Computational stylometry and the synoptic problem

An analysis of the traditions of Luke's Gospel

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Outline

The sources of Luke

Traditions within Luke's Gospel

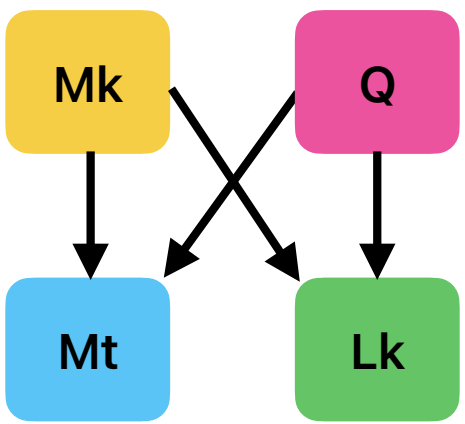
Different categorization of traditions :

- **Triple tradition** : episode that is available within the three Gospels (Mark - Matthew - Luke).
- **Double tradition** : episode that is available within Matthew - Luke
- **Sondergut** : episode that is available in a single tradition.

Solutions to the synoptic problem : two source hypothesis

The two-source hypothesis posits that :

- Matthew and Luke were written **independently** ;
- The double tradition comes **from an external source Q** (*Quelle*) ;



Research questions

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- Is there a distinctive **vocabulary distribution** between **double** and **triple tradition** ?
- Is there a distinctive **stylistic difference** between **double** and **triple tradition** ?

$\rightarrow$ A significant difference in style would point towards different sources.

Research questions

Previous work [Unraveling the Synoptic puzzle : stylometric insights into Luke's potential use of Matthew] indicated difference in style at the pericope level.

→ Let's see how these results hold up focusing on sayings only !

State of the art : the synoptic problem and statistics

The possible approaches to using statistics to understand the relationship between the gospels

Solages 1959 :8

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- Study of **the verbal agreements** and their distribution across the gospels.
- Study of the distribution of **lexicometric** and **stylistic features** of the text.

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- **Pre-suppose the Q hypothesis** and confirm/infirm (Rosché 1960 ; Mattila 2004 ; O'Rourke 1974...) ;
- **Do not suppose the Q hypothesis** (Honoré 1968 ; Carlston et Norlin 1971 ; Bergemann 1993..) ;

Severe disagreements on the agreements.. :

- Should the synonyms be taken into account ?
- Should the words be inflicted/conjugated ?
- Identical in forms and/or sequence ?

Back and forth controversy regarding verbal annotation agreements : Carlston et Norlin 1971 ; Mattila 2004...

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Poirier 2008

Landmark study gloomily concludes : « *The prospect that the use of* ***word statistics*** *would provide* ***an objective measure for the study of gospel interrelations*** *has often been held out with* ***an unrealistic hope*** *[...] having too often amounted* ***to coded expressions*** *of their user's commitments.* »

Stylometric analysis

Other possible approaches : take into account the **stylometry** of the gospel as :

- Stylometric changes can indicate **different sources** ;
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Mealand 2011

*The question at issue is **whether the style of the Q material does or does not provide evidence** to raise the probability that it comes from a distinct source.*

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- **Supervised approach** : 2ST is pre-supposed and treated as such using statistical tests (Mealand 2011) ;
- **Unsupervised approach** : No model pre-supposed, data is analyzed and/or visualized, and then compared to the tagged data (Mealand 1997 ; Mealand 1995 ; Linmans 1998 ; Mealand 2011).

Mealand 2011 tries both and concludes regarding the existence of Q using stylistic analysis by **analyzing Matthew only**.

Limit of the studies

Limits of verbal agreements : Poirier seems right, relying on verbal agreements encodes pre-supposed theories.

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Limits of existing stylometric analysis :

- Comprehensive analysis of Matthew's gospel only ;
- Stop words analysis instead of whole range of possible speech features ;

Our contribution

Contribution of this study

- Stylometric analysis of **Luke's Jesus logia** using stylometric features ;
- Working at **discourse level** (instead of a gliding window).

Computational stylometry and lexicometry

How can we compute style ?

Through :

- **Grammatical constructs** ;

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Lexicometry is the application of the study of vocabulary usage across a text ;

Stylometry is the application of the study of linguistic style, usually to written language.

It is said **to be computational** when it relies on systematic features and analyzed through computing techniques.

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Textual data need to be projected into a numerical space representative of style $\rightarrow$ we need **to build *vectors* representative of a text *style*.**

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We work **at the saying level** : we want to **embed** every saying into a numerical space.

Luke 10:28

28 εἶπεν δὲ αὐτῷ· ὀρθῶς ἀπεκρίθης· τοῦτο ποίει καὶ ζήσῃ.

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- **Computing the ratio of use of lemmatized** :
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- **Computing the ratio of** :
  - Part Of Speech ;
  - Verb tense ;
  - Gender ;
  - Person ;
  - Mood ;
  - Case ;
  - Number
  - Sentence length : between conjunctions ;
  - Non-significant words occurrences : conjunctions, temporal markers.

We compute :

- **Embeddings** :
  - 6078 words frequency ;
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- On 123 of Luke's sayings ;
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We have 4 work matrixes :

M^{style}_{double} M^{vocab}_{double}

M^{style}_{triple} M^{vocab}_{triple}

Required comparison

Intra-Gospel analysis

Is there distinctive changes across traditions within Luke's Gospel ?

Are the samples and subsequent sub-samples of M_{double} and M_{triple} **drawn from the same probability distribution** ?

Two-sample tests using Machine Learning classifiers

Two samples classifiers

Two sample tests have for goal **to assess the likelihood of two samples** $S_p \sim P^n$ and $S_q \sim Q^m$ being drawn from the same statistical distribution.

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In a standard paradigm :

1. Establish two competing hypothesis ;
2. Select significance level ;
3. Compute a summary statistics ;
4. Evaluate the likelihood of observing this statistics under one hypothesis (p-value) ;
5. Conclude using the significance level.

Two samples classifiers

But what in the case of large multi-dimensional vectors ?
Possible solutions include :

$\rightarrow$ **New possible approach using Machine Learning classifiers**, developed in Lopez-Paz et Oquab

Binary Machine Learning classifier

A **binary classifier** is a function that attributes 0 or 1 to an input vector.

The used classifiers are **Random Forest** : build several decision trees that **allow to discriminate between the different traditions**.

Two samples classifiers

Intuitively, if $P = Q$, a **binary classifier should not be able to discriminate between the two samples**.
Inversely, if it succeeds, then **we can assume the distributions are statistically different** ($P \neq Q$).

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We compare the performance of a binary classifier on :

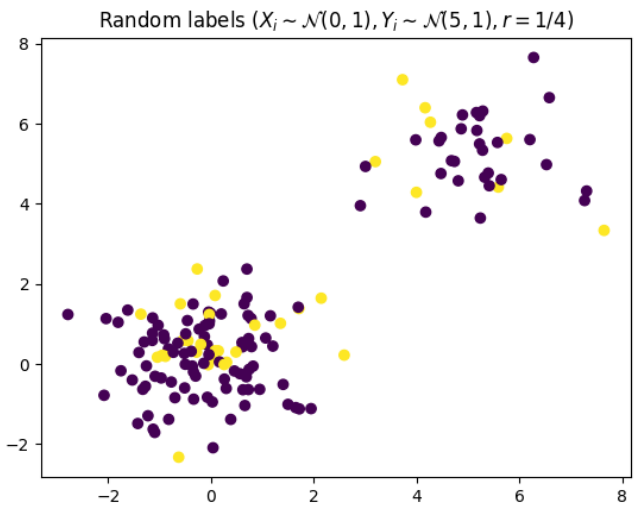
- Randomly generated labels ;
- The measured data.

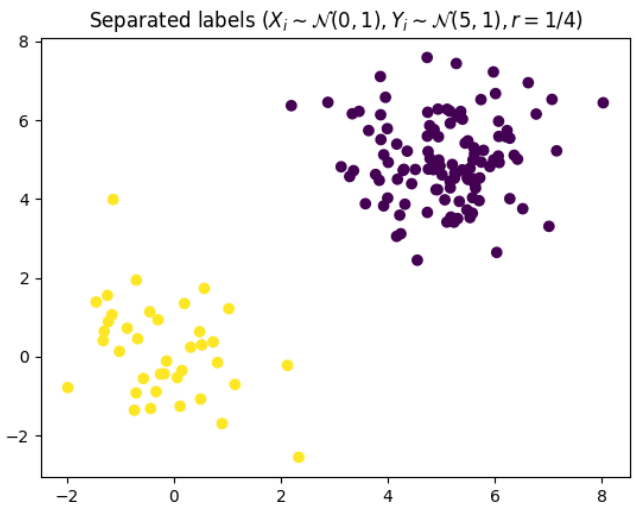
Accuracy then acts as the C2ST statistics.

Two samples classifiers

Example :

- Classifier : Random Forest
- $N = 150$



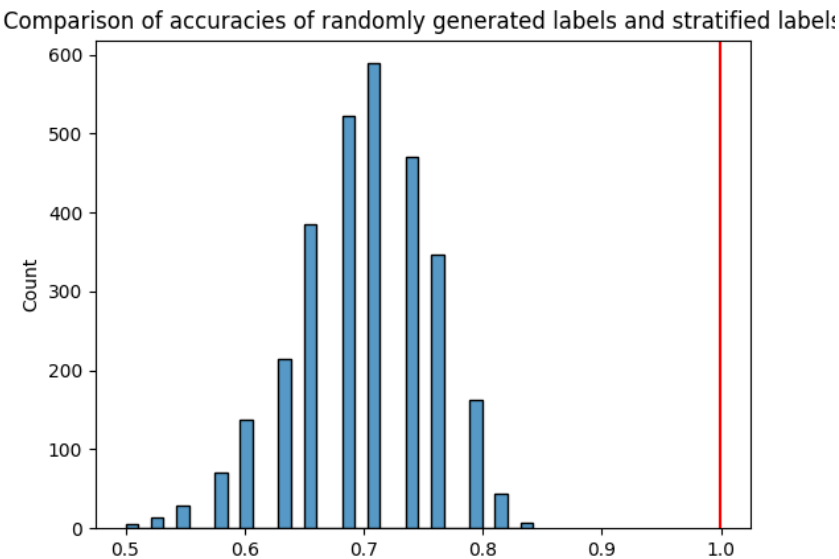


Two samples classifiers

Example :

- Classifier : Random Forest
- $N = 150$
- Trials for accuracy = 3000

$$\rightarrow p_{value} = 0$$



Tested hypothesis

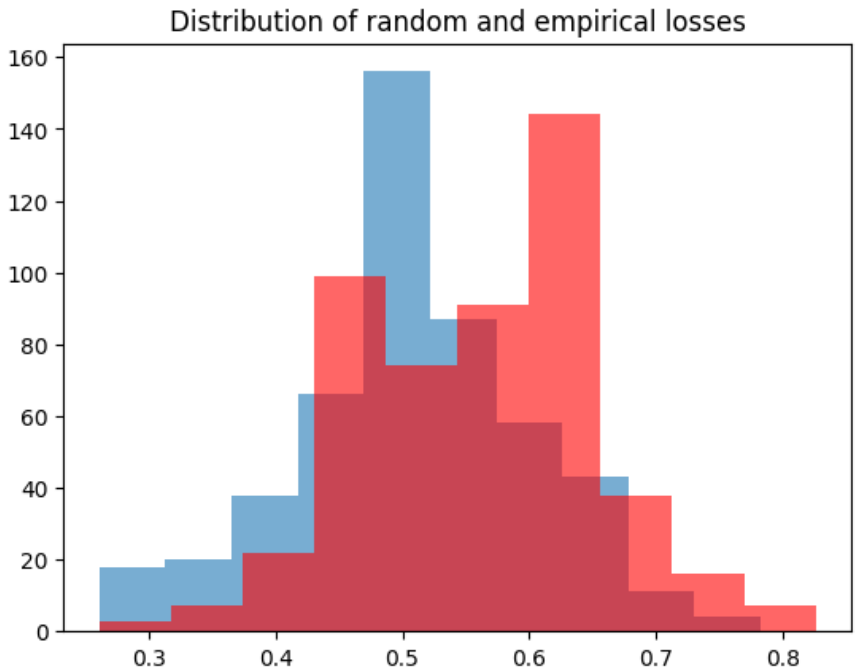
Can a binary classifier discriminate accurately between the triple and the double tradition ?

- **Test.style** : do the **style** of the **double and triple tradition differ** ?
- **Test.vocab** : do the **vocabulary** of the **double and triple tradition differ** ?

Results on double/triple tradition and further works

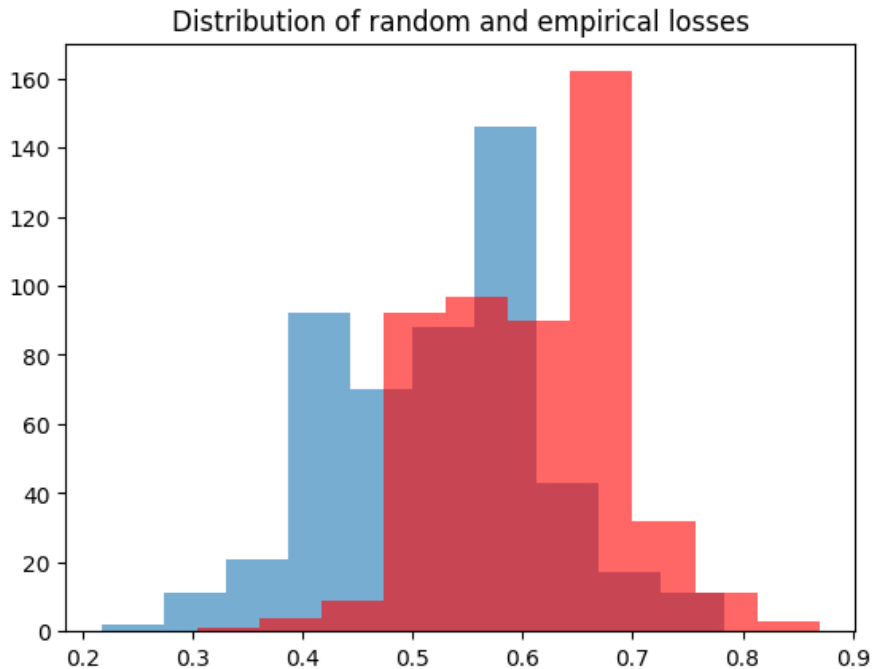
Results of analysis : Style

ID	Alternative hypothesis	p-value
1.style	There is a significative difference in **style** between double and triple tradition	0.4



Results of analysis : Vocabulary

ID	Alternative hypothesis	p-value
1.vocab	There is a significative difference in **vocabulary** between double and triple tradition	0.14



Results

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- Style **differs** between double and triple tradition ;

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Even with very simple features :

- Style **differs** between double and triple tradition ;
- Vocabulary **differs** between double and triple tradition ;
- Shows that lexicometric and stylometric analysis is **pointing towards the two source hypothesis**, by adding another argument for this hypothesis.

Impact

This study :

- **Revives the use of computational tools** to solve the synoptic problem with a fresh take ;

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- Introduces **innovative analytical tools** for style analysis ;

However :

- does not provide a definitive answer to the synoptic problem
- **other variables beyond style are necessary for a comprehensive solution**
- continuous dialog with the synoptic Gospel community.

On-going works @ University of Lorraine

1. **Improve features selected for style embedding ;**

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2. **On-going work on the transmission of textual traditions** :
   - **Taking into account manuscript specific style** : asserting the importance of scribal work for textual tradition, **with possible tremendous influence on textual analysis**.

Further reads

If this presentation motivated you to learn more :-) :
Related paper (2023 Computational Humanities Research) :
Unraveling the Synoptic puzzle : stylometric insights into Luke's potential use of Matthew.

Further reads

On computational solutions to the synoptic problems :
A. Abakuks (2015). The Synoptic Problem and Statistics. Chapman & Hall ; S. Mattila (2004). « Negotiating the Clouds around Statistics and ■Q■ : A Rejoinder and Independent Analysis ». In : Novum Testamentum 16(2), p. 105-131 ;
A. Linmans (1998). « Correspondence Analysis of the Synoptic Gospels ». In : Literary and Linguistic Computing 13(1), p. 1-13 ;
D. Mealand (2011). « Is there Stylometric Evidence for Q ? » In : New Testament Studies 57(4), p. 483-507

Questions

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