The reference material comes from another writer



Quest.

Ref.

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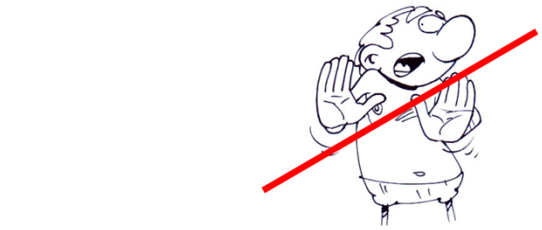
LR: investigative framework



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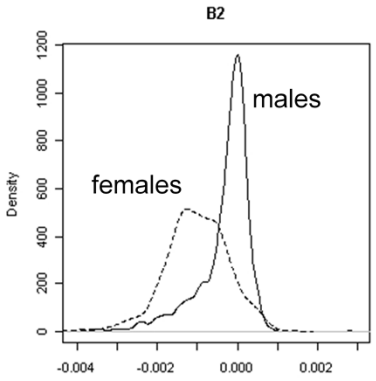
LR: investigative framework



> Coefficient B_2 of:
60 males (1566 letters *d*),
20 females (4260 letters *d*)

> Given measurements on questioned characters:

$$LR = \frac{f(y|H_1)}{f(y|H_2)}$$

H1: the author is a male
H2: the author is a female

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LR: investigative framework

- 5 values of B2 of a writer are taken from the male population
- The LR is computed
- This operation is repeated 10'000 times

LR apportionments	Males	Females
$<10^{-3}$	45	54
$10^{-3} – 10^{-2}$	1329	5559
$10^{-2} – 10^{-1}$	2103	2487
1 – 10	1758	615
$10 – 10^{2}$	2493	615
$10^{2} – 10^{3}$	1446	328
$10^{3} – 10^{4}$	535	233
$>10^{4}$	291	109
<1	3477	8100
>1	6523	1900

$$\frac{328}{1446+328} \rightarrow 18\%$$

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Conclusion

> The model supports the correct hypothesis

> The model provides a quantitative tool

> Measurements should be treated carefully in investigative scenarios

> The procedure is automated

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Perspectives

> Three-level model

> Open curves

> Comparison of simulated handwritings

> Application of the model to other fields

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Thank you for your attention!

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