Estimating and Rating the Quality of Optically Character Recognised Text

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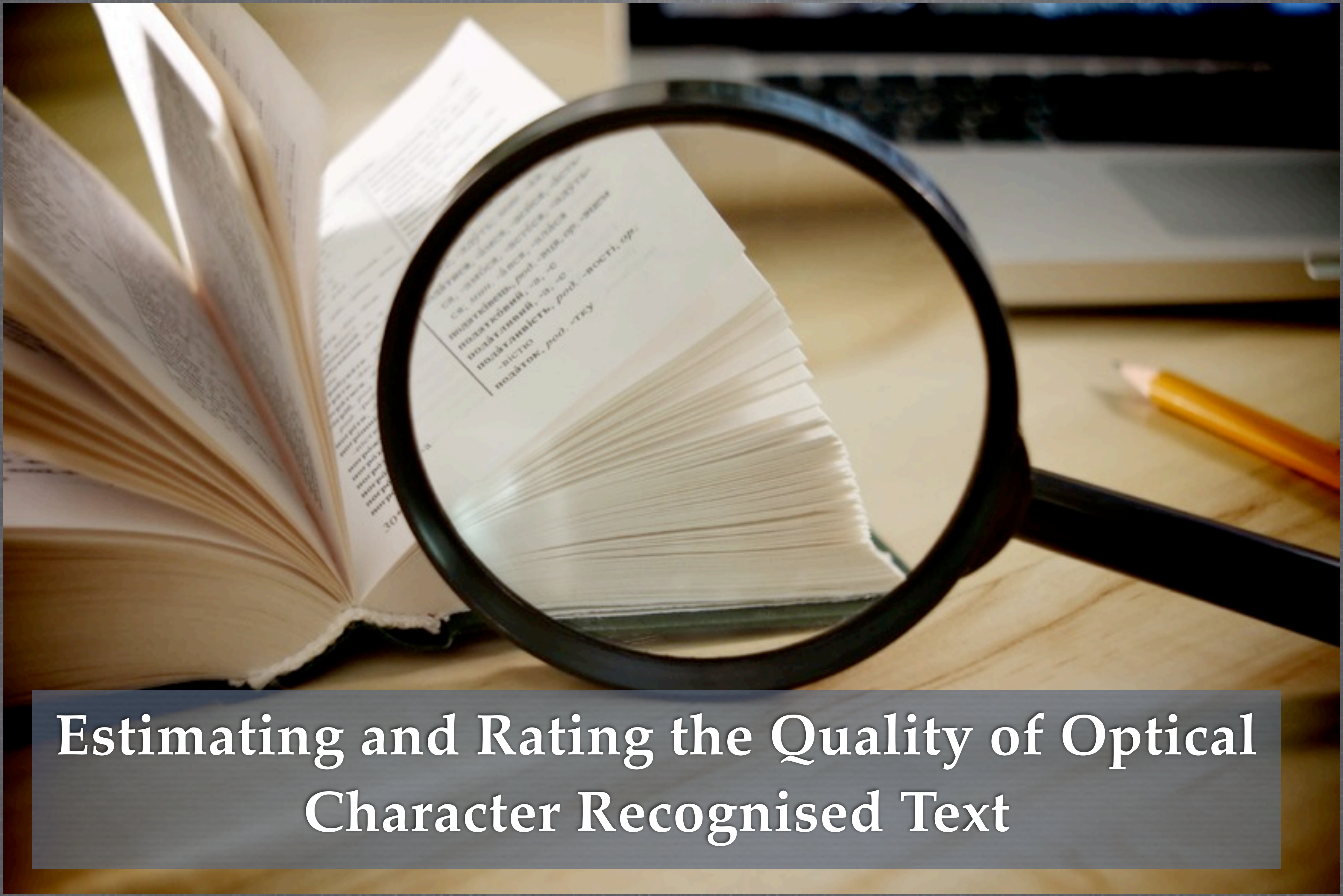


Estimating and Rating the Quality of Optical Character Recognised Text

THE UNIVERSITY of EDINBURGH
informatics

Beatrice Alex
balex@inf.ed.ac.uk

Trading Consequences

DATeCH 2014, May 20th 2014

OVERVIEW

- Background: Trading Consequences
- OCR accuracy estimation
  - Motivation
  - Related work
  - OCR errors in text mining (eye-balling data versus quantitative evaluation)
  - Computing text quality
  - Manual vs. automatic rating
- Summary and conclusion

TRADING CONSEQUENCES

- JISC/SSHRC Digging into Data Challenge II (2 year project, 2012-2013)
- Text mining, data extraction and information visualisation to explore big historical datasets.
- Focus on how commodities were traded across the globe in the 19th century.
- Help historians to discover novel patterns and explore new research questions.

PROJECT TEAM

THE UNIVERSITY *of* EDINBURGH informatics

Ewan Klein, Bea Alex, Claire Grover, Richard Tobin: *text mining*

YORK UNIVERSITÉ UNIVERSITY

Colin Coates, Andrew Watson: *historical analysis*

UNIVERSITY OF SASKATCHEWAN

Jim Clifford: *historical analysis*

EDINA

James Reid, Nicola Osborne: *data management, social media*

University of St Andrews

Aaron Quigley, Uta Hinrichs: *information visualisation*

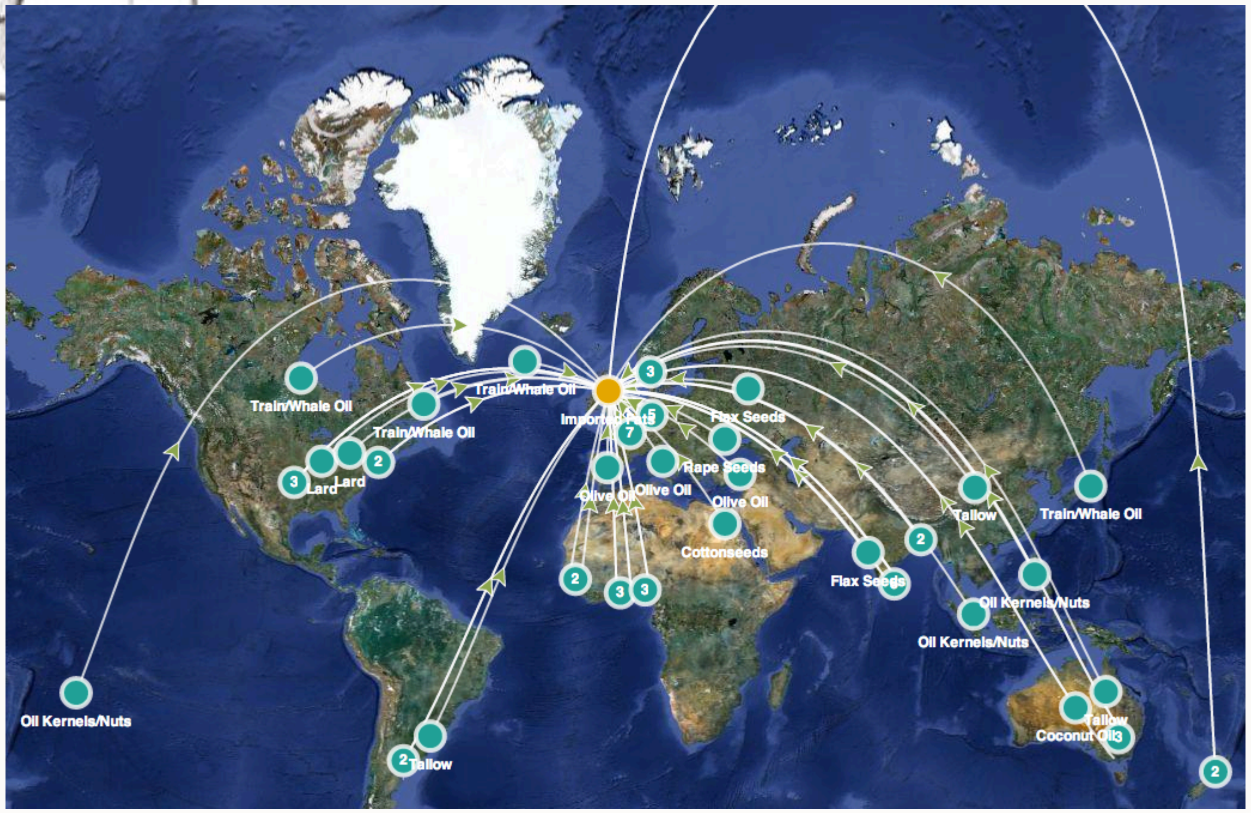
TRADITIONAL HISTORICAL RESEARCH

U. S. A.
GULF OF MEXICO
MEXICO
Cuba
Jamaica
Santo Domingo
Porto Rico
ATLANTIC
BRITISH HONDURAS
GUATEMALA
SALVADOR
NICARAGUA
COSTA RICA
CENTRAL AMERICA
PANAMA
VENEZUELA
Georgetown
Bogota
COLOMBIA
Br. Du. Fr. GUIANAS
PACIFIC
Equator
ECUADOR
Iquitos
Para
SOUTH
BRAZIL
Pernambuco
OCEAN
Callao
PERU
AMERICA
BOLIVIA

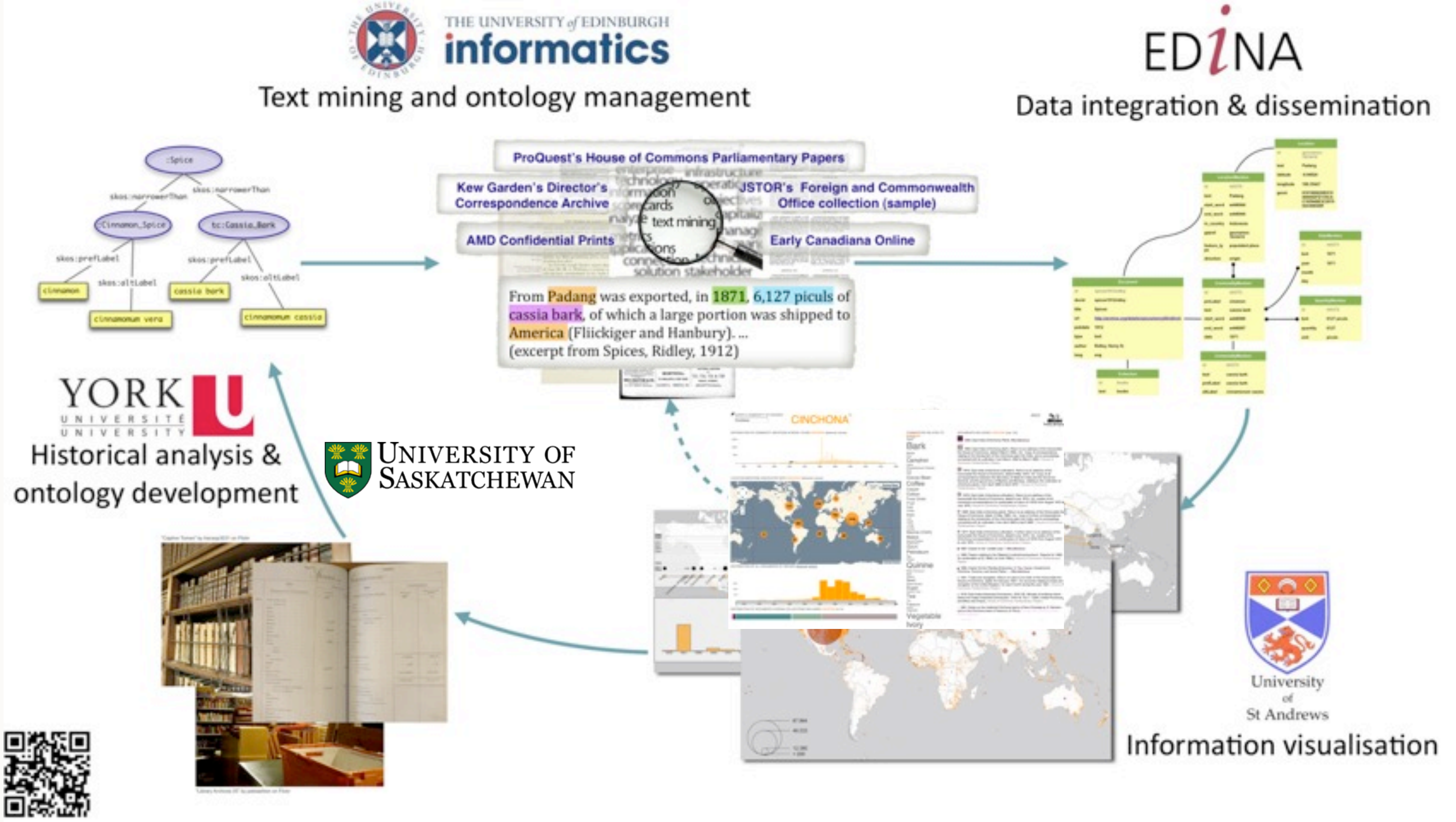
Map showing the areas where mahogany is grown

Gillow and the Use of Mahogany in the Eighteenth Century, Adam Bowett, Regional Furniture, v.XII, 1998.

Global Fats Supply 1894-98



PROJECT OVERVIEW



THE UNIVERSITY of EDINBURGH informatics

Text mining and ontology management

EDiNA

Data integration & dissemination

YORK UNIVERSITÉ UNIVERSITY

Historical analysis & ontology development

UNIVERSITY OF SASKATCHEWAN

University of St Andrews

Information visualisation

ProQuest's House of Commons Parliamentary Papers

Kew Garden's Director's Correspondence Archive

JSTOR's Foreign and Commonwealth Office collection (sample)

AMD Confidential Prints

Early Canadiana Online

From Padang was exported, in 1871, 6,127 piculs of cassia bark, of which a large portion was shipped to America (Flückiger and Hanbury). ...
(excerpt from Spices, Ridley, 1912)

Scotland's National Collections and the Digital Humanities, Edinburgh, 14/02/2014

DOCUMENT COLLECTIONS

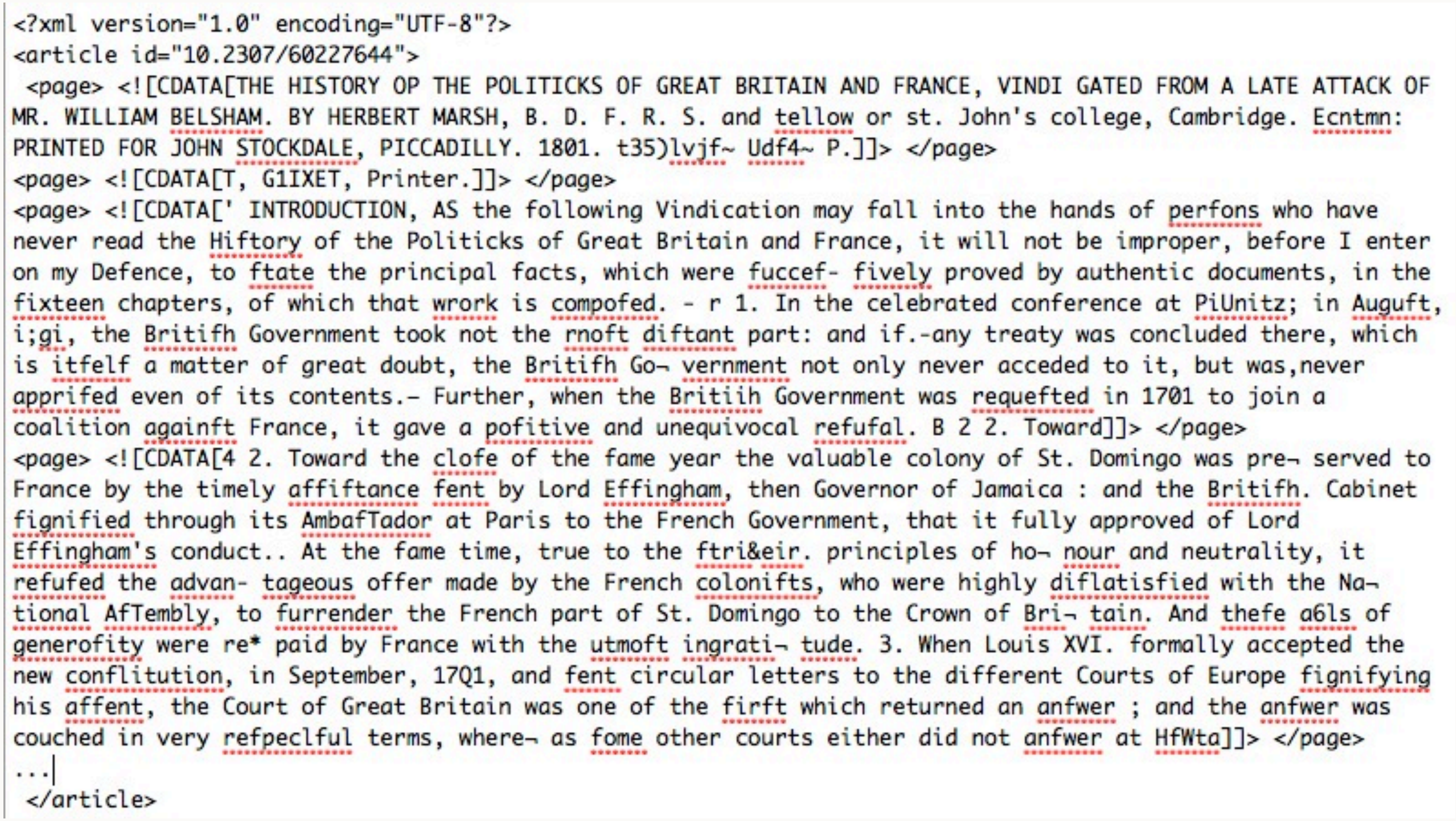
Collection	# of Documents	# of Images
House of Commons Parliamentary Papers (ProQuest)	118,526	6,448,739
Early Canadiana Online	83,016	3,938,758
Directors’ Letters of Correspondence (Kew)	14,340	n/a
Confidential Prints (Adam Matthews)	1,315	140,010
Foreign and Commonwealth Office Collection	1,000	41,611
Asia and the West (Gale)	4,725	948,773 (OCRed: 450,841)

DOCUMENT COLLECTIONS

Collection	# of Documents	# of Images
House of Commons Parlia		9
Early C		8
Dire Corres		
Confide		
I Comm Collection		
Asia and the West (Gale)	4,725	948,773 (OCRed: 450,841)

Over 10 million document pages,
Over 7 billion word tokens.

OCR-ED TEXT



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 <page> <![CDATA[THE HISTORY OP THE POLITICKS OF GREAT BRITAIN AND FRANCE, VINDI GATED FROM A LATE ATTACK OF
MR. WILLIAM BELSHAM. BY HERBERT MARSH, B. D. F. R. S. and tellow or st. John's college, Cambridge. Ecntmn:
PRINTED FOR JOHN STOCKDALE, PICCADILLY. 1801. t35)lvjf~ Udf4~ P.]]> </page>
<page> <![CDATA[T, G1IXET, Printer.]]> </page>
<page> <![CDATA[' INTRODUCTION, AS the following Vindication may fall into the hands of perfons who have
never read the Hiftory of the Politicks of Great Britain and France, it will not be improper, before I enter
on my Defence, to ftate the principal facts, which were fuccef- fively proved by authentic documents, in the
fixteen chapters, of which that wrork is compofed. - r 1. In the celebrated conference at PiUnitz; in Auguft,
i;gi, the Britifh Government took not the rnoft diftant part: and if.-any treaty was concluded there, which
is itfelf a matter of great doubt, the Britifh Go¬ vernment not only never acceded to it, but was,never
apprifed even of its contents.- Further, when the Britiih Government was requefted in 1701 to join a
coalition againft France, it gave a pofitive and unequivocal refufal. B 2 2. Toward]]> </page>
<page> <![CDATA[4 2. Toward the clofe of the fame year the valuable colony of St. Domingo was pre¬ served to
France by the timely affiftance fent by Lord Effingham, then Governor of Jamaica : and the Britifh. Cabinet
fignified through its AmbafTador at Paris to the French Government, that it fully approved of Lord
Effingham's conduct.. At the fame time, true to the ftri&eir. principles of ho¬ nour and neutrality, it
refufed the advan- tageous offer made by the French colonifts, who were highly diflatisfied with the Na¬
tional AfTembly, to furrender the French part of St. Domingo to the Crown of Bri¬ tain. And thefe a6ls of
generofity were re* paid by France with the utmoft ingrati¬ tude. 3. When Louis XVI. formally accepted the
new conflitution, in September, 17Q1, and fent circular letters to the different Courts of Europe fignifying
his affent, the Court of Great Britain was one of the firft which returned an anfwer ; and the anfwer was
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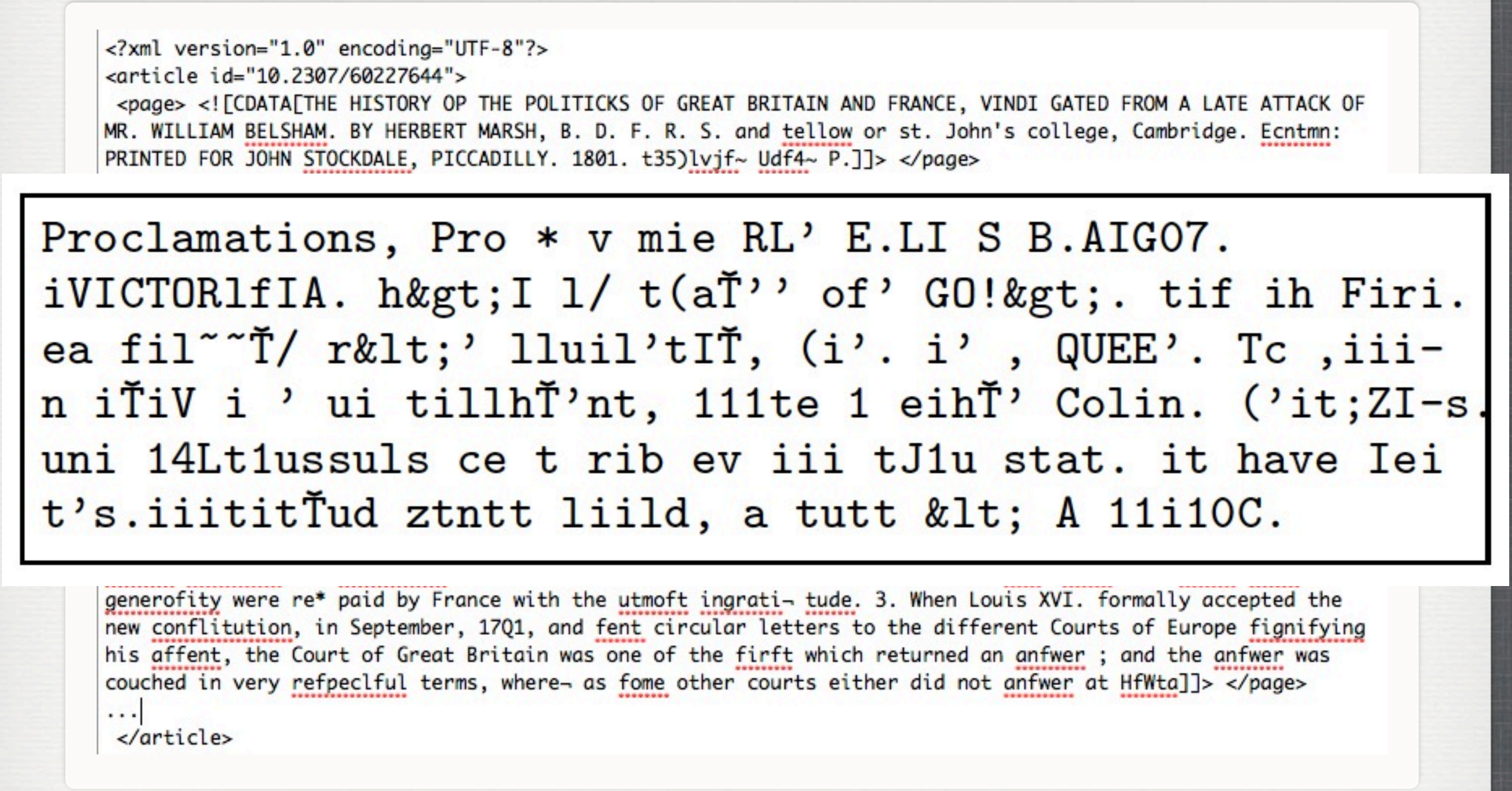

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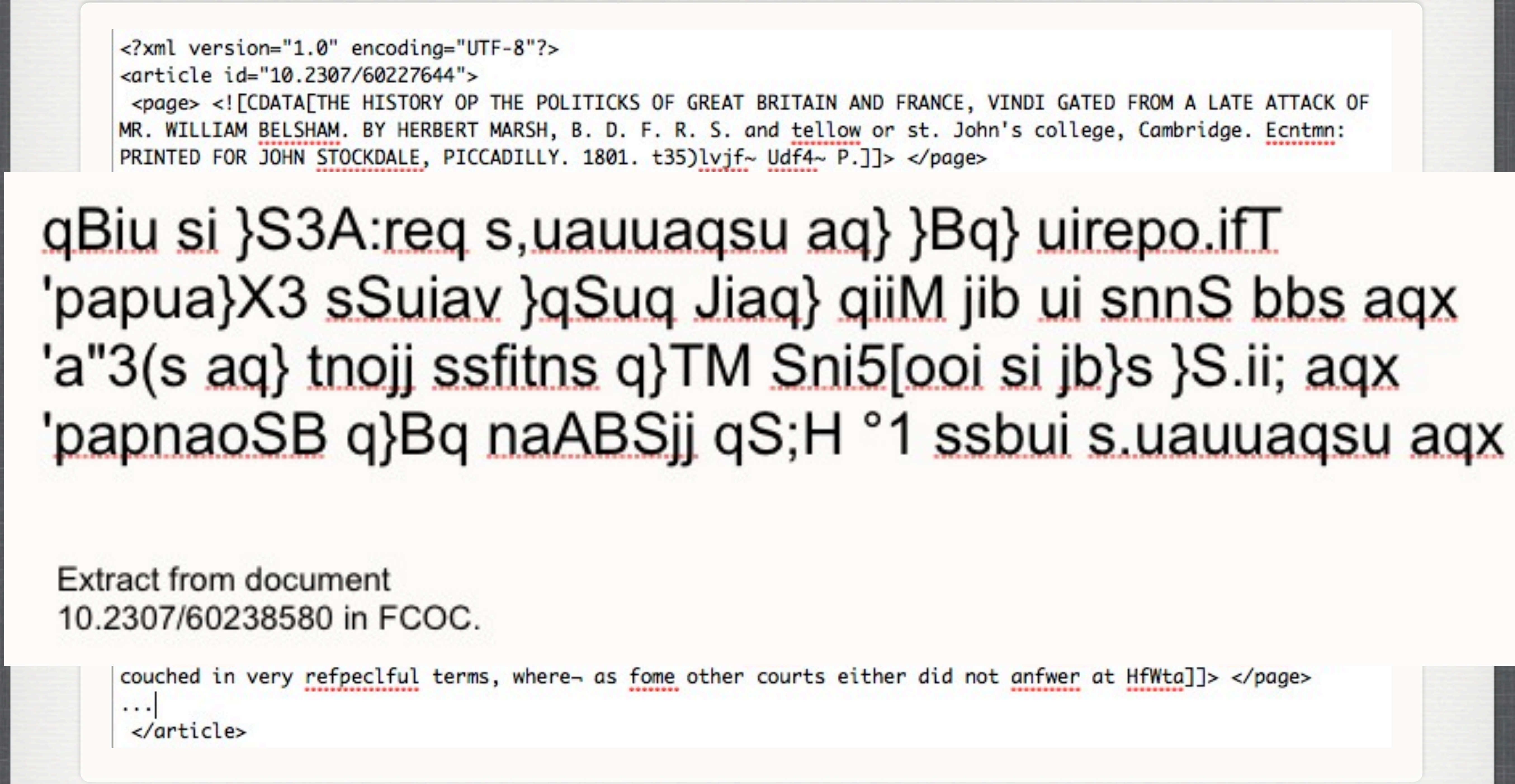

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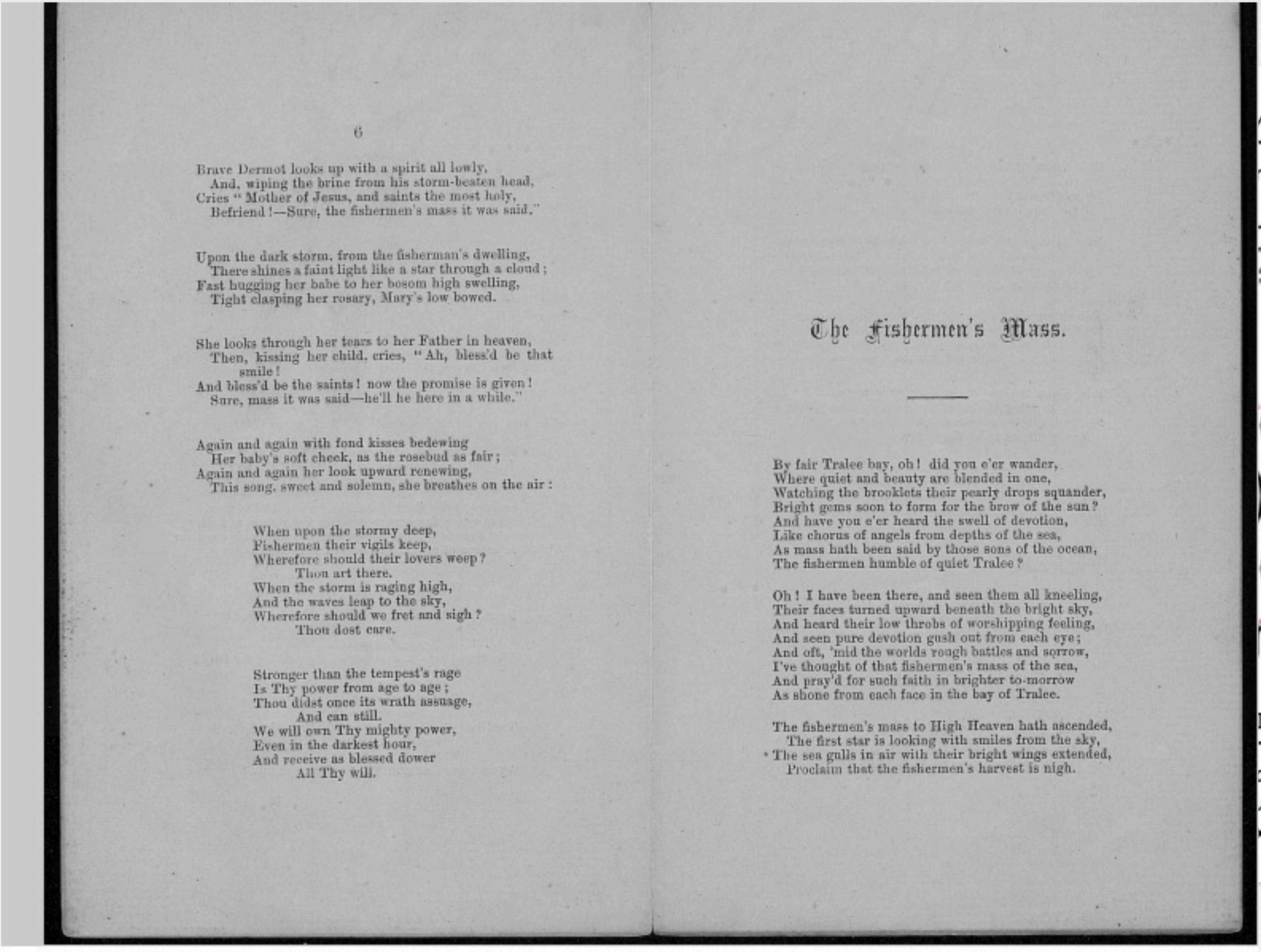
OCR-ED TEXT



Brave Dermot looks up with a spirit all lowly,
And, wiping the brine from his storm-beaten head,
Cries " Mother of Jesus, and saints the most holy,
Befriend !—Sure, the fishermen's mass it was said."

Upon the dark storm, from the fisherman's dwelling,
There shines a faint light like a star through a cloud ;
Fast hugging her babe to her bosom high swelling,
Tight clasping her rosary, Mary's low bowed.

She looks through her tears to her Father in heaven,
Then, kissing her child, cries, " Ah, bless'd be that
smile !
And bless'd be the saints ! now the promise is given !
Sure, mass it was said—he'll he here in a while."

Again and again with fond kisses bedewing
Her baby's soft cheek, as the rosebud as fair ;
Again and again her look upward renewing,
This song, sweet and solemn, she breathes on the air :

When upon the stormy deep,
Fishermen their vigils keep,
Wherefore should their lovers weep ?
Thou art there.
When the storm is raging high,
And the waves leap to the sky,
Wherefore should we fret and sigh ?
Thou dost care.

Stronger than the tempest's rage
Is Thy power from age to age ;
Thou didst once its wrath assuage,
And can still.
We will own Thy mighty power,
Even in the darkest hour,
And receive as blessed dower
All Thy will.

The Fishermen's Mass.

By fair Tralee bay, oh ! did you e'er wander,
Where quiet and beauty are blended in one,
Watching the brooklets their pearly drops squander,
Bright gems soon to form for the brow of the sun ?
And have you e'er heard the swell of devotion,
Like chorus of angels from depths of the sea,
As mass hath been said by those sons of the ocean,
The fishermen humble of quiet Tralee ?

Oh ! I have been there, and seen them all kneeling,
Their faces turned upward beneath the bright sky,
And heard their low throbs of worshipping feeling,
And seen pure devotion gush out from each eye ;
And oft, 'mid the worlds rough battles and sorrow,
I've thought of that fishermen's mass of the sea,
And pray'd for such faith in brighter to-morrow
As shone from each face in the bay of Tralee.

The fishermen's mass to High Heaven hath ascended,
The first star is looking with smiles from the sky,
The sea gulls in air with their bright wings extended,
Proclaim that the fishermen's harvest is nigh.

WHY OCR ACCURACY ESTIMATION?

- A reasonable amount of already digitised books (some with very bad text quality). Can we mine some of them now.

- To what extent do OCR errors affect text mining? What is their effect when dealing with big data?

- What text is of sufficient high quality to be understood? How bad is too bad? What happens to the rest?

- Can we measure text quality? How does it compare to human quality ranking of text?

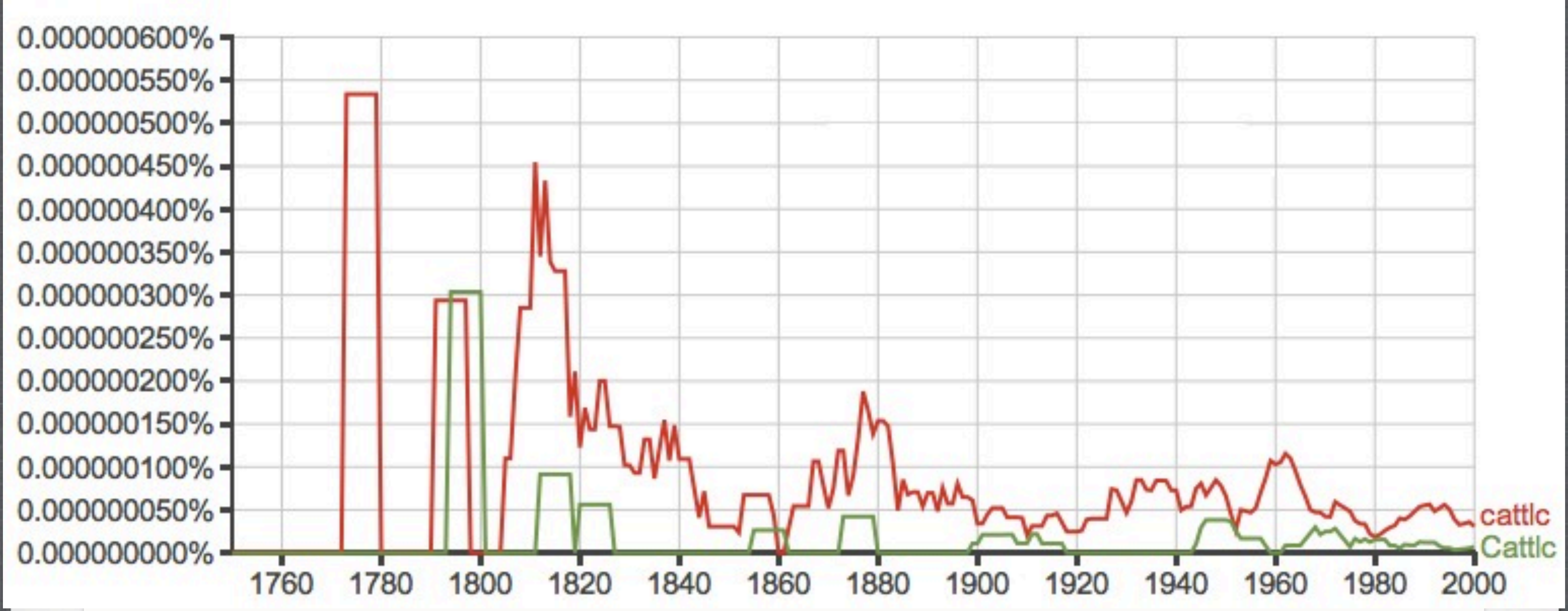
RELATED WORK

- Some OCR output contains character-based accuracy rates which can be very deceptive.
- Popat, 2009:
  - Extensive study on quality ranking of short OCRed text snippets in different languages. Examined rank order of text snippets of inter-, intra- and machine ratings.
  - Compared spatial and sequential character n-gram-based approaches to a dictionary-based approach (web corpus, capped at 50K most frequent words per language).
  - Compared random to balanced (stratified) sampling.
  - Metric: average rank correlation.

OCR ERRORS AND BIG DATA

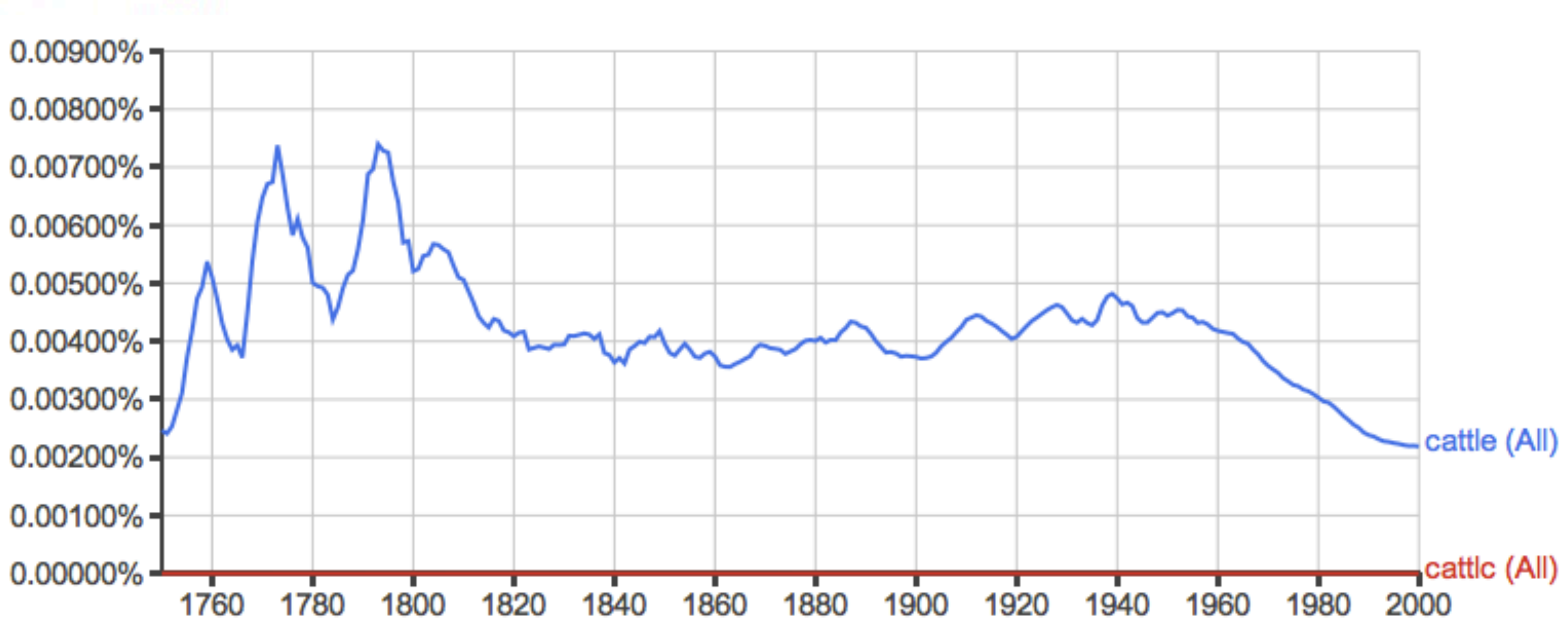
- Are OCR errors negligible when mining big data to detect trends?
- Our data suffers from all the common OCR error types (at best just a few character insertions, substitutions and deletions), at worst much worse (page upside down).
- Character confusion examples:
  - e -> c, a -> o, h -> b, l -> t, m -> n, f -> s

OCR ERRORS



PQIS All Team Meeting, ProQuest, April 23rd 2014

OCR ERRORS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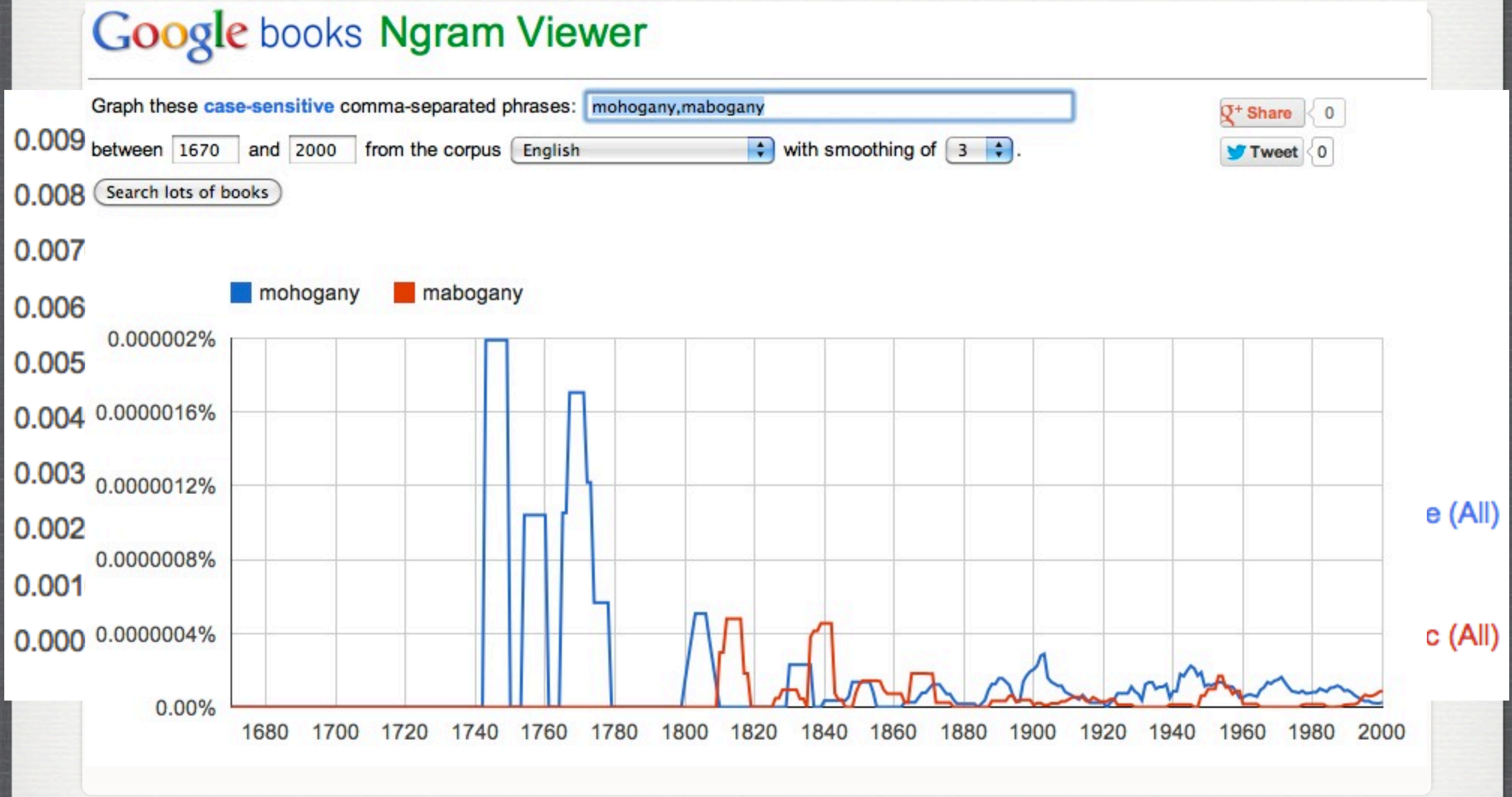
OCR ERRORS

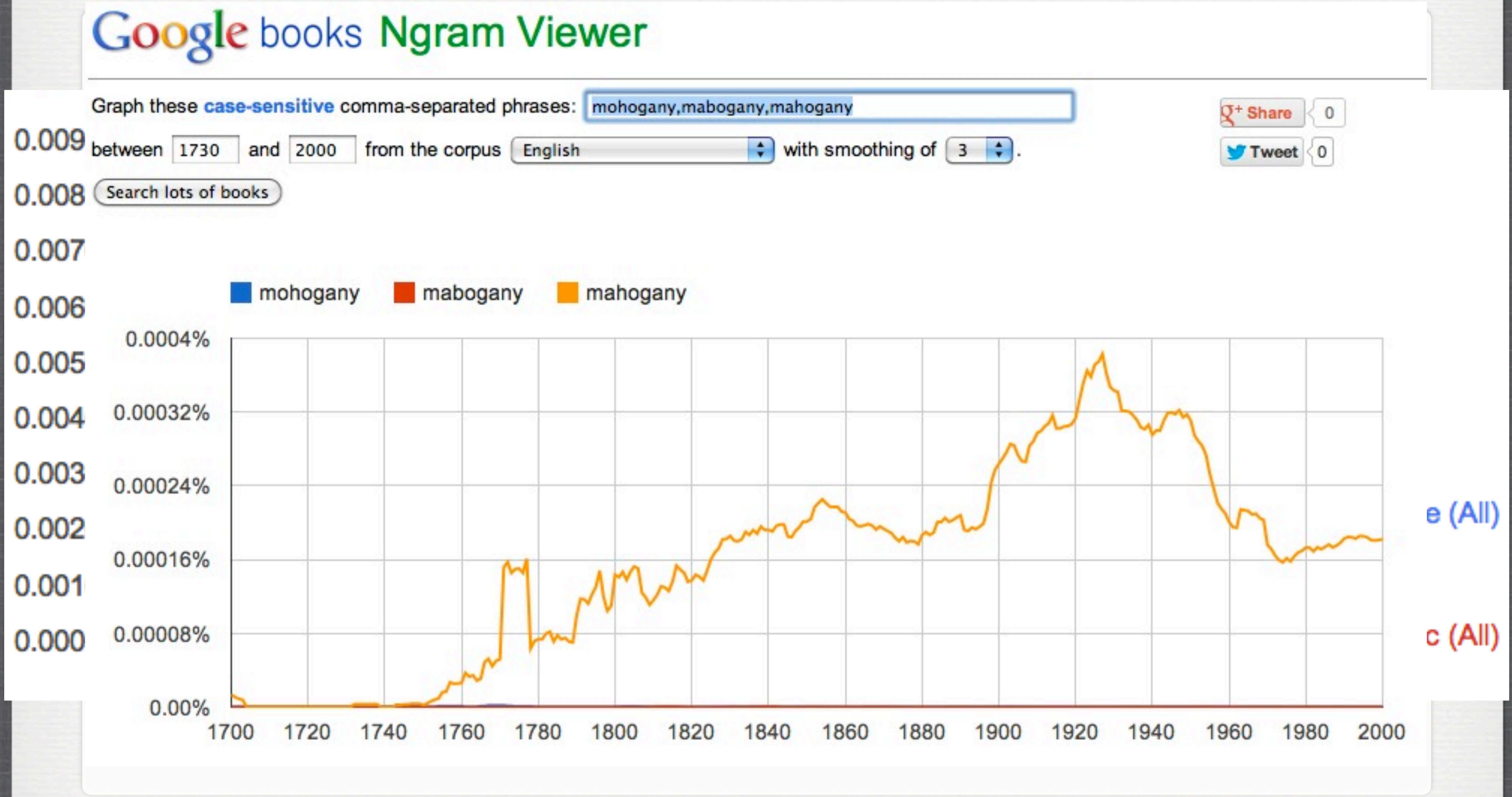


Graph these case-sensitive comma-separated phrases: mohogany,mabogany

between 1670 and 2000 from the corpus English with smoothing of 3 .

PQIS All Team Meeting, ProQuest, April 23rd 2014

OCR ERRORS

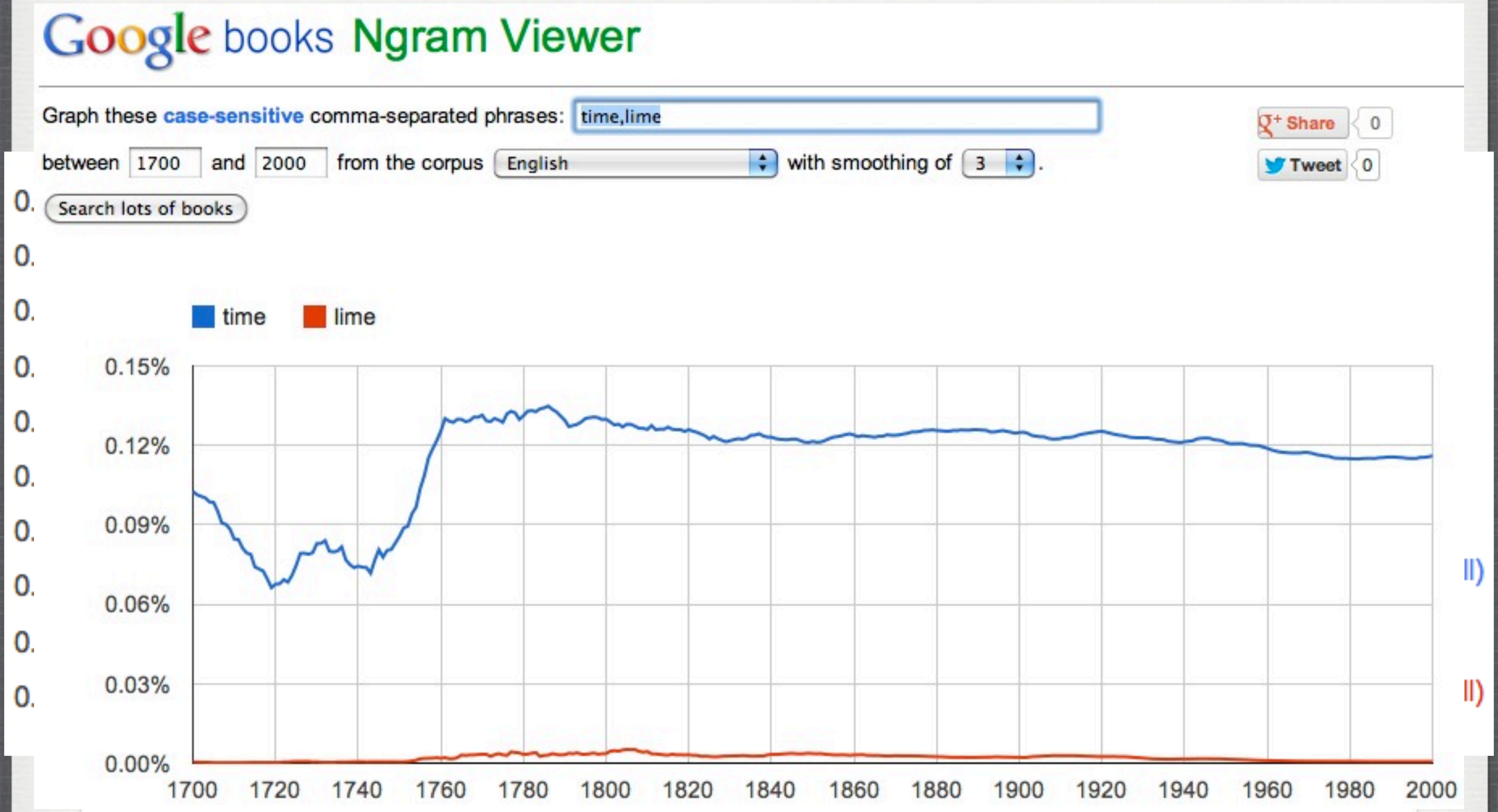


Google books Ngram Viewer

Graph these case-sensitive comma-separated phrases: mohogany,mabogany,mahogany

between 1730 and 2000 from the corpus English with smoothing of 3.

OCR ERRORS



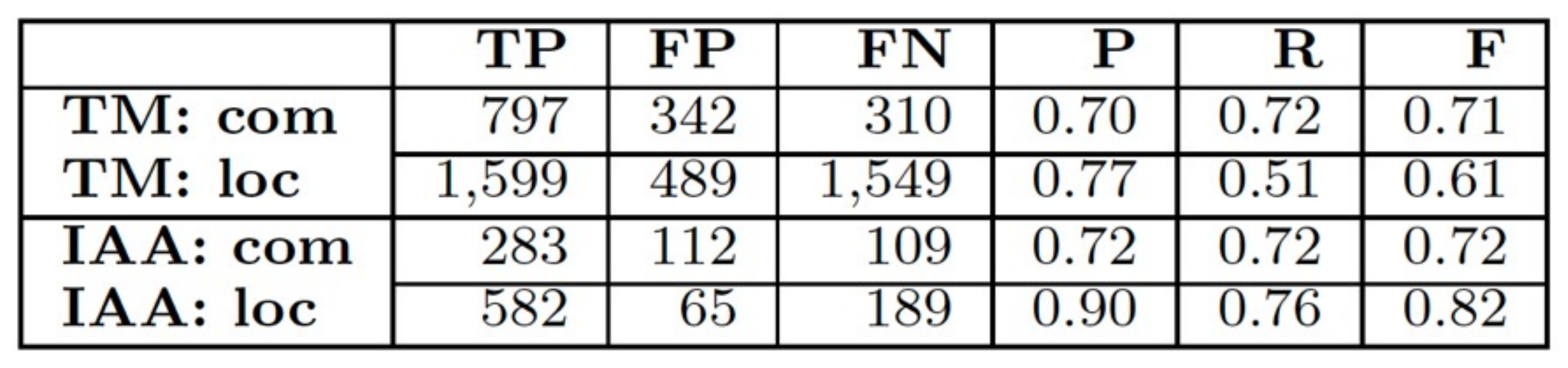
Google books Ngram Viewer

Graph these case-sensitive comma-separated phrases: time,lime

between 1700 and 2000 from the corpus English with smoothing of 3.

OCR ERRORS AND TEXT MINING

- Need a more quantitative analysis.
- Built a commodity and location recognition tool.
- Evaluated it against manually annotated gold standard.

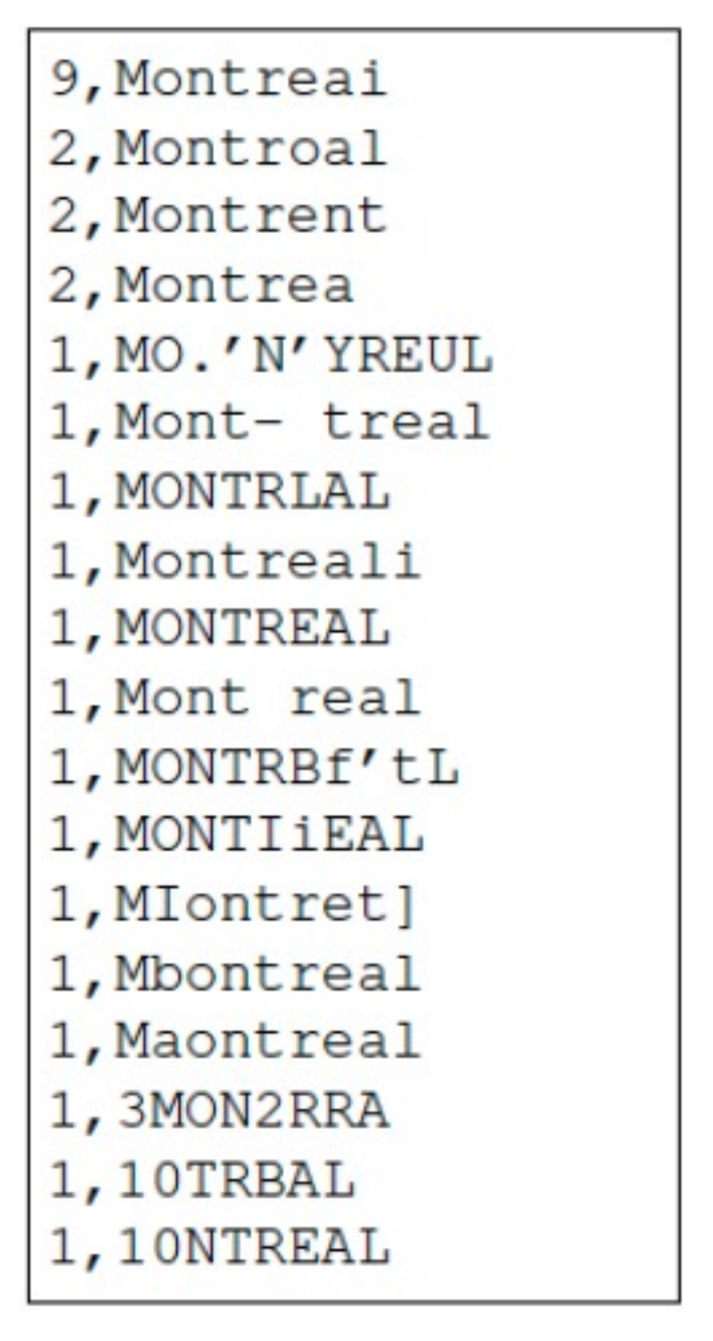


	TP	FP	FN	P	R	F
TM: com	797	342	310	0.70	0.72	0.71
TM: loc	1,599	489	1,549	0.77	0.51	0.61
IAA: com	283	112	109	0.72	0.72	0.72
IAA: loc	582	65	189	0.90	0.76	0.82

OCR ERRORS AND TEXT MINING

- 32.6% of false negative commodity mentions (101 of 310) contain OCR errors (= 9.1% of all commodity mentions in the gold standard)
  - *sainon*, *rubher*, *tmber*
- 30.2% of false negative location mentions (467 of 1,549) contain OCR errors (= 14.8% of all location mentions in the gold standard)
  - *Montreai*, *Montroal*, *Mont- treal* and *10NTREAL*.

OCR ERRORS AND TEXT MINING



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9,Montreai
2,Montroal
2,Montrent
2,Montrea
1,MO.’N’YREUL
1,Mont- treal
1,MONTRLAL
1,Montreali
1,MONTREAL
1,Mont real
1,MONTRBf’tL
1,MONTIiEAL
1,MIontret]
1,Mbontreal
1,Maontreal
1,3MON2RRA
1,10TRBAL
1,10NTREAL
```

PREDICTING TEXT QUALITY

- Can we compute a simple quality score for a large data collection (i.e. over 7 billion words)?
- How easily can humans perform document-level quality rating?

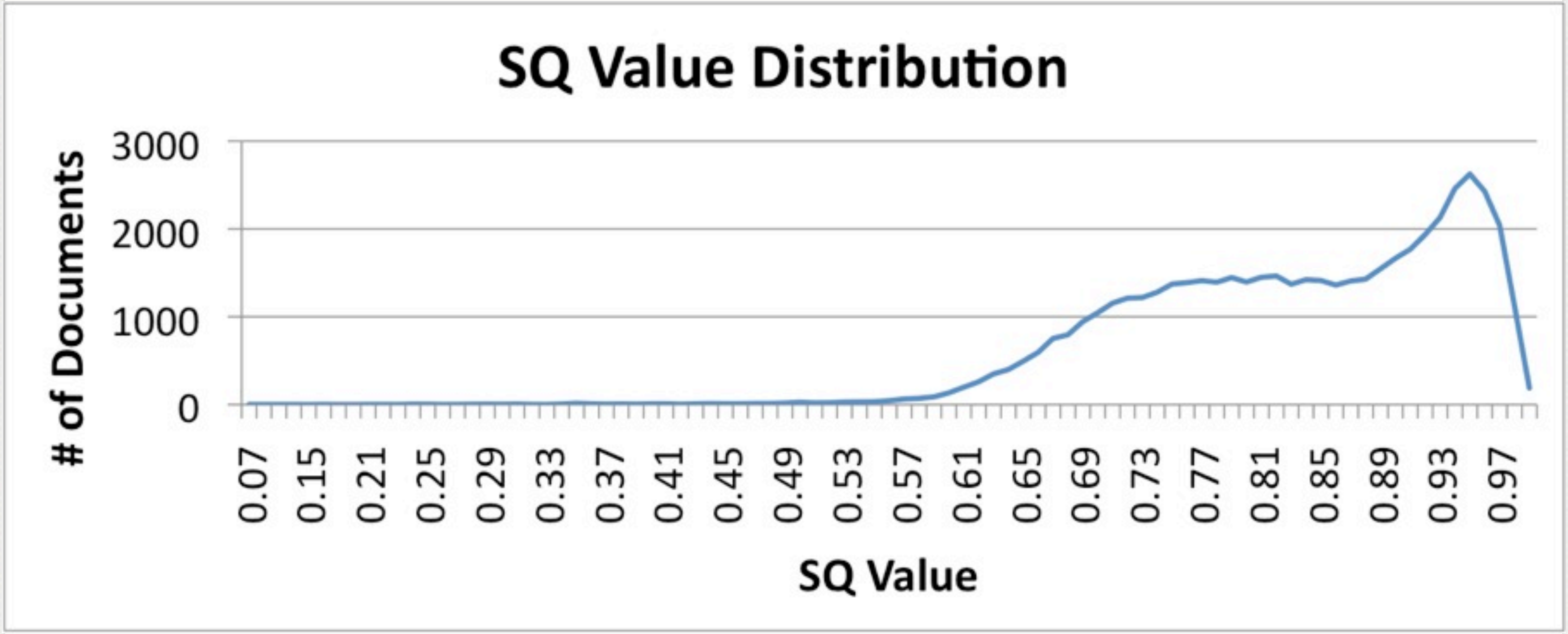
COMPUTING TEXT QUALITY

- Simple document-level quality score to get a rough estimate of how good a document is.
- Word tokens found in an English dictionary (aspell “en”) and Roman/Arabic numbers over all word tokens in the text.
- Scores range between 0 and 1.
- Caveat: it does not consider historic variants.

$$SQ = \frac{W_{good}}{W_{all} + 1}$$

COMPUTING TEXT QUALITY

- Score distribution over the English Early Canadiana Online data (55,313 documents).



DATA PREPARATION

- Early Canadiana Online (books, magazines and government publications relevant to Canadian history ranging from 1600 to the 1940s)
- 83,016 documents (almost 4 million images containing text mostly in English and French but also in 10 First Nation languages, European languages and Latin).
- Language identification (or meta data information) to retain only English content (55,313 documents).

DATA PREPARATION

- Ran the automatic scoring over all English ECO documents.
- Applied stratified sampling to collect 100 documents by randomly selecting:
  - 20 documents where 0 >= SQ < 0:2,
  - 20 documents where 0.2 >= SQ < 0.4,
  - 20 documents where 0.4 >= SQ < 0.6,
  - 20 documents where 0.6 >= SQ < 0.8,
  - 20 documents where 0.8 >= SQ < 1.
- Shuffled documents and removed the quality score.

MANUAL RATING

- Two raters looked at each document and rated it on a 5-point scale.

  5 ... OCR quality is high. There are few errors. The text is easily readable and understandable.

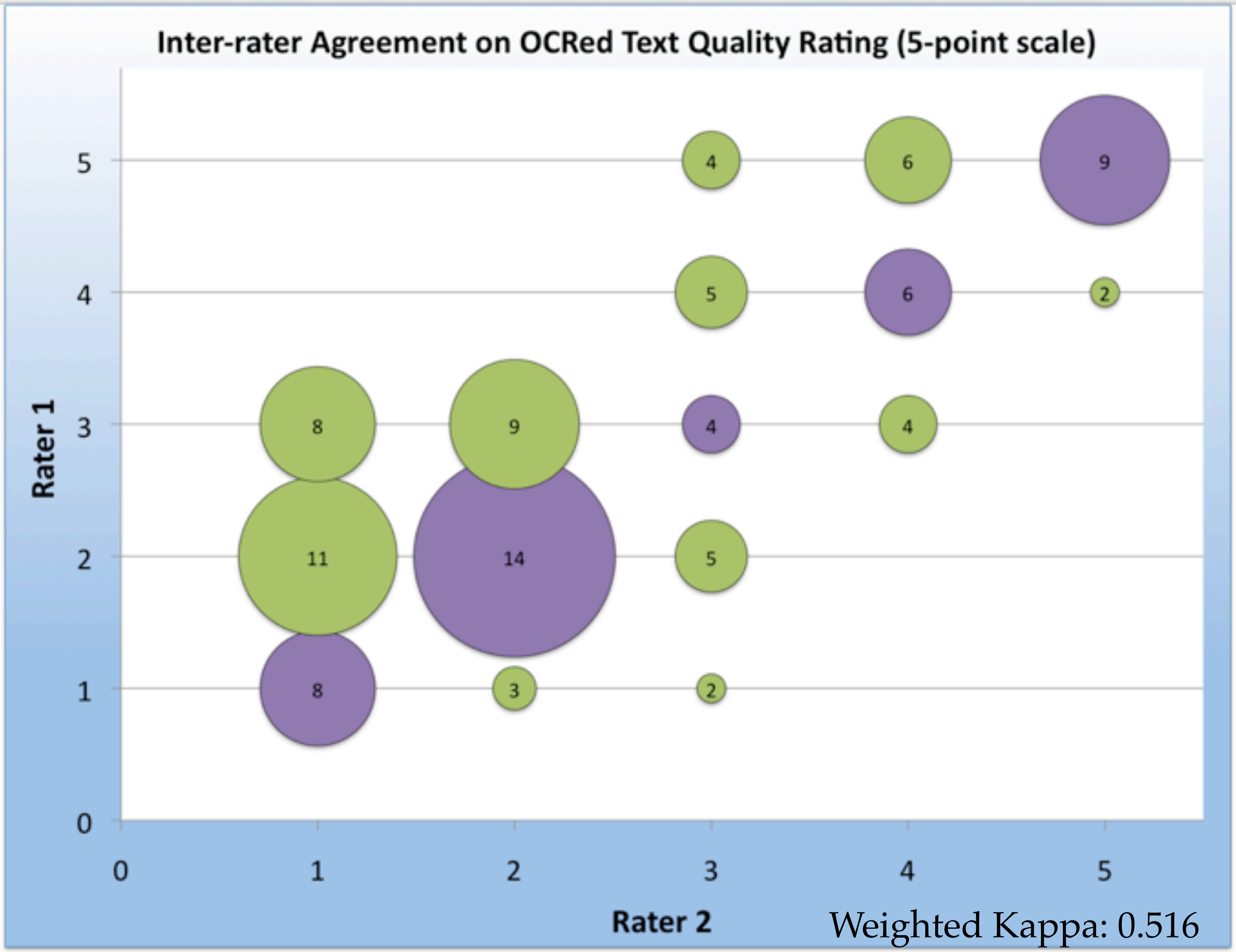
  4 ... OCR quality is good. There are some errors but they are limited in number and the text is still mostly readable and understandable.

  3 ... OCR quality is mediocre. There are numerous OCR errors and only part of the text is readable and understandable.

  2 ... OCR quality is low. There is a large number of OCR errors which seriously affect the readability and understandability of the majority of the text.

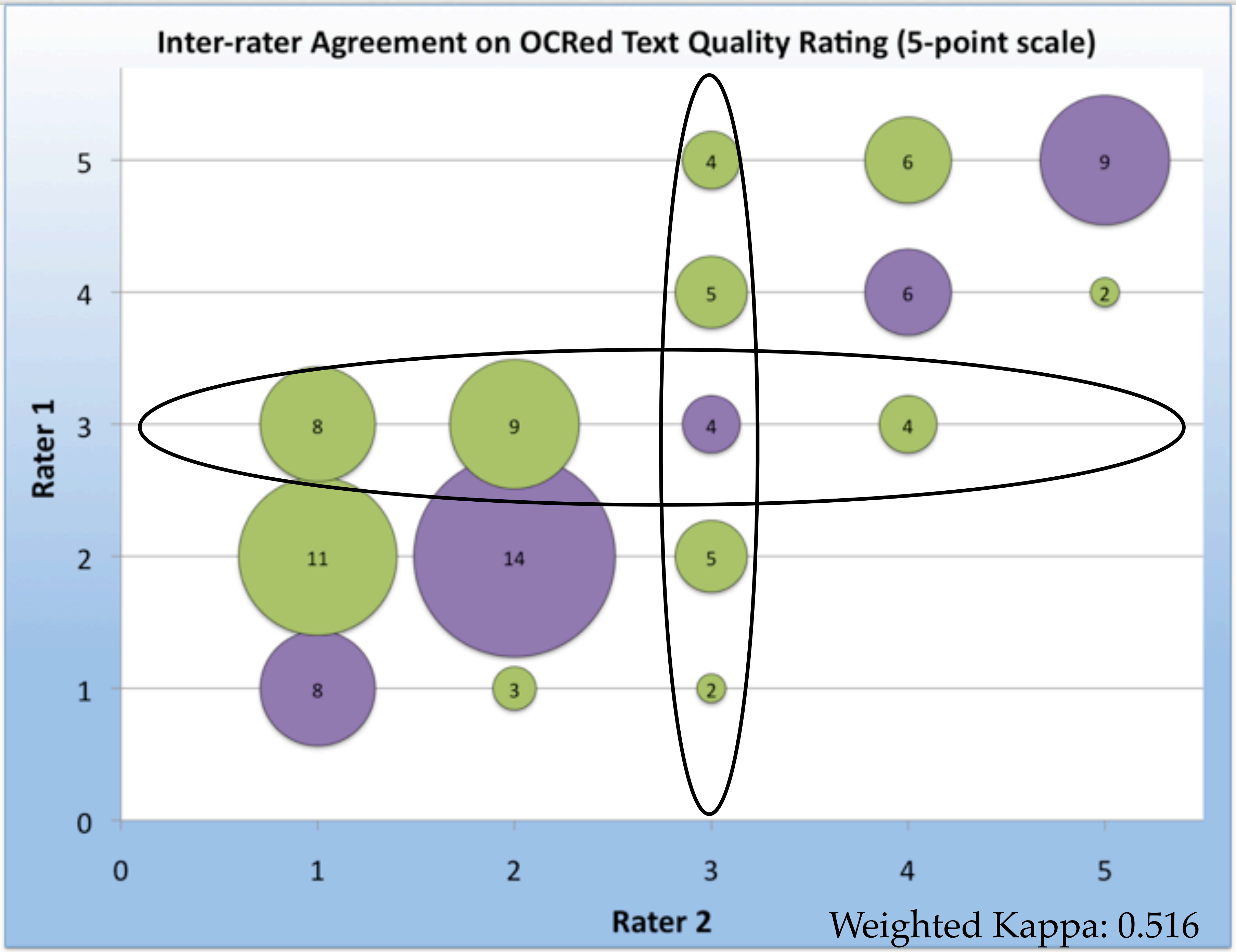
  1 ... OCR quality is extremely low. The text is so full of errors that it is not readable and understandable.

INTER-RATER AGREEMENT



Weighted Kappa: 0.516

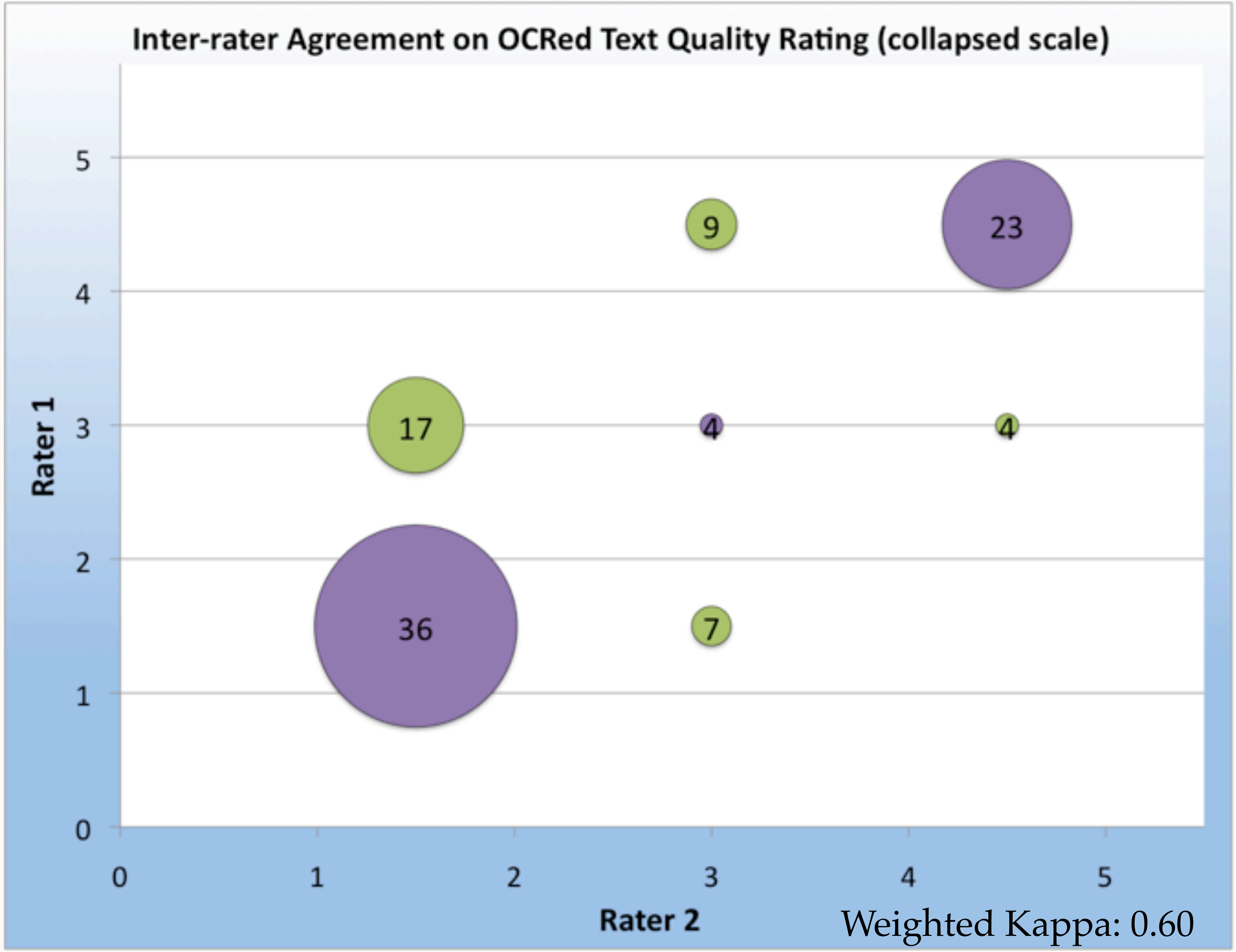
INTER-RATER AGREEMENT



Weighted Kappa: 0.516

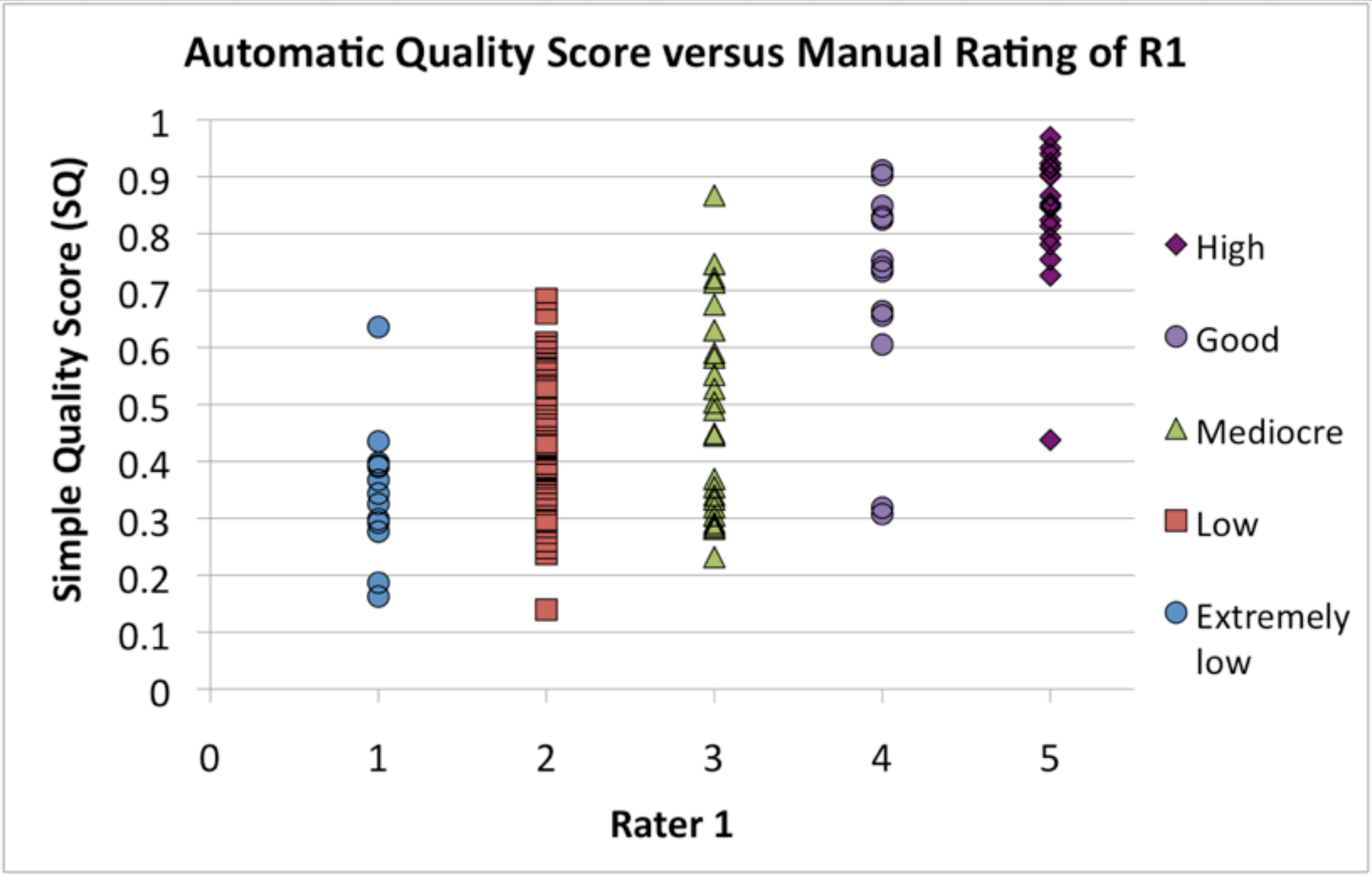
DATeCH 2014, May 20th 2014

INTER-RATER AGREEMENT



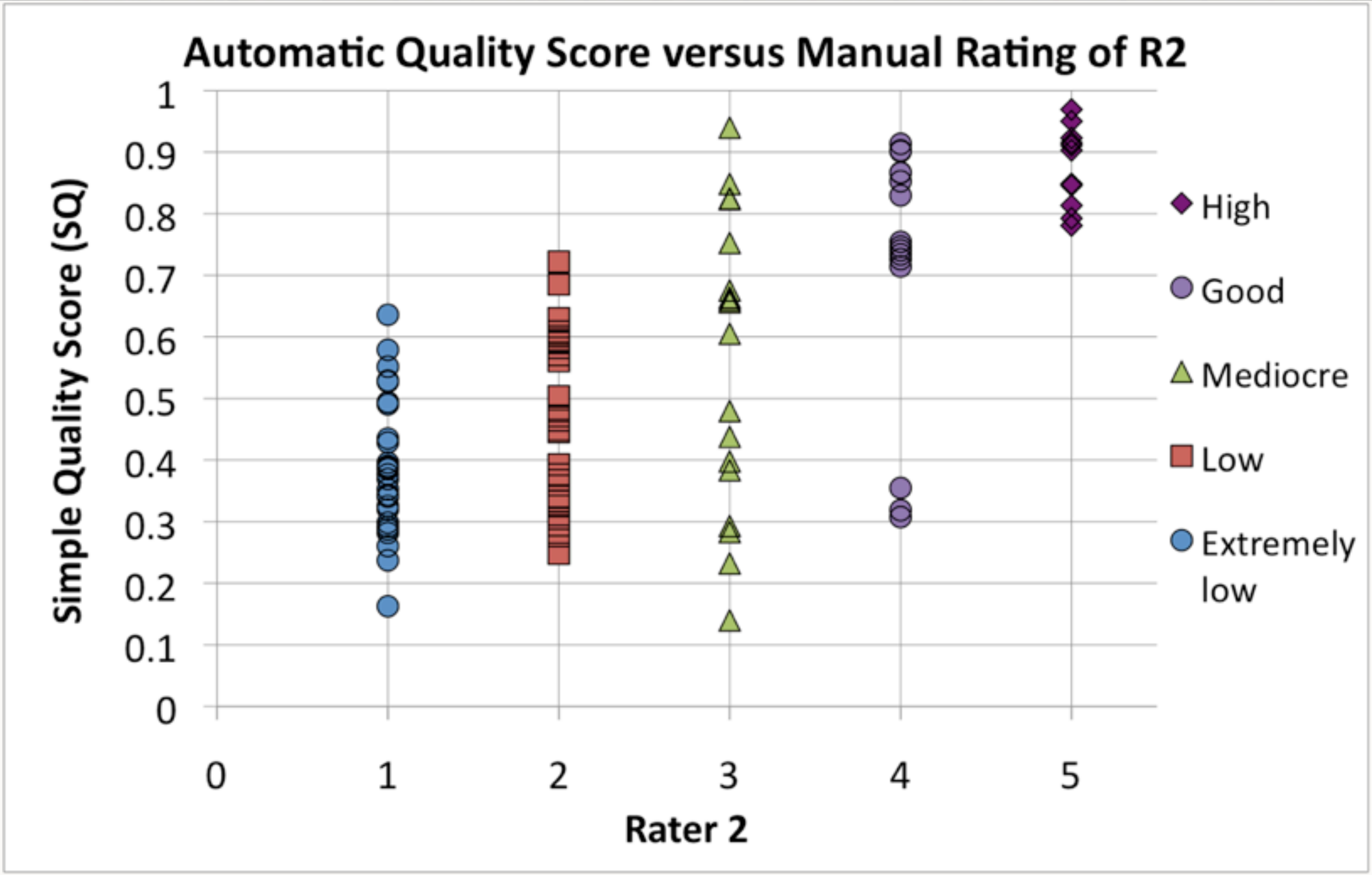
Weighted Kappa: 0.60

AUTOMATIC VS HUMAN



DATeCH 2014, May 20th 2014

AUTOMATIC VS HUMAN



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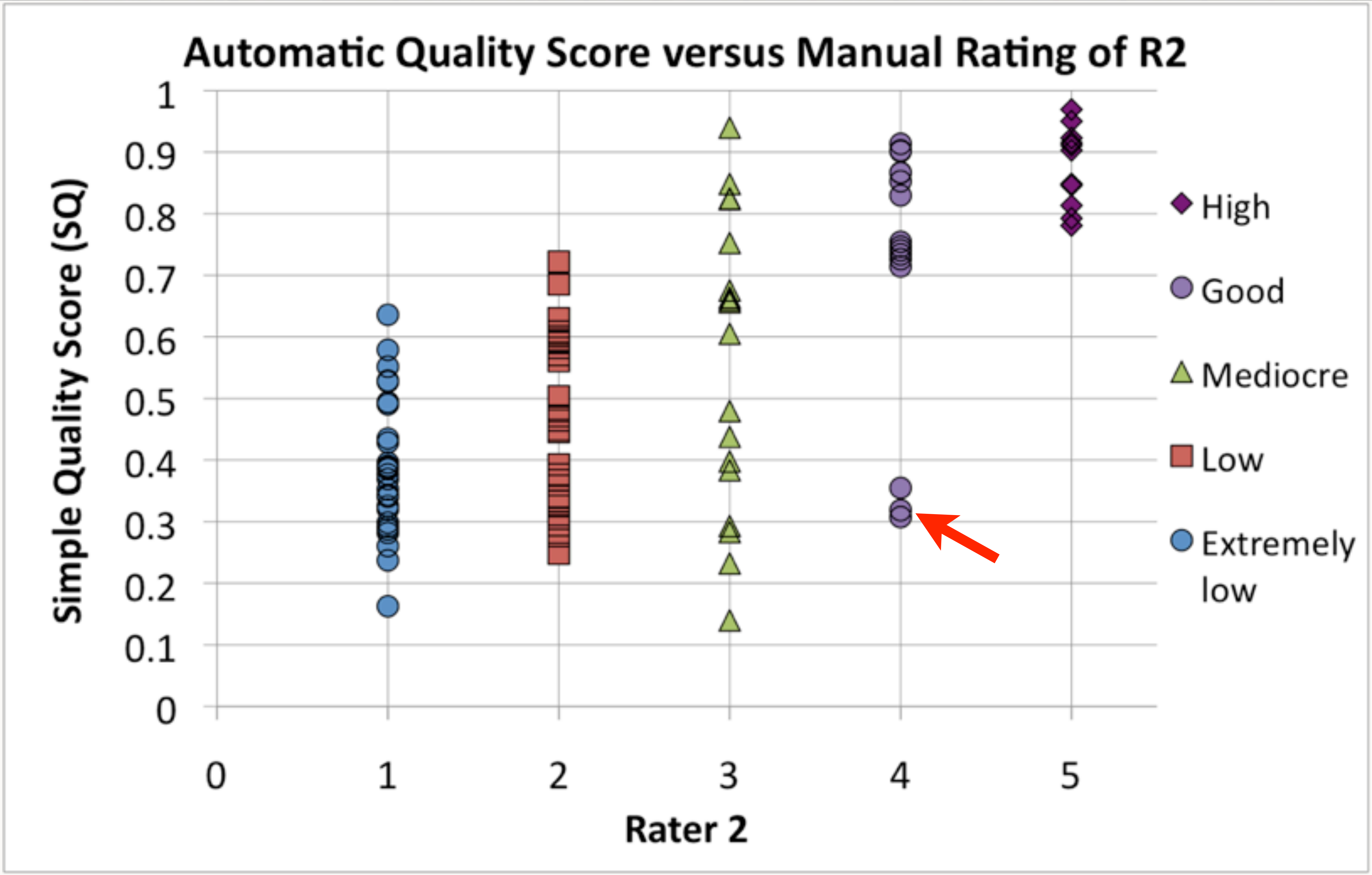

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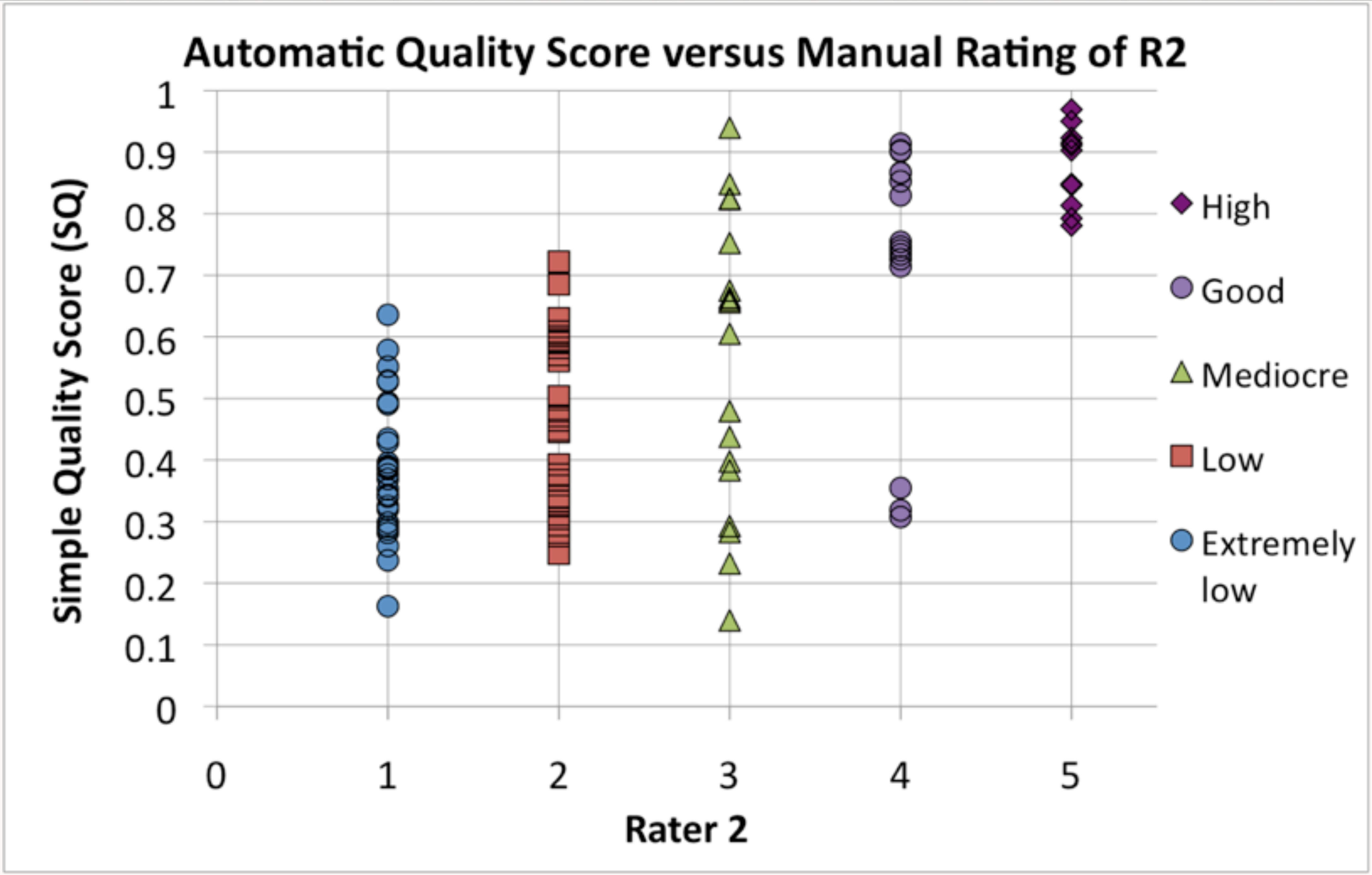

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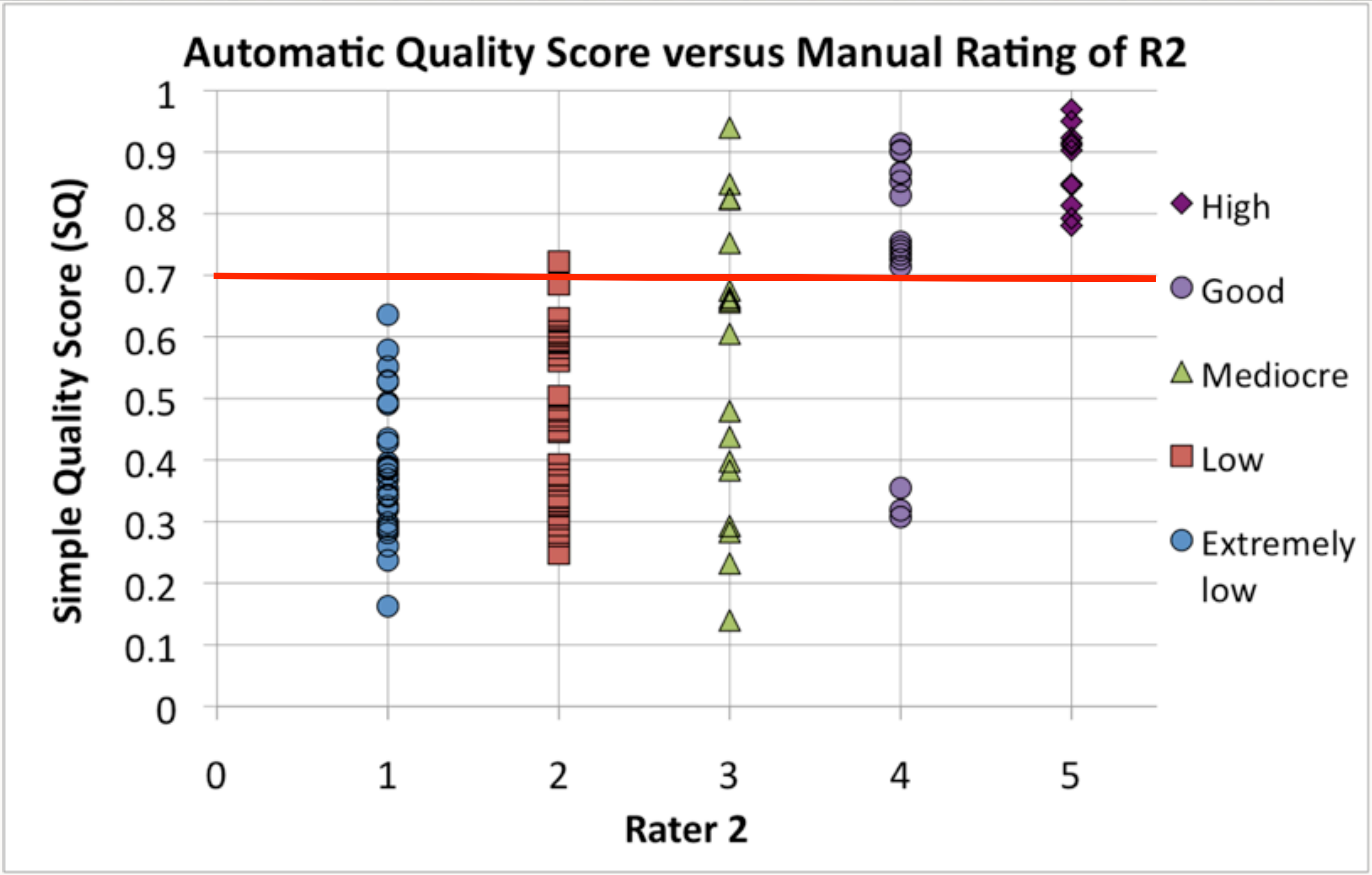
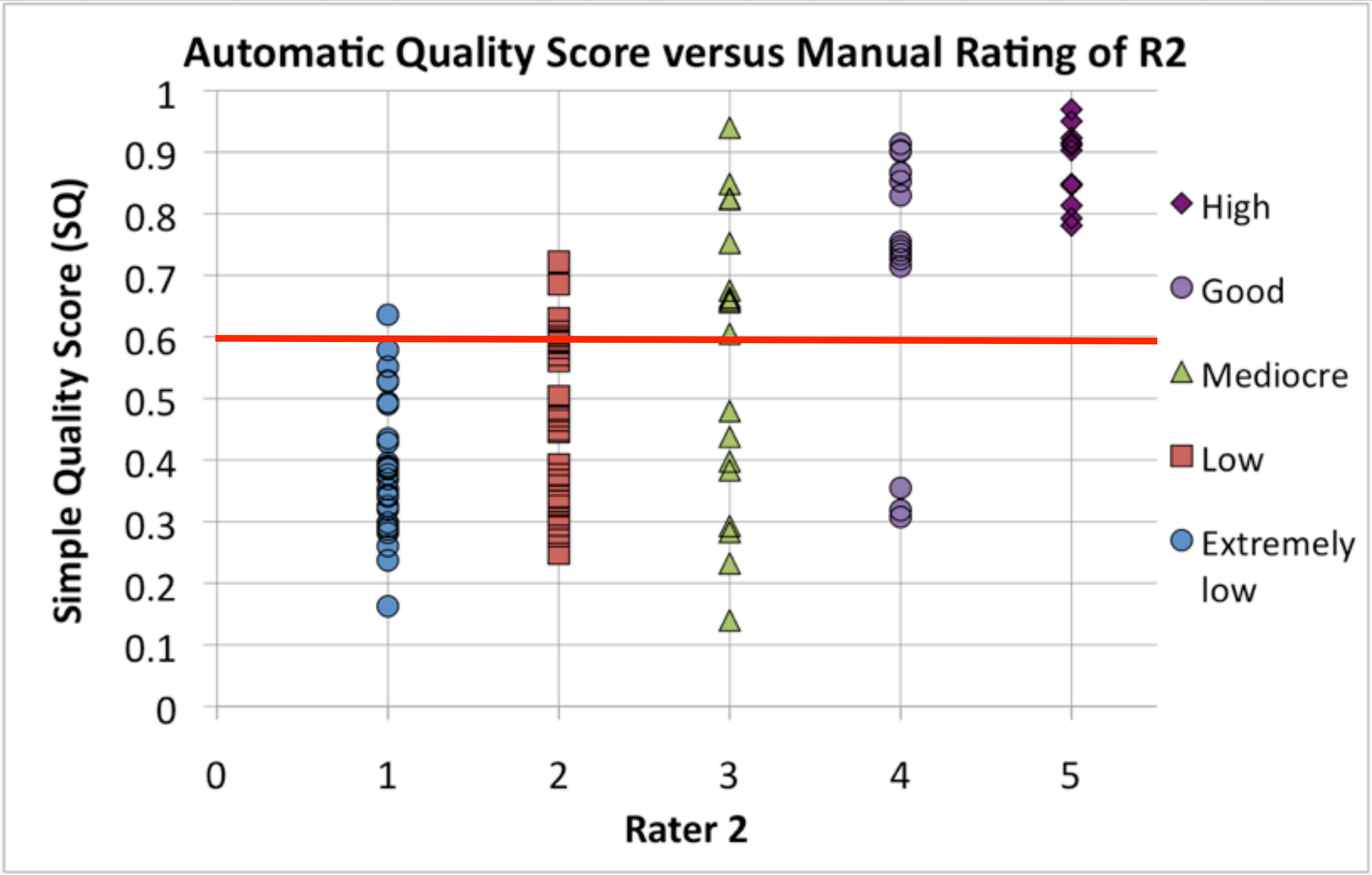
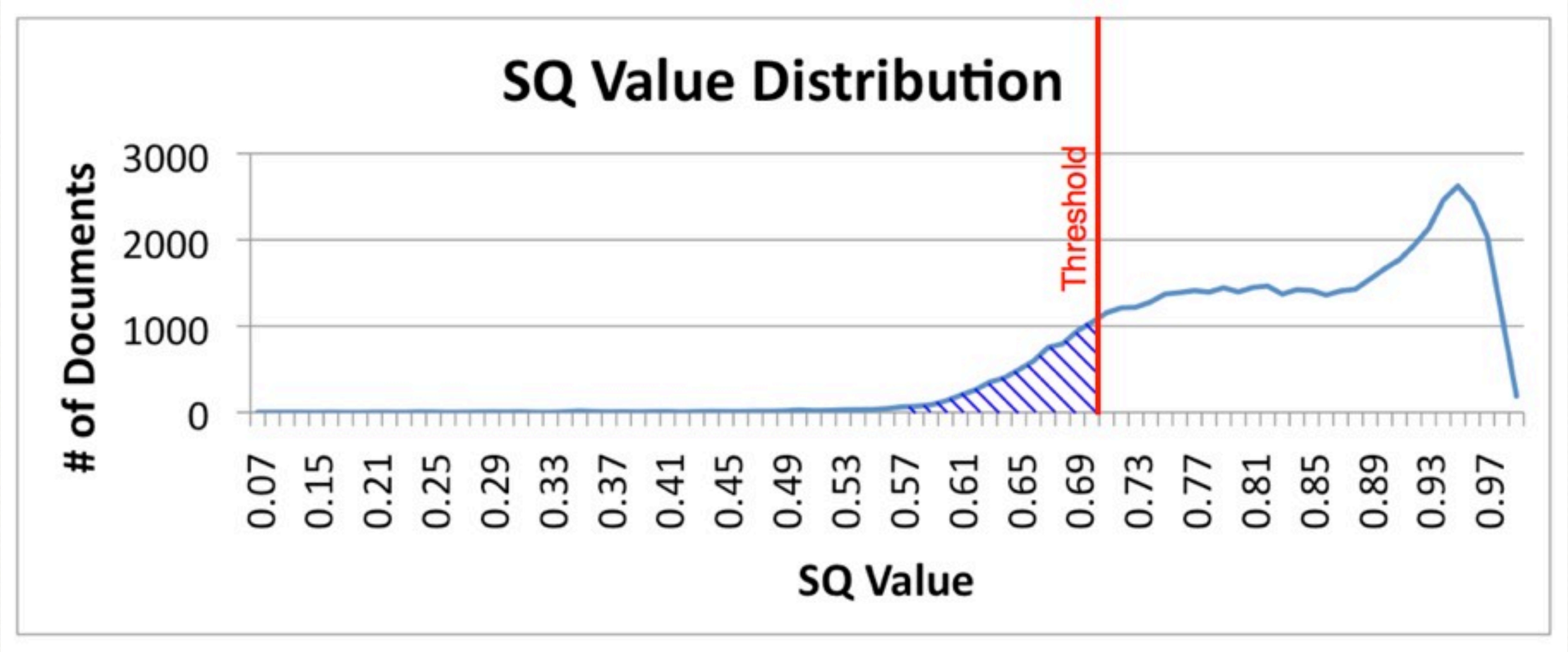


AUTOMATIC VS HUMAN



THRESHOLD?


SQ Value Distribution
Threshold
# of Documents
3000
2000
1000
0
0.07
0.15
0.21
0.25
0.29
0.33
0.37
0.41
0.45
0.49
0.53
0.57
0.61
0.65
0.69
0.73
0.77
0.81
0.85
0.89
0.93
0.97
SQ Value

CONCLUSION

- We applied a simple quality scoring method to a large document collection and showed that automatic rating correlates with human rating.
- Document-level rating is not easy to do manually.
- Automatic document-level rating is not ideal but it give us a first “taste” of how good the quality of a document is. It is much more consistent than a person doing the same task.
- Many OCR errors are noise in big data but when added up they affect a significant amount of text.
- We found that named entities are effected worse than common words.
- HSS scholars need to be made much more aware of OCR errors affecting their search results for historical collections.

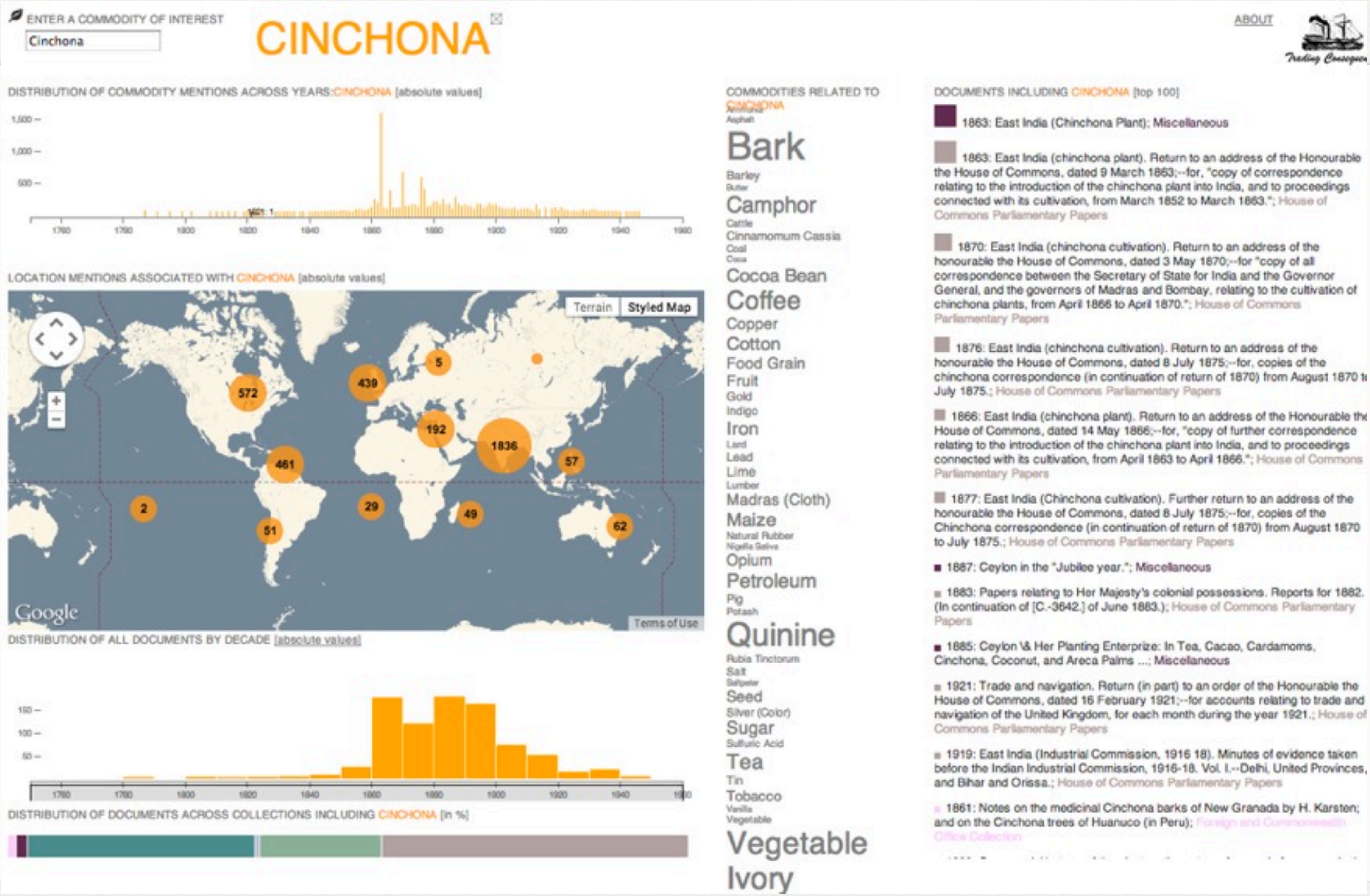
FUTURE WORK

- Consider publication date and digitisation date when doing OCR quality estimation.
- Examine the bad documents identify those worth post-correcting.
- AHRC big data project (Palimpsest) on mining and geo-referencing literature set in Edinburgh. Collaboration with literary scholars interested in loco-specificity and its context in literature.

THANK YOU

- Rating annotation guidelines and doubly rated data available on GitHub (digtrade)
- Contact: balex@inf.ed.ac.uk
- Website: http://tradingconsequences.blogs.edina.ac.uk/
- Twitter: @digtrade

BRINGING ARCHIVES ALIVE



ENTER A COMMODITY OF INTEREST: Cinchona

CINCHONA

ABOUT

Trading Consequences

DISTRIBUTION OF COMMODITY MENTIONS ACROSS YEARS:CINCHONA [absolute values]

LOCATION MENTIONS ASSOCIATED WITH CINCHONA [absolute values]

DISTRIBUTION OF ALL DOCUMENTS BY DECADE [absolute values]

DISTRIBUTION OF DOCUMENTS ACROSS COLLECTIONS INCLUDING CINCHONA [in %]

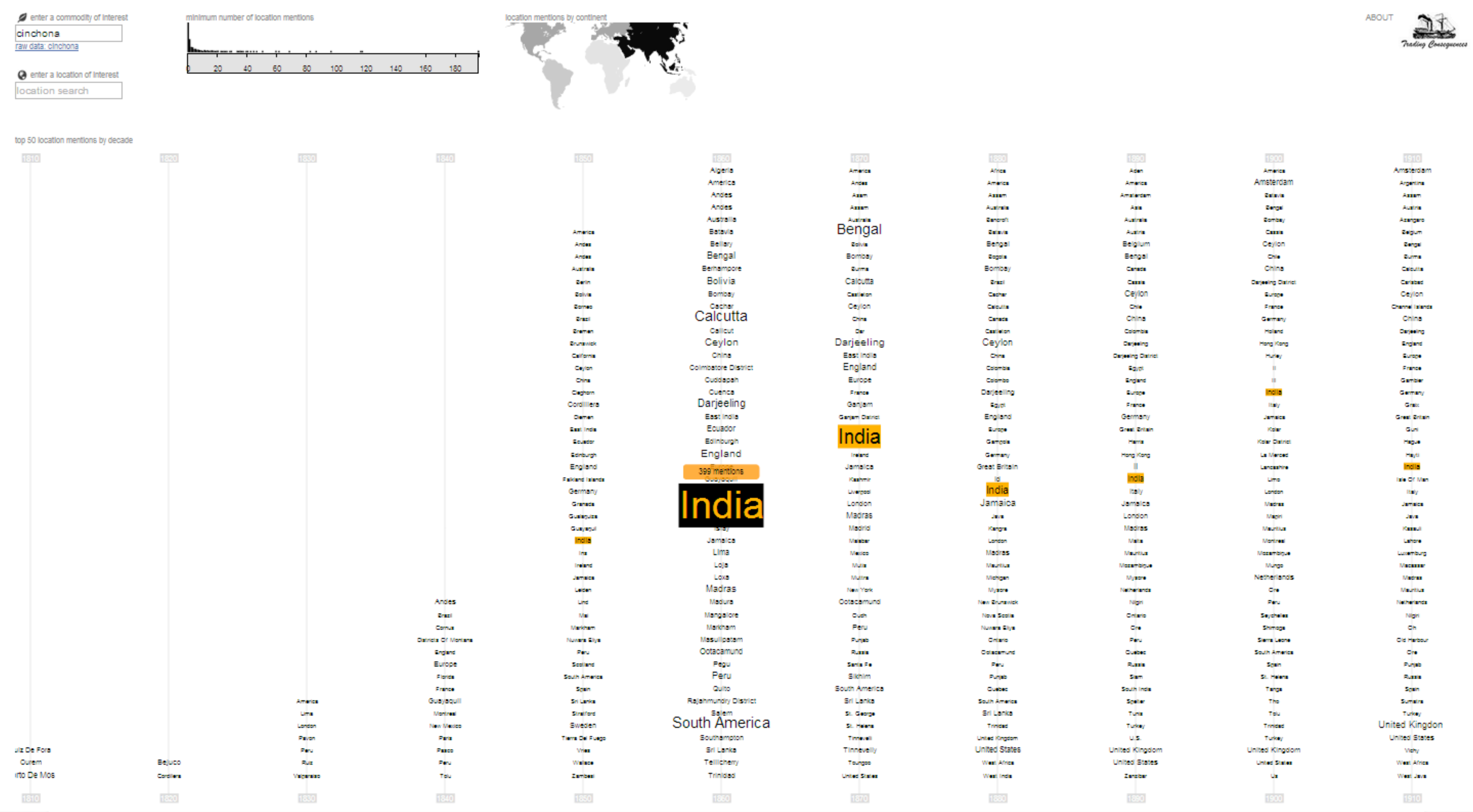
COMMODITIES RELATED TO CINCHONA

Ammonia
Asphalt
Bark
Barley
Butter
Camphor
Cattle
Cinnamomum Cassia
Coal
Coca
Cocoa Bean
Coffee
Copper
Cotton
Food Grain
Fruit
Gold
Indigo
Iron
Lard
Lead
Lime
Lumber
Madras (Cloth)
Maize
Natural Rubber
Nigella Sativa
Opium
Petroleum
Pig
Potash
Quinine
Rubia Tinctorum
Salt
Saltpeter
Seed
Silver (Color)
Sugar
Sulfuric Acid
Tea
Tin
Tobacco
Vanilla
Vegetable
Vegetable
Ivory

DOCUMENTS INCLUDING CINCHONA [top 100]

- 1863: East India (Chinchona Plant); Miscellaneous
- 1863: East India (chinchona plant). Return to an address of the Honourable the House of Commons, dated 9 March 1863;--for, "copy of correspondence relating to the introduction of the chinchona plant into India, and to proceedings connected with its cultivation, from March 1852 to March 1863."; House of Commons Parliamentary Papers
- 1870: East India (chinchona cultivation). Return to an address of the honourable the House of Commons, dated 3 May 1870;--for "copy of all correspondence between the Secretary of State for India and the Governor General, and the governors of Madras and Bombay, relating to the cultivation of chinchona plants, from April 1866 to April 1870."; House of Commons Parliamentary Papers
- 1876: East India (chinchona cultivation). Return to an address of the honourable the House of Commons, dated 8 July 1875;--for, copies of the chinchona correspondence (in continuation of return of 1870) from August 1870 t July 1875.; House of Commons Parliamentary Papers
- 1866: East India (chinchona plant). Return to an address of the Honourable the House of Commons, dated 14 May 1866;--for, "copy of further correspondence relating to the introduction of the chinchona plant into India, and to proceedings connected with its cultivation, from April 1863 to April 1866."; House of Commons Parliamentary Papers
- 1877: East India (Chinchona cultivation). Further return to an address of the honourable the House of Commons, dated 8 July 1875;--for, copies of the Chinchona correspondence (in continuation of return of 1870) from August 1870 to July 1875.; House of Commons Parliamentary Papers
- 1887: Ceylon in the "Jubilee year."; Miscellaneous
- 1883: Papers relating to Her Majesty's colonial possessions. Reports for 1882. (In continuation of [C.-3642.] of June 1883.); House of Commons Parliamentary Papers
- 1885: Ceylon \& Her Planting Enterprize: In Tea, Cacao, Cardamoms, Cinchona, Coconut, and Areca Palms ...; Miscellaneous
- 1921: Trade and navigation. Return (in part) to an order of the Honourable the House of Commons, dated 16 February 1921;--for accounts relating to trade and navigation of the United Kingdom, for each month during the year 1921.; House of Commons Parliamentary Papers
- 1919: East India (Industrial Commission, 1916 18). Minutes of evidence taken before the Indian Industrial Commission, 1916-18. Vol. I.--Delhi, United Provinces, and Bihar and Orissa.; House of Commons Parliamentary Papers
- 1861: Notes on the medicinal Cinchona barks of New Granada by H. Karsten; and on the Cinchona trees of Huanuco (in Peru); Foreign and Commonwealth Office Collection

BRINGING ARCHIVES ALIVE



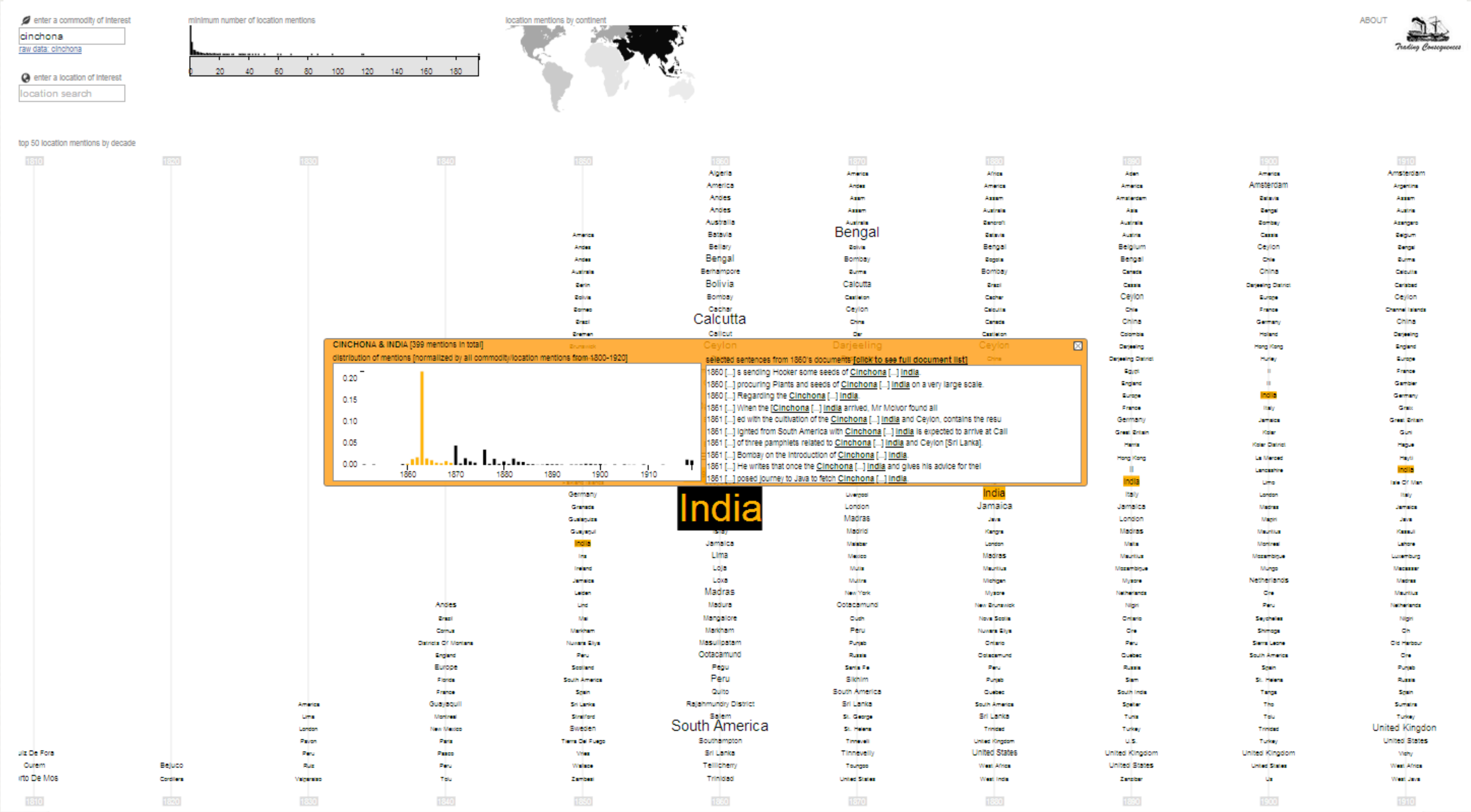
enter a commodity of interest: cinchona

raw data: cinchona

enter a location of interest: location search

DATeCH 2014, May 20th 2014

BRINGING ARCHIVES ALIVE



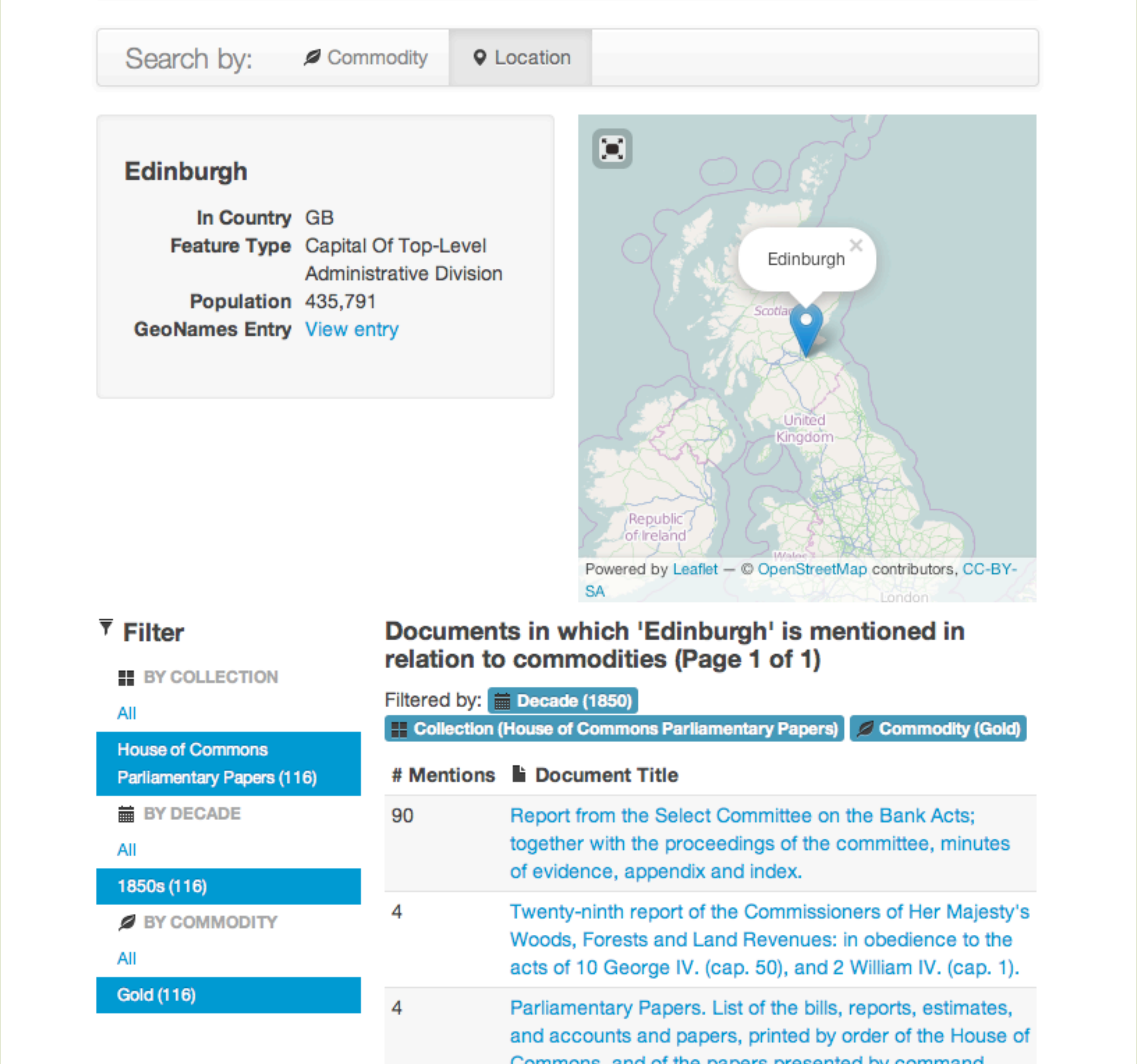
CINCHONA & INDIA [399 mentions in total]

distribution of mentions [normalized by all commodity/location mentions from 1800-1920]

selected sentences from 1860's documents [click to see full document list]

1860 [...] s sending Hooker some seeds of Cinchona [...] India.
1860 [...] procuring Plants and seeds of Cinchona [...] India on a very large scale.
1860 [...] Regarding the Cinchona [...] India.
1861 [...] When the [Cinchona [...] India arrived, Mr McIvor found all
1861 [...] ed with the cultivation of the Cinchona [...] India and Ceylon, contains the resu
1861 [...] ighted from South America with Cinchona [...] India is expected to arrive at Cali
1861 [...] of three pamphlets related to Cinchona [...] India and Ceylon [Sri Lanka].
1861 [...] Bombay on the introduction of Cinchona [...] India.
1861 [...] He writes that once the Cinchona [...] India and gives his advice for thei
1861 [...] posed journey to Java to fetch Cinchona [...] India.

DATeCH 2014, May 20th 2014



Search by: Commodity | Location

Edinburgh

In Country	GB
Feature Type	Capital Of Top-Level Administrative Division
Population	435,791
GeoNames Entry	View entry

Edinburgh ×

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Filter

BY COLLECTION

All

House of Commons Parliamentary Papers (116)

BY DECADE

All

1850s (116)

BY COMMODITY

All

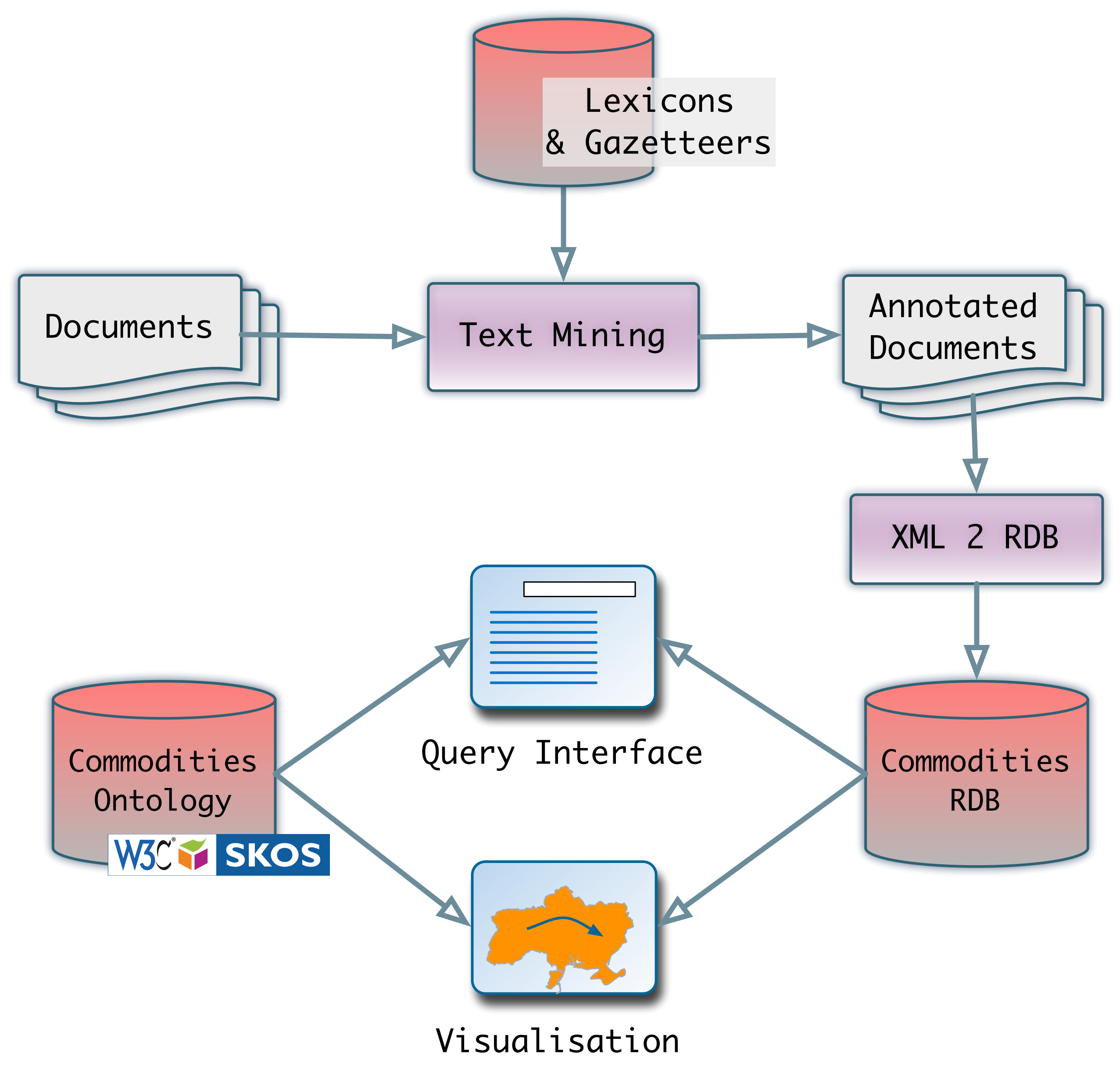
Gold (116)

Documents in which 'Edinburgh' is mentioned in relation to commodities (Page 1 of 1)

Filtered by: Decade (1850) Collection (House of Commons Parliamentary Papers) Commodity (Gold)

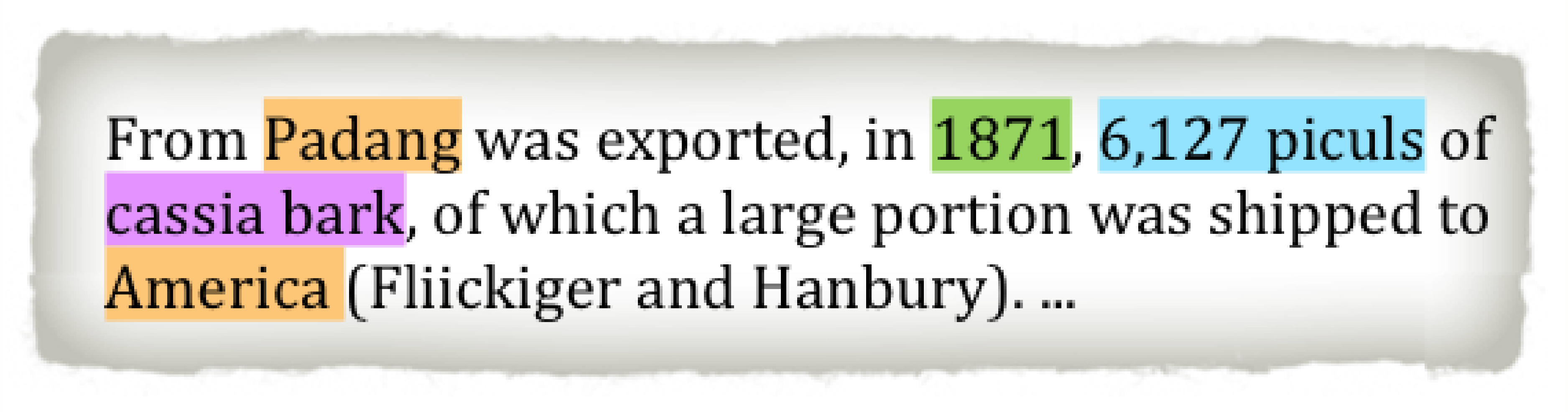
# Mentions	Document Title
90	Report from the Select Committee on the Bank Acts; together with the proceedings of the committee, minutes of evidence, appendix and index.
4	Twenty-ninth report of the Commissioners of Her Majesty's Woods, Forests and Land Revenues: in obedience to the acts of 10 George IV. (cap. 50), and 2 William IV. (cap. 1).
4	Parliamentary Papers. List of the bills, reports, estimates, and accounts and papers, printed by order of the House of Commons, and of the papers presented by command

SYSTEM


Lexicons
& Gazetteers
Documents
Text Mining
Annotated Documents
XML 2 RDB
Query Interface
Commodities Ontology
W3C SKOS
Commodities RDB
Visualisation

MINED INFORMATION

- Example sentence:

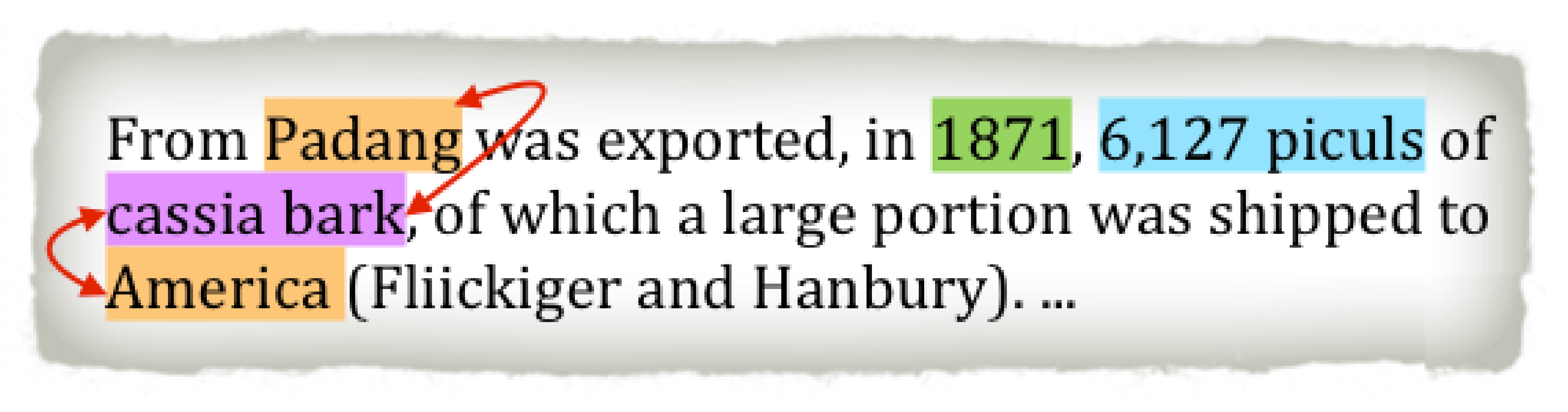


From Padang was exported, in 1871, 6,127 piculs of cassia bark, of which a large portion was shipped to America (Fliickiger and Hanbury). ...

- Normalised and grounded entities:
  - commodity: cassia bark [concept: Cinnamomum cassia]
  - date: 1871 (year=1871)
  - location: Padang (lat=-0.94924;long=100.35427;country=ID)
  - location: America (lat=39.76;long=-98.50;country=n/a)
  - quantity + unit: 6,127 piculs

MINED INFORMATION

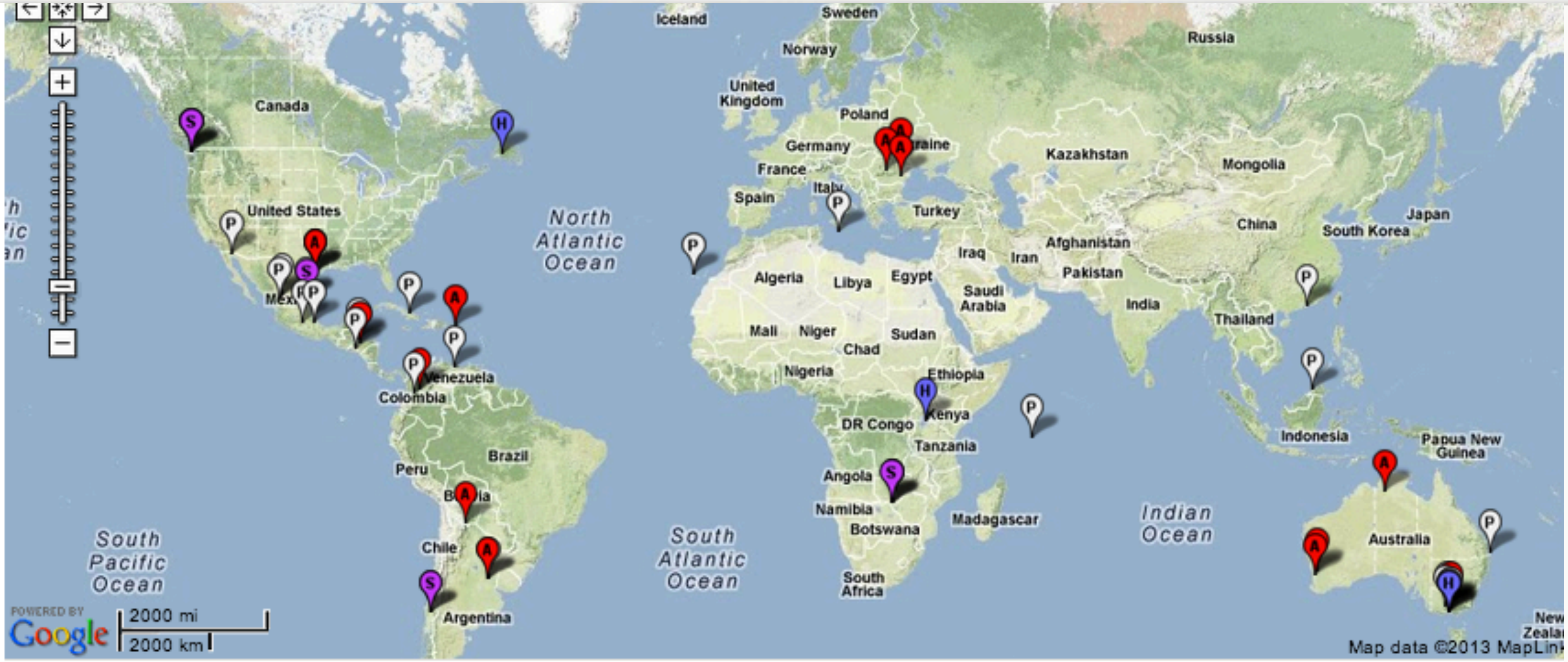
- Example sentence:



From Padang was exported, in 1871, 6,127 piculs of cassia bark, of which a large portion was shipped to America (Fliickiger and Hanbury). ...

- Extracted entity attributes and relations:
  - origin location: Padang
  - destination location: America
  - commodity–date relation: cassia bark – 1871
  - commodity–location relation: cassia bark – Padang
  - commodity–location relation: cassia bark – America

EDINBURGH GEOPARSER



only 50 objects displayed, zoom in or deselect some features

	Name	country	feature	km to center
1 P	Ciudad Victoria	Mexico	seat of a first-order administrative division	11435.01 km
2 P	Victoria	Seychelles	capital of a political entity	5126.1 km
3 P	Victoria	Canada	seat of a first-order administrative division	11180.98 km
4 A	State of Victoria	Australia	first-order administrative division	14782.65 km
5 P	Hong Kong	Hong Kong	capital of a political entity	9688.28 km
6 P	Victoria	Malaysia	seat of a first-order administrative division	10558.79 km
7 P	Durango	Mexico	seat of a first-order administrative division	11882.99 km
8 P	Victoria	Malta	seat of a first-order administrative division	1494.57 km
9 A	Victoria	Honduras	second-order administrative division	10832.96 km
10 P	Victoria	United States	seat of a second-order administrative division	10954.12 km

Scotland’s National Collections and the Digital Humanities, Edinburgh, 14/02/2014

CONCLUSION

- Importance of two-way collaboration between technology and humanities expert in digital HSS projects.
- Value of iterative development and rapid prototyping.
- Geo-referencing text is very important for historical analysis.
- Most OCR errors are noise in big data but HSS scholars need to be made more aware of OCR errors affecting their search results for historical collections.