Texts, Treebanks, Networks descriptions and analysis of languages

XINYING CHEN

University of Ostrava, Nov. 8, 2017

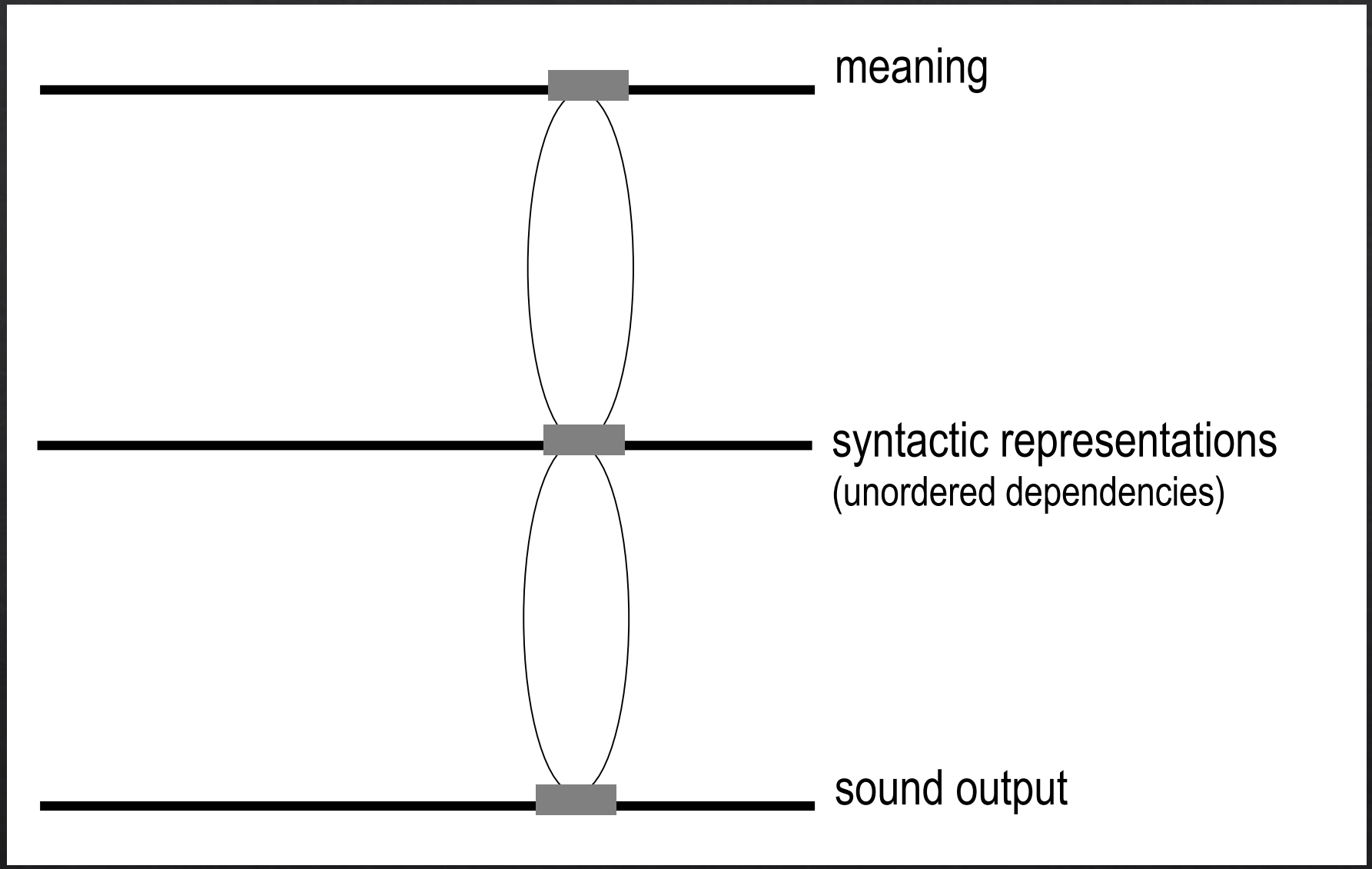
Outline

- Why different language descriptions and analysis
- Texts
- Treebanks
- Networks
- Questions & comments

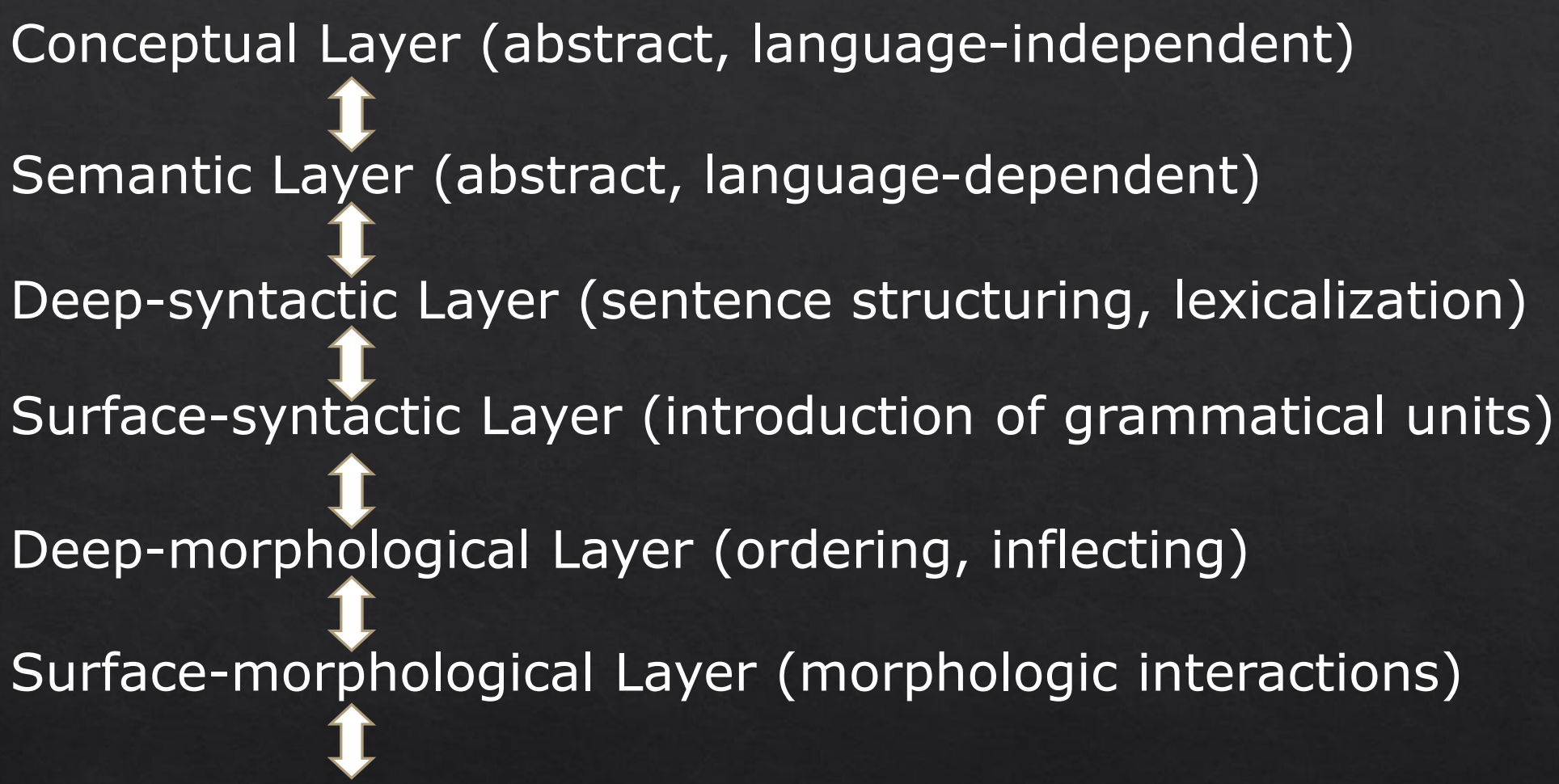
Outline

- Why different language descriptions and analysis

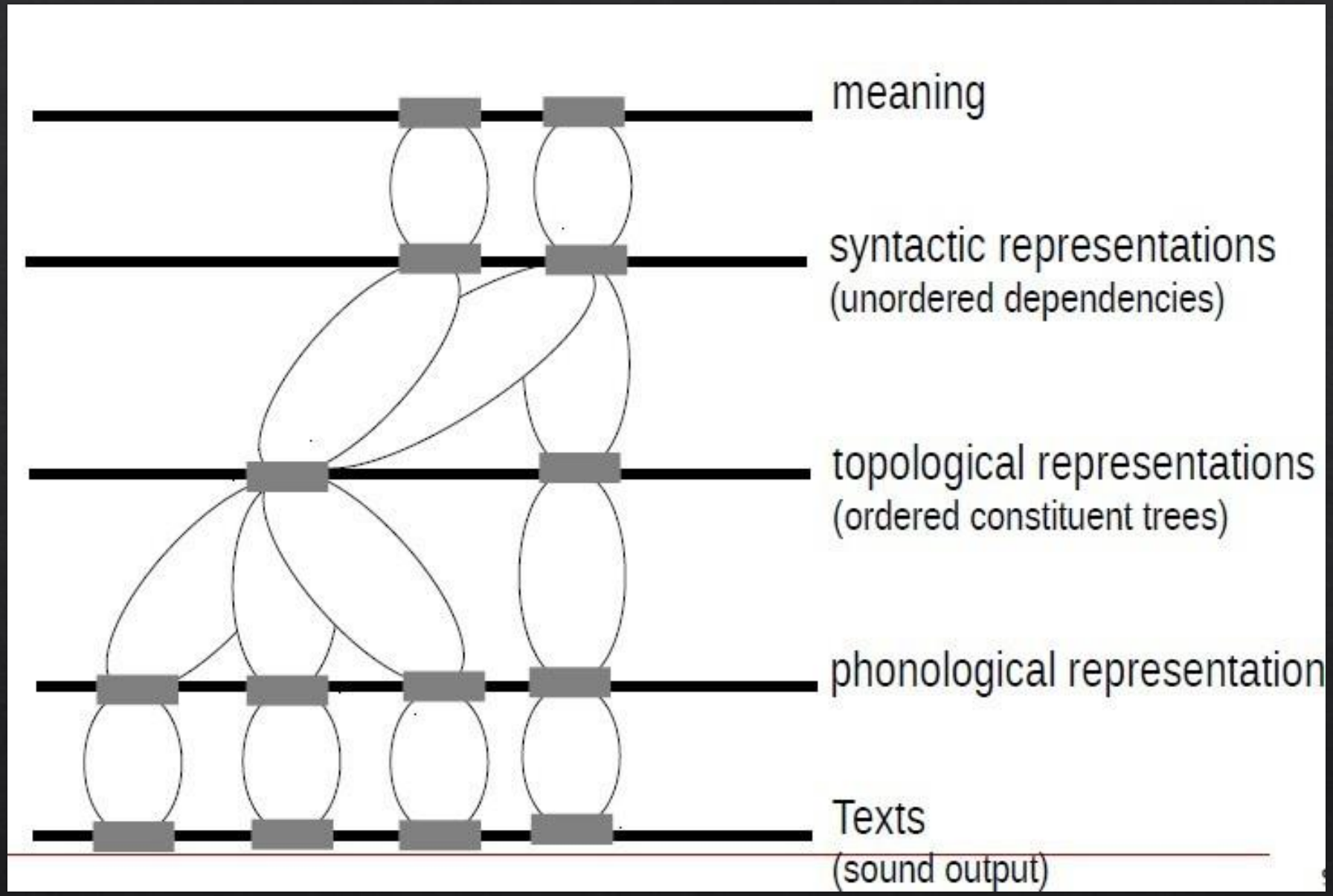
language is a system of signs, each of which is an arbitrary union of sound and meaning… Any given sign, is defined by its relationships with the others. (Saussure 1959)



Saussure’s signified and signifier (2011)
Mel’čuk’s meaning and text (1981)
Chomsky’s logical and phonetic structure (2002)


Conceptual Layer (abstract, language-independent)
Semantic Layer (abstract, language-dependent)
Deep-syntactic Layer (sentence structuring, lexicalization)
Surface-syntactic Layer (introduction of grammatical units)
Deep-morphological Layer (ordering, inflecting)
Surface-morphological Layer (morphologic interactions)
Text (full-fledged sentences)

Mel’čuk 1986



surface-deep hierarchy Mel’čuk 1986

Language understanding and generation require deconstructions or constructions of units on different language layers. Different language descriptions, therefore, yield to this nature of language communications.

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- Why different language descriptions and analysis
- Texts

Texts

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  - word, token, type, lemma, phrase, ngram, sentence, paragraph…
  - word length, frequency, size…
  - genre, style, authorship…

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  - More available (OCR, Google books…)
  - Easier to test hypothesis (Zip’f law…)

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- Disadvantages
  - One dimensional description (linear modals)
  - Missing details of language understanding or generation

Structural Complexity of Chinese Characters and Zipf’s Law

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- Hypothesis
  - The relationship between the frequency of Chinese characters and structural complexity of characters should be in accordance with Zipf's law due to the principle of least effort

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  - Chinese Characters' Frequency Dictionary
    - the most frequent 3,061 different Chinese characters and their frequency in People's Daily, a famous newspaper in China, Corpus. (99.43%)

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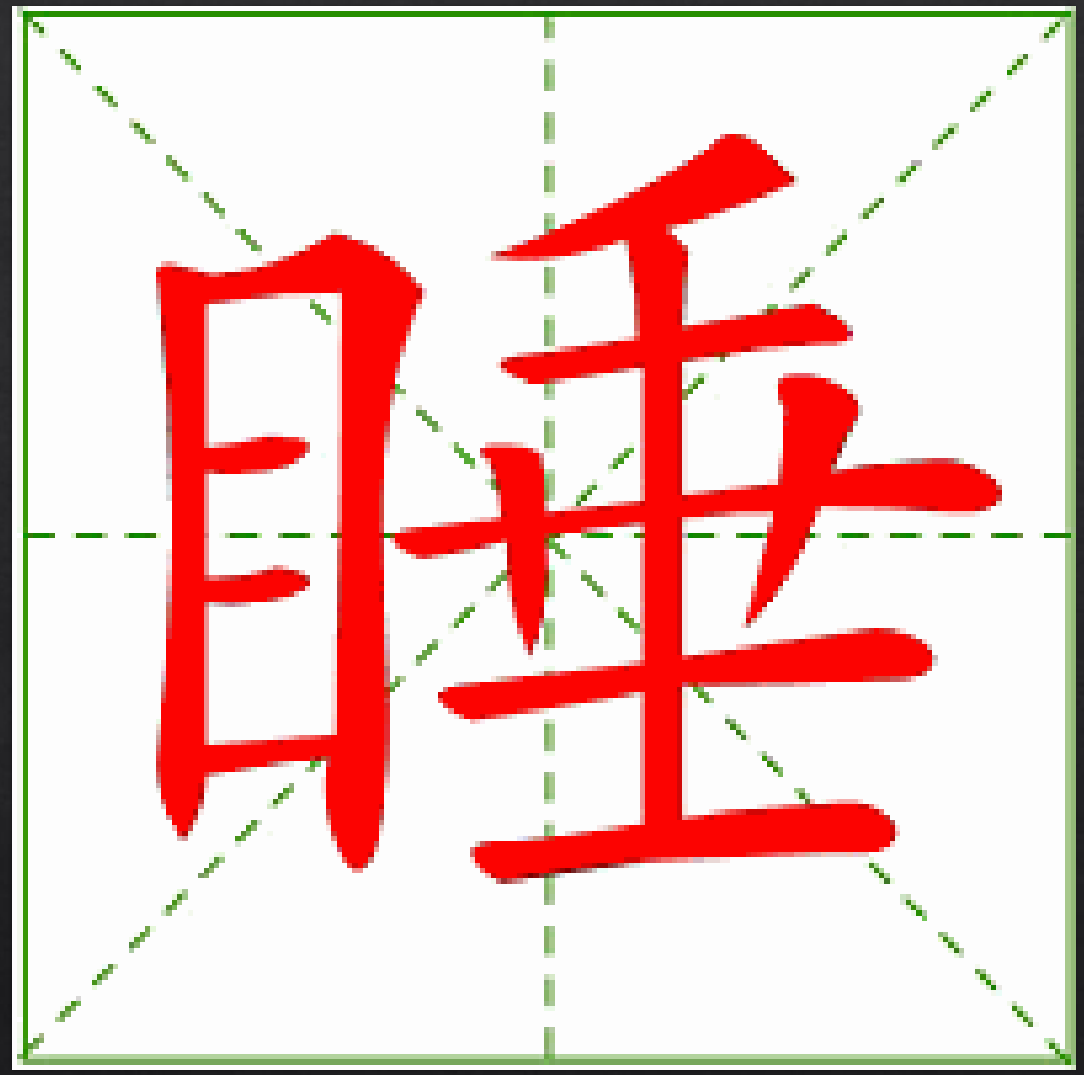
- Structural Complexity
  - Number of strokes
  - Number of components
    - Both counted based on dictionaries and issued formal documents.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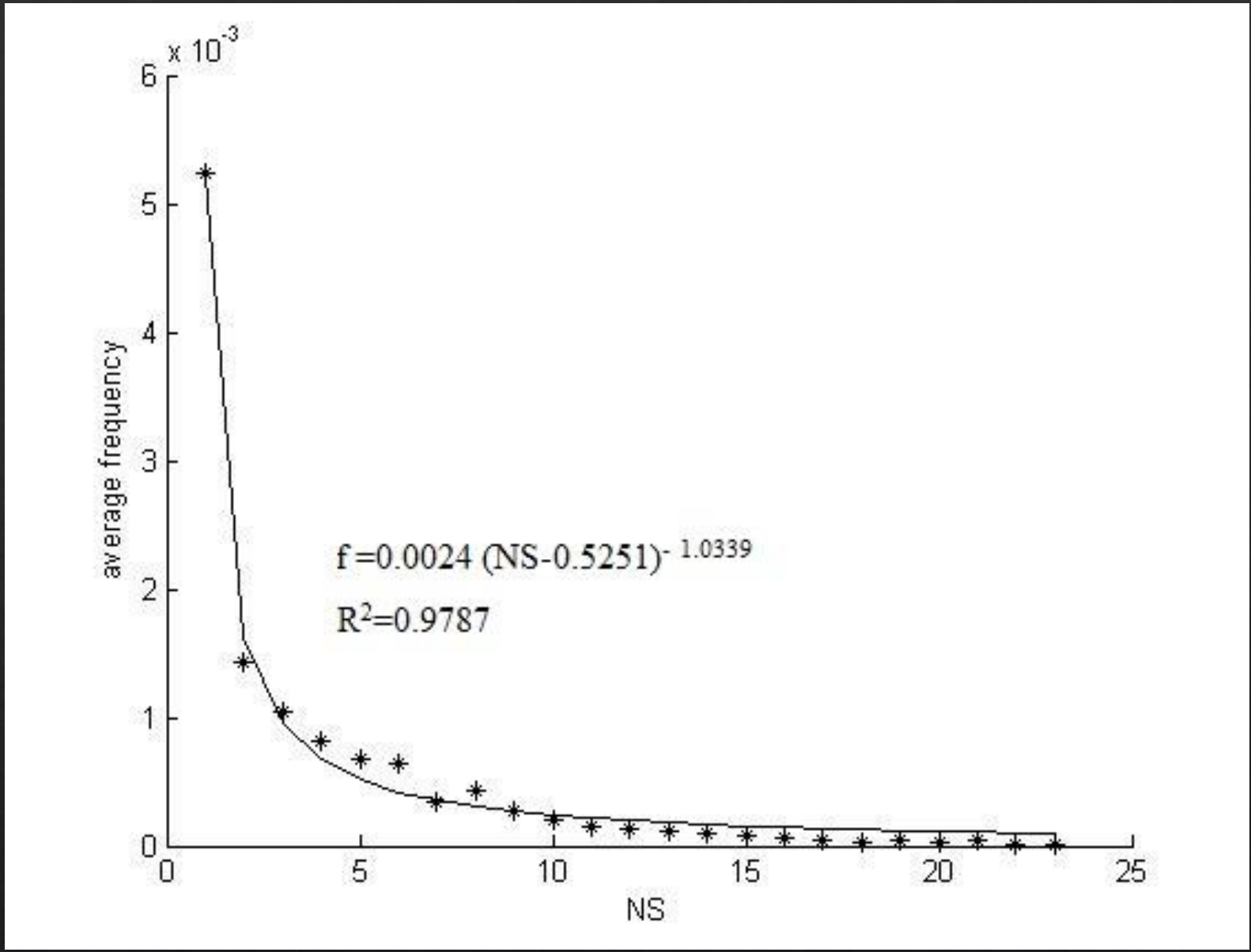
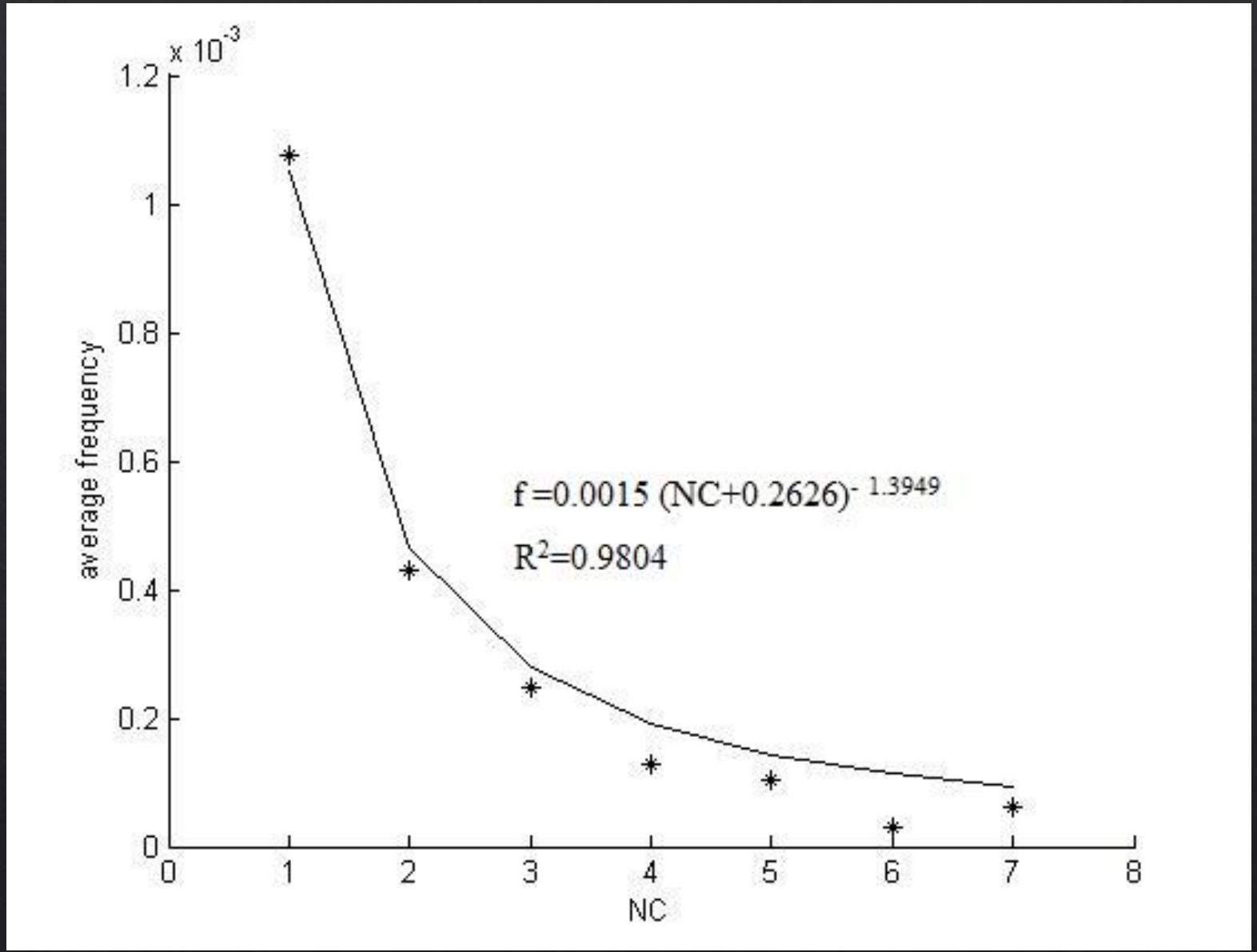
Number of Stroks	Number of Chracters	Examples	Cumulative frequency	Average frequency
1	2	一,乙	0.0104818889	0.0052409444
2	19	人,了,力	0.0270823814	0.0014253885
3	51	大,上,工	0.0535283278	0.0010495751
4	113	中,不,为	0.0924586324	0.0008182180
5	145	发,业,民	0.0989700908	0.0006825524
6	237	在,有,年	0.1514154083	0.0006388836
7	307	作,这,来	0.1035224004	0.0003372065
8	379	的,国,和	0.1611448260	0.0004251842
9	368	是,要,政	0.1006057580	0.0002733852
10	343	家,部,展	0.0675444718	0.0001969227
11	290	理,得,基	0.0437326729	0.0001508023
12	276	就,等,提	0.0366750136	0.0001328805
13	177	新,意,解	0.0215748566	0.0001218918
14	124	道,管,赛	0.0111661176	0.0000900493
15	100	题,增,德	0.0084463093	0.0000844631
16	55	整, 融,器	0.0033965338	0.0000617552
17	33	藏,繁,疑	0.0012677566	0.0000384169
18	11	翻,覆,藤	0.0002244518	0.0000204047
19	13	警,疆,攀	0.0005720697	0.0000440054
20	11	籍,灌,耀	0.0002580577	0.0000234598
21	4	露,霸,髓	0.0001694056	0.0000423514
22	2	囊,镶	0.0000231615	0.0000115808
23	1	罐	0.0000151569	0.0000151569



The relationship between NS and the average frequency of Chinese characters that share the same NS

Number of Components	Number of Characters	Examples	Cumulative frequency	Average frequency
1	187	一,中,人	0.2008274347	0.0010739435
2	969	的,国,和	0.4164280467	0.0004297503
3	1186	在,是,发	0.2922298614	0.0002463995
4	534	高,能,说	0.0682191084	0.0001277511
5	150	题,领,解	0.0153812537	0.0001025417
6	32	歌,疑,衡	0.0010030980	0.0000313468
7	3	疆,凝,颤	0.0001869466	0.0000623155



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Diachronic observation of Chinese Words Based on Google Ngram

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- Observation
  - the lexicon changes of a language during a time period
- Hypothesis verification
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- The Chinese Google 1-gram data (segmented-words frequency)
  - Symbols, Japanese, Roman letters, Arabic numerals
  - 1710 ~ 2009 (300 years)
    - × Before 1710 (sparse, segmentation accuracy)
    - 6 * 50 (years)
    - 1710~59, 1760~1809, 1810~59, 1869~1909, 1910~59, and 1960~2009

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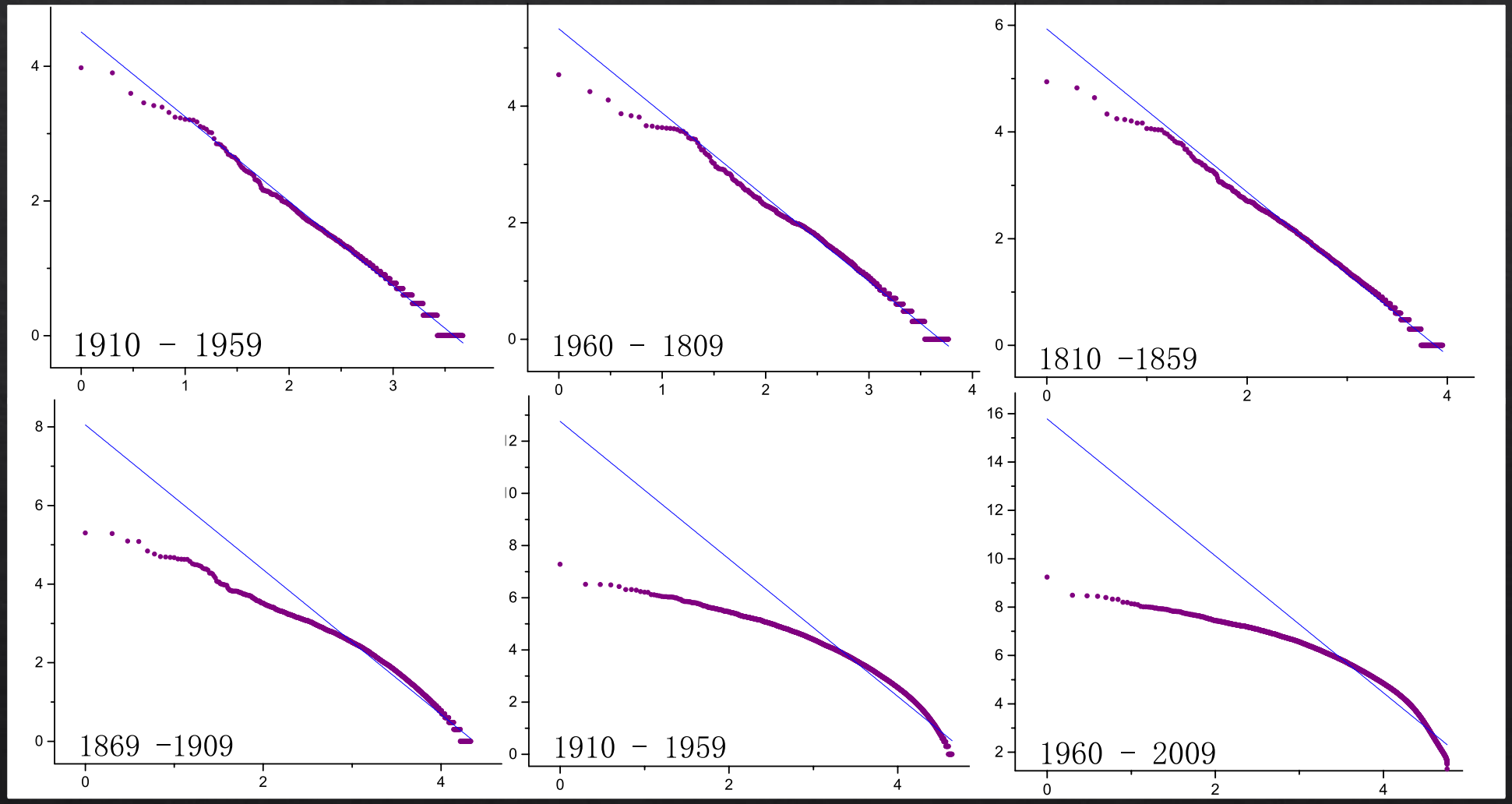
- Power law fitting

Power Law Fitting



Power Law Fitting: $y = a*x^{-b}$

Time Period	a	b	R^2
1760-1809	34,791	-0.98122	0.98755
1810-1859	96,530	-0.94701	0.96039
1860-1909	249,946	-0.82656	0.92599
1910-1959	16,579,000	-1.09064	0.91207
1960-2009	1,512,270,000	-1.05617	0.90595

- all the six frequency lists fit the Power Law well (the minimum R2 is 0.90595) despite the huge data scale (the largest list includes more than 21 billion tokens)
- The Google Ngram data should be suitable for doing some linguistic studies

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- Average word length

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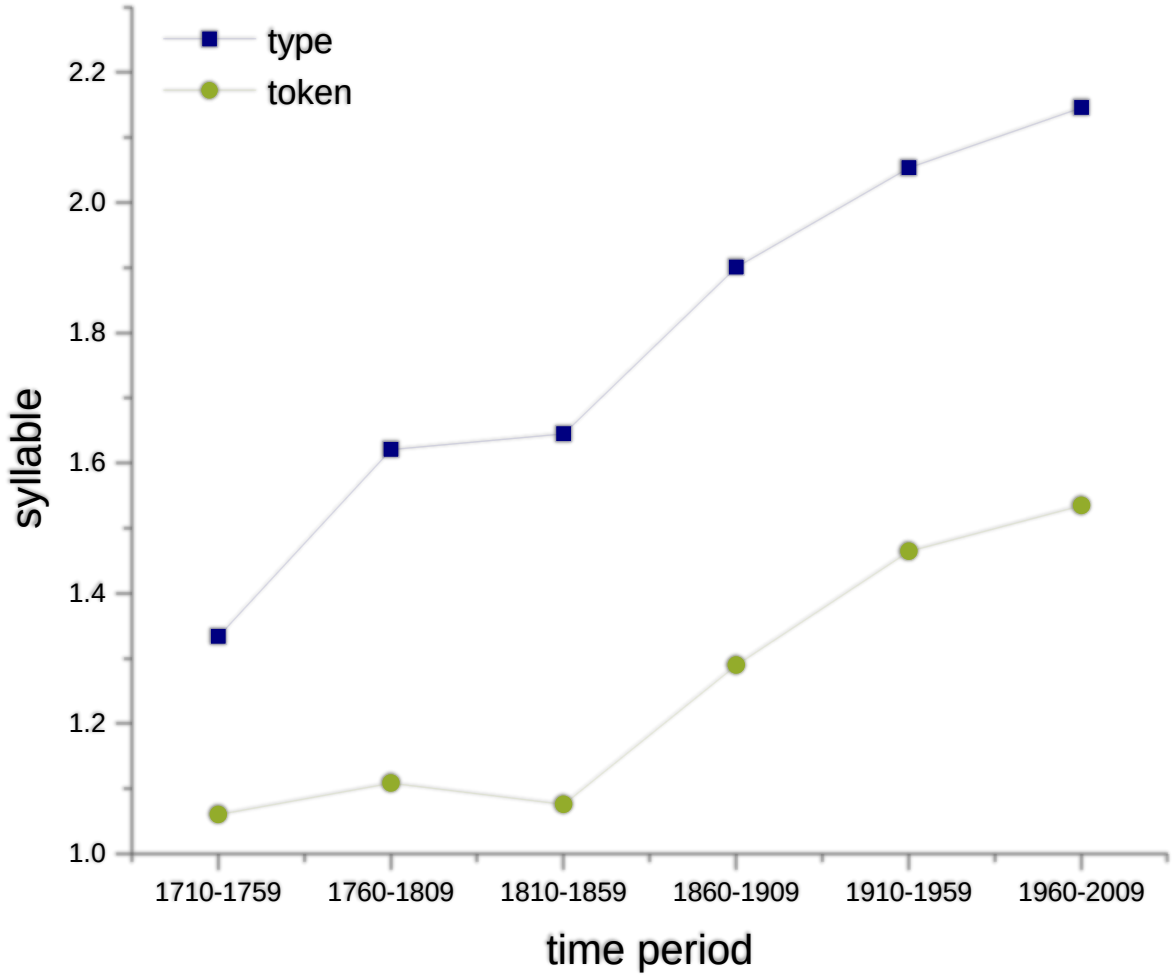
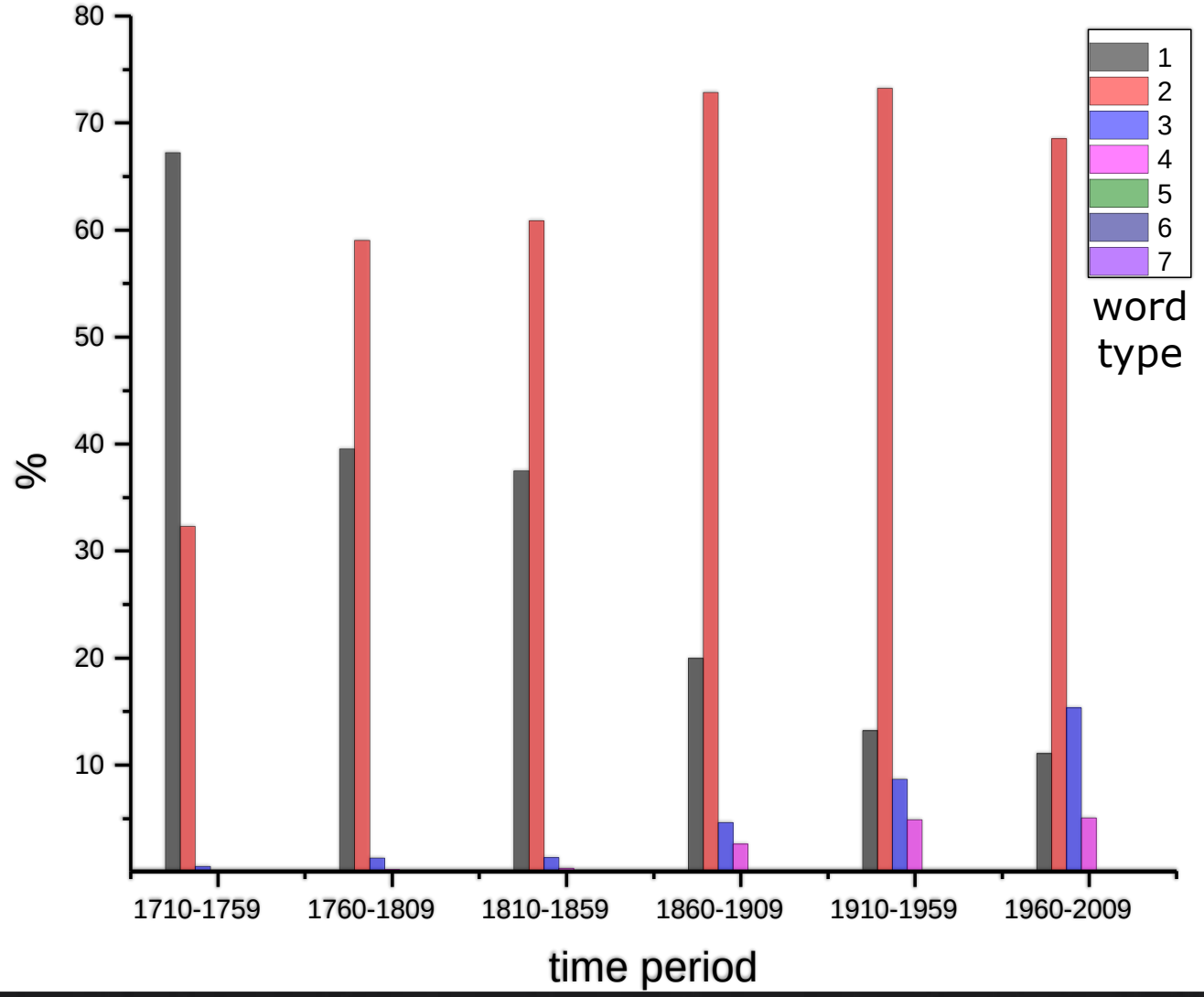


Word length distribution



Outline

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- Texts
- Treebanks

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  - Grammar, syntax, semantics…
  - Predicator, agent, patient, subject, object, modifier, valence…
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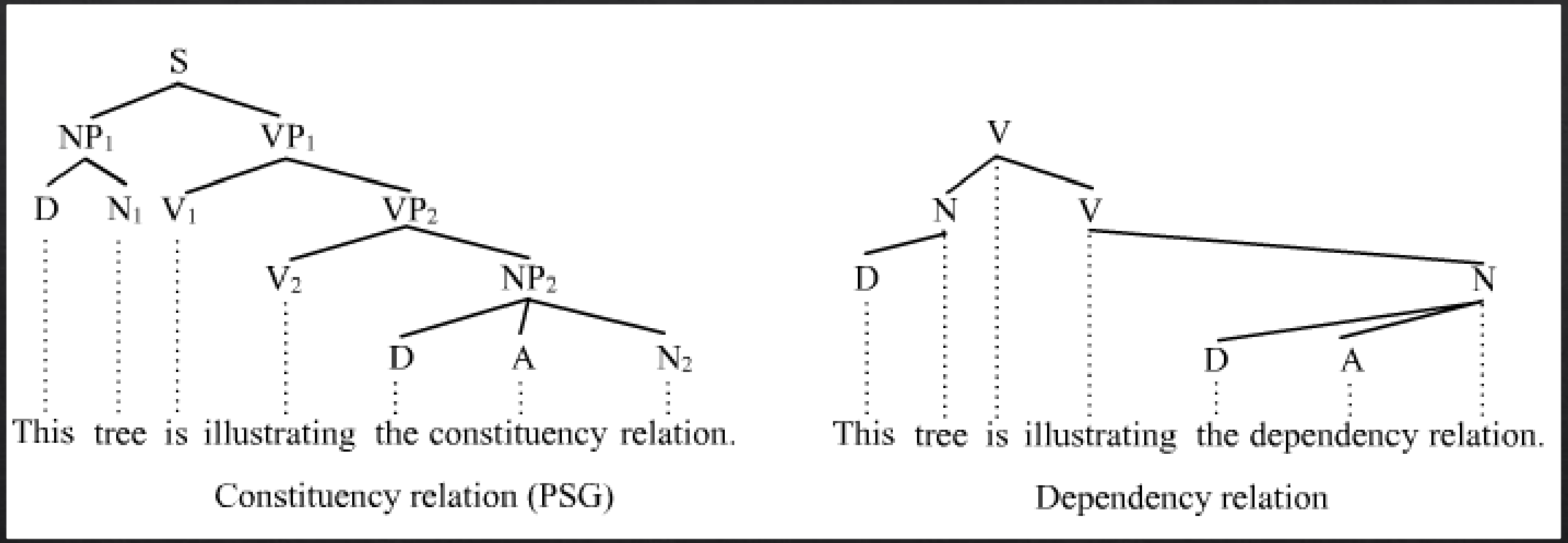
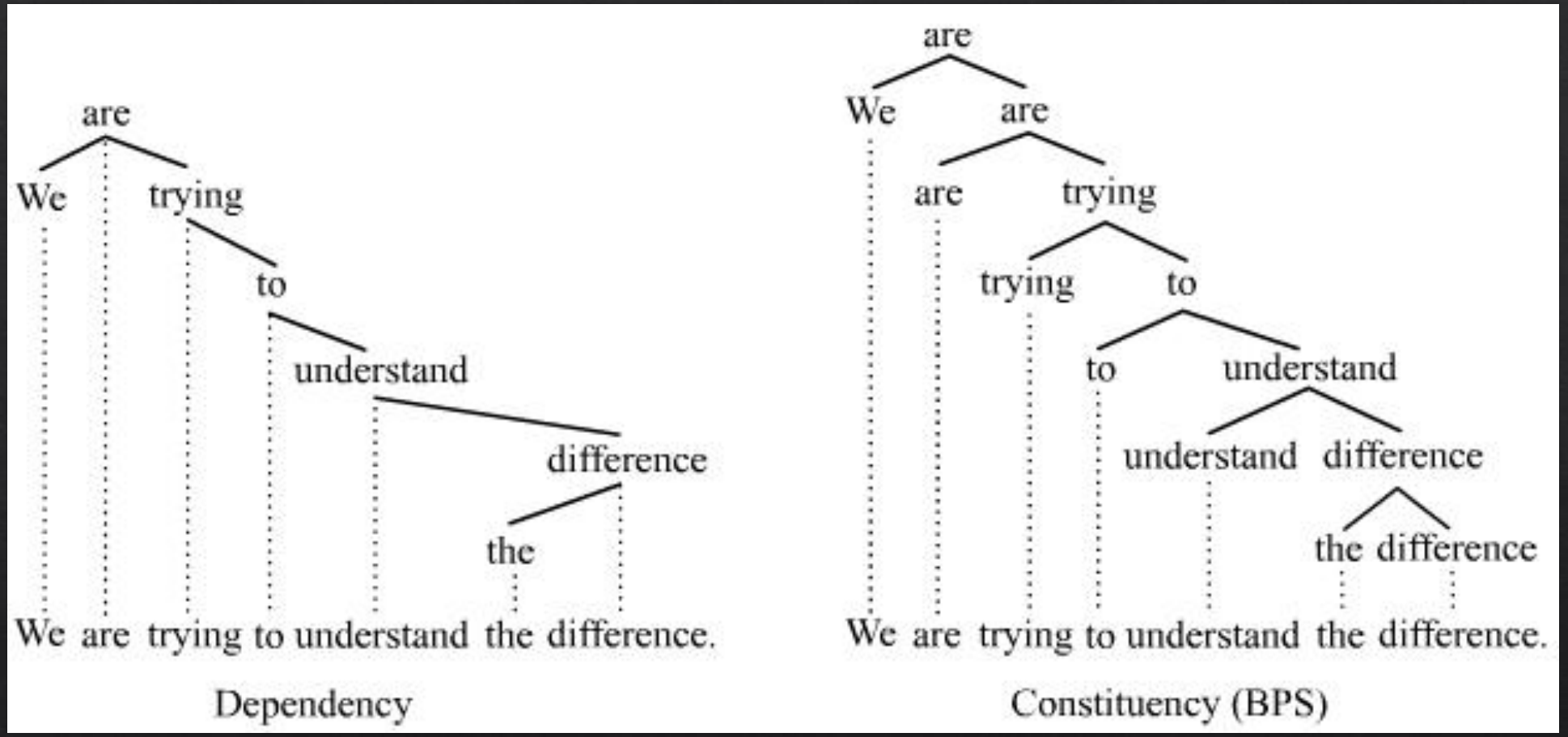
- What is treebank

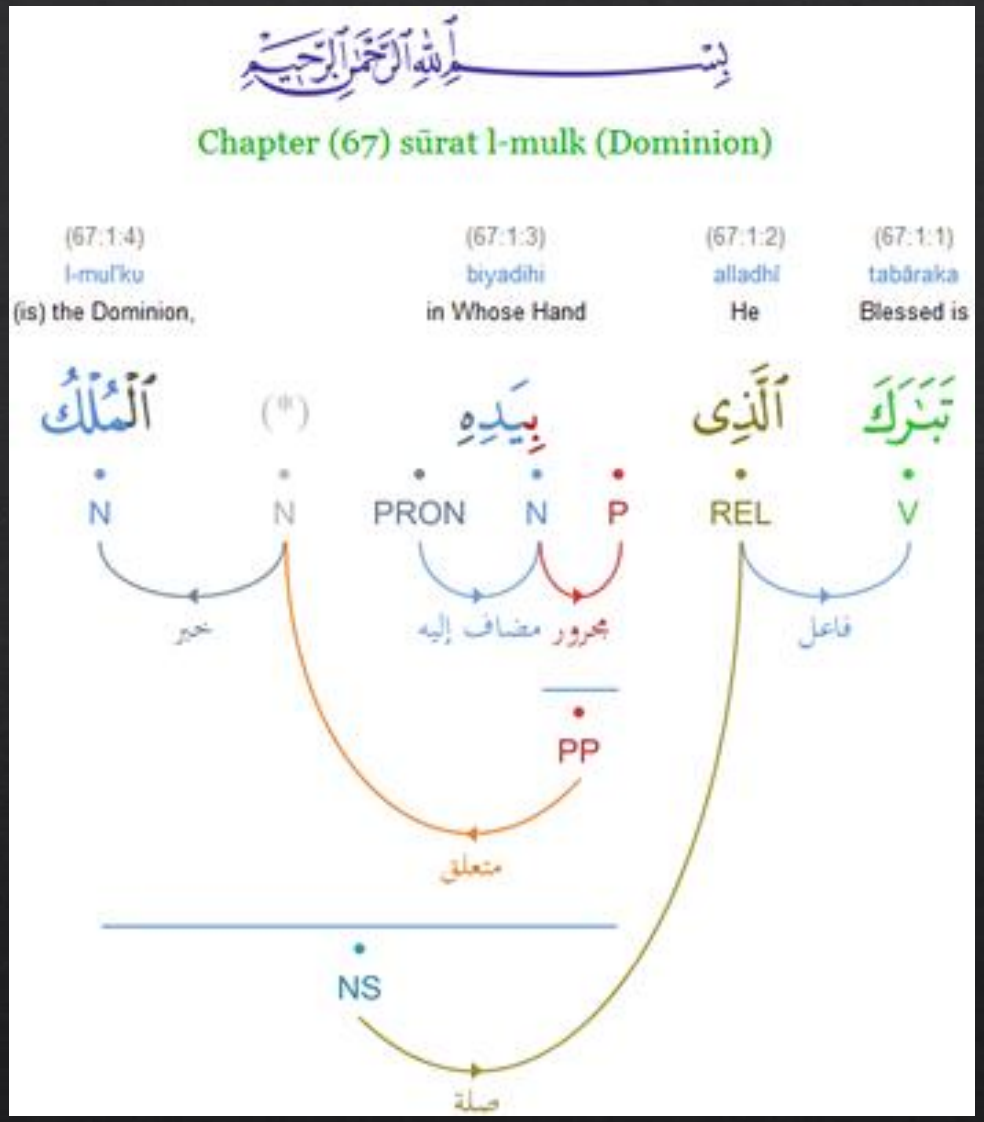


http://en.wikipedia.org/wiki/Phrase_structure_grammar



http://en.wikipedia.org/wiki/Dependency_grammar

Hybrid constituency/dependency tree from the Quranic Arabic Corpus



http://en.wikipedia.org/wiki/Treebank

```
1    Pricing        pricing        NN    _    2    NMOD
2    details        detail         NNS   _    3    SBJ
3    were           be             VBD   _    0    ROOT
4    n't            not            RB    _    3    ADV
5    immediately    immediately    RB    _    6    AMOD
6    available      available      JJ    _    3    PRD
7    .              .              .     _    3    P

1    She            she            PRP   _    2    SBJ
2    bought         buy            VBD   _    0    ROOT
3    a              a              DT    _    4    NMOD
4    car            car            NN    _    2    OBJ
5    .              .              .     _    2    P
```

CoNLL-X

Other format (xml)

```
<?xml-stylesheet type="text/xsl" href="nlp_style.xsl" ?>↓
<xml4nlp>↓
    <doc>↓
        <para id="0">↓
            <sent id="0" cont="迈向充满希望的新世纪——一九九八年新年讲话（附图
片1张）">↓
                <word id="0" cont="迈向" pos="v" parent="-1" relate="HED" />↓
                <word id="1" cont="充满" pos="v" parent="3" relate="DE" />↓
                <word id="2" cont="希望" pos="n" parent="1" relate="VOB" />↓
                <word id="3" cont="的" pos="u" parent="5" relate="ATT" />↓
                <word id="4" cont="新" pos="a" parent="5" relate="ATT" />↓
                <word id="5" cont="世纪" pos="n" parent="0" relate="VOB" />↓
                <word id="6" cont="——" pos="wp" parent="-2" relate="PUN" />↓
                <word id="7" cont="一九九八年" pos="nt" parent="8" relate="ATT"
```

https://code.google.com/p/clearparser/wiki/DataFormat

Classifying Languages by Dependency Structure

Typologies of Delexicalized Universal Dependency Treebanks

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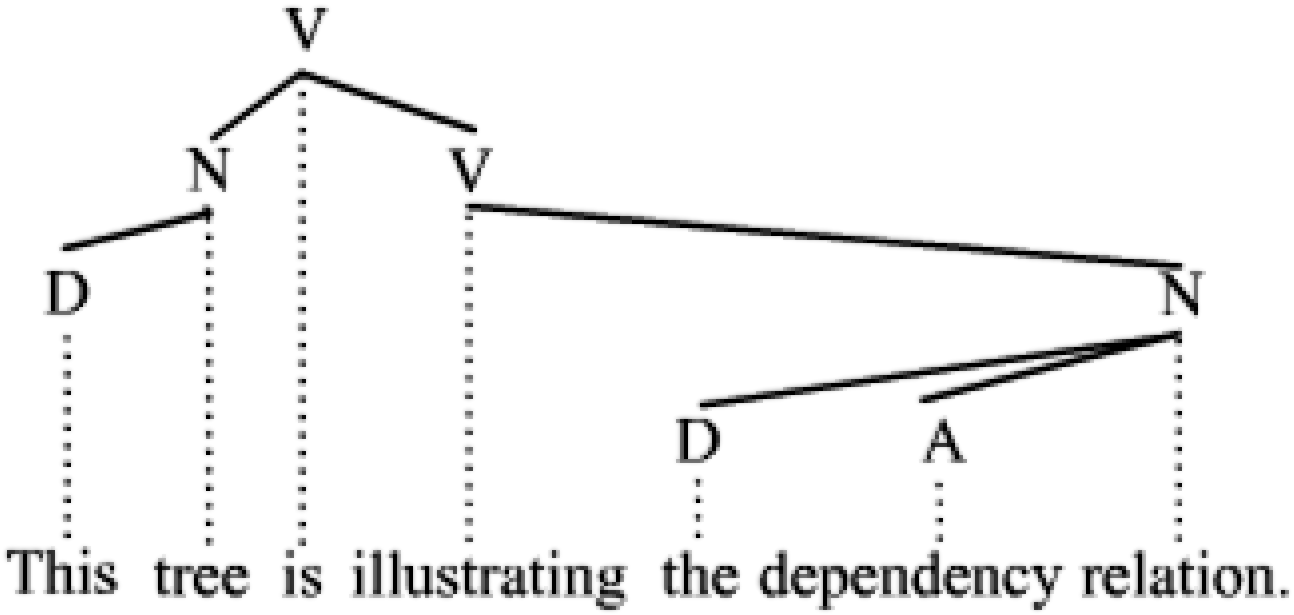
- Distributions of frequencies
- Clustering algorithm

Dependency Length



DL(this-is)=3-1=2

DL(is-illustrating)=3-4=-1

Dependency Length

$$DDD(R) = \frac{\sum_{r \in R} distance(r)}{frequency(R)}$$

R: type of dependencies r: dependencies

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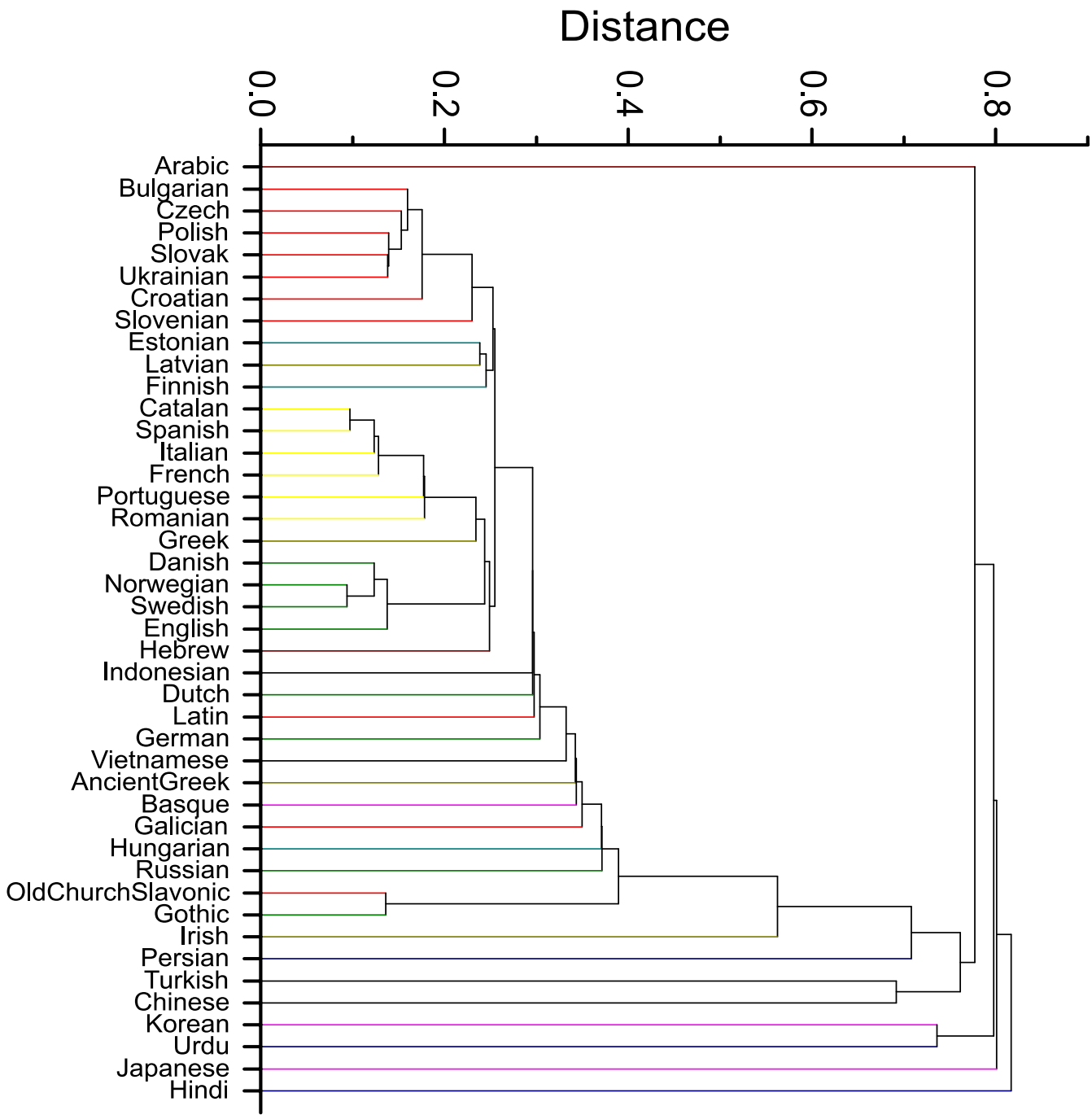
Distance
0.0
0.2
0.4
0.6
0.8
Arabic
Bulgarian
Czech
Polish
Slovak
Ukrainian
Croatian
Slovenian
Estonian
Latvian
Finnish
Catalan
Spanish
Italian
French
Portuguese
Romanian
Greek
Danish
Norwegian
Swedish
English
Hebrew
Indonesian
Dutch
Latin
German
Vietnamese
AncientGreek
Basque
Galician
Hungarian
Russian
OldChurchSlavonic
Gothic
Irish
Persian
Turkish
Chinese
Korean
Urdu
Japanese
Hindi

0.8
0.6
0.4
0.2
0.0
ar
bg
cs
cs_cac
pl
sk
uk
hr
ru
cs_cltt
sl
ca
es_ancora
es
fr
fr_partut
it_partut
it
pt
fr_sequoia
gl_treegal
ro
el
da
no_bokmaal
no_nynorsk
sv
sv_lines
en_lines
en
en_partut
he
et
fi
lv
pt_br
de
nl
id
la_itt
vi
eu
hu
grc
la
gl
cu
got
la_proiel
grc_proiel
fi_ftb
ru_syntagrus
sl_sst
ga
ar_nyuad
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Origin and development

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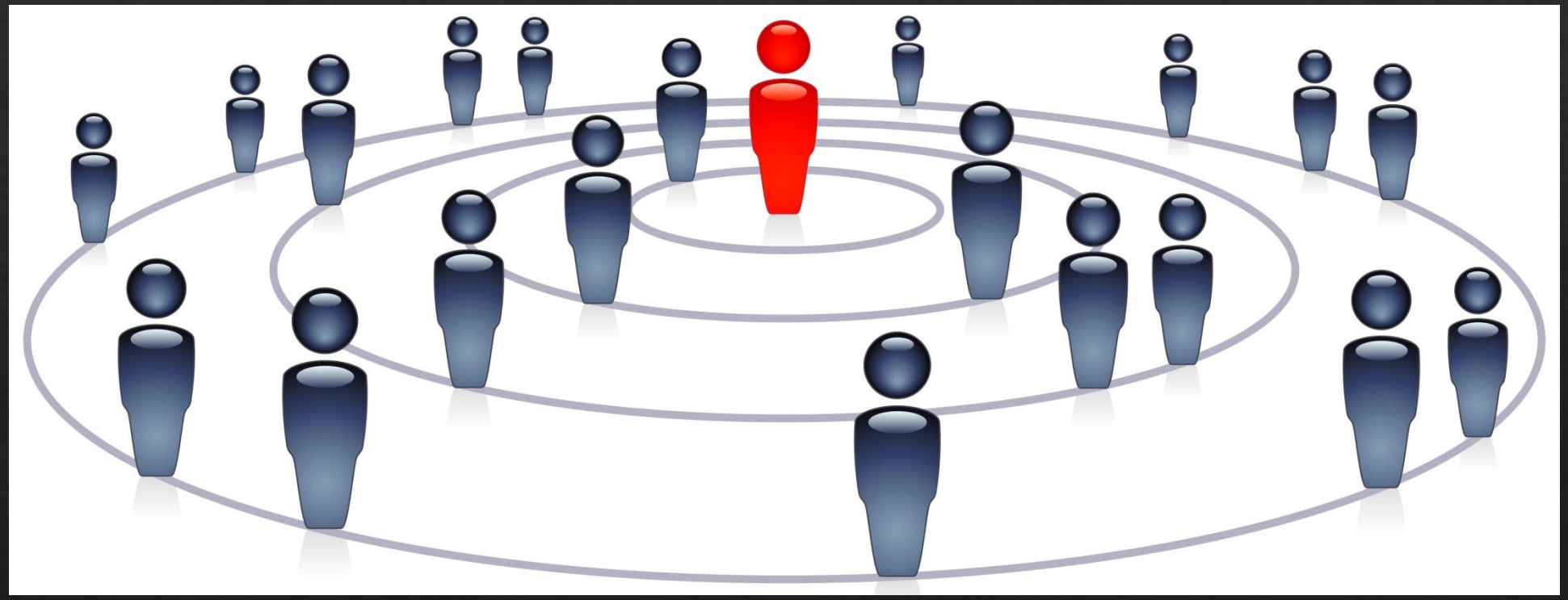
- Six Degrees of Separation



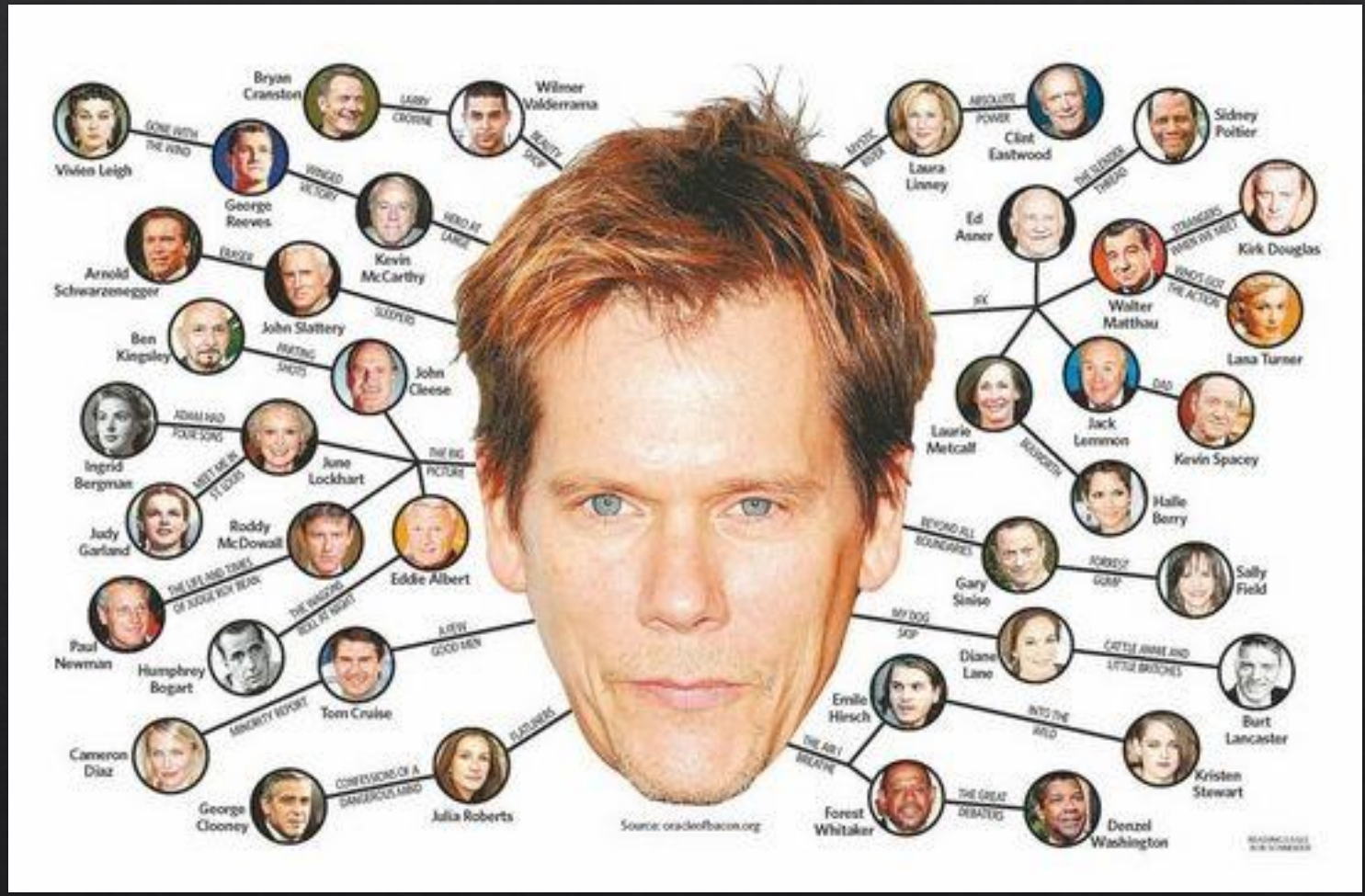
http://indianvox.com/articles/news/143667.php

Origin and development

- Six Degrees of Separation
  - Harvard psychologist Stanley Milgram 1967
    - U.S. / 300 letters / >60 / 6

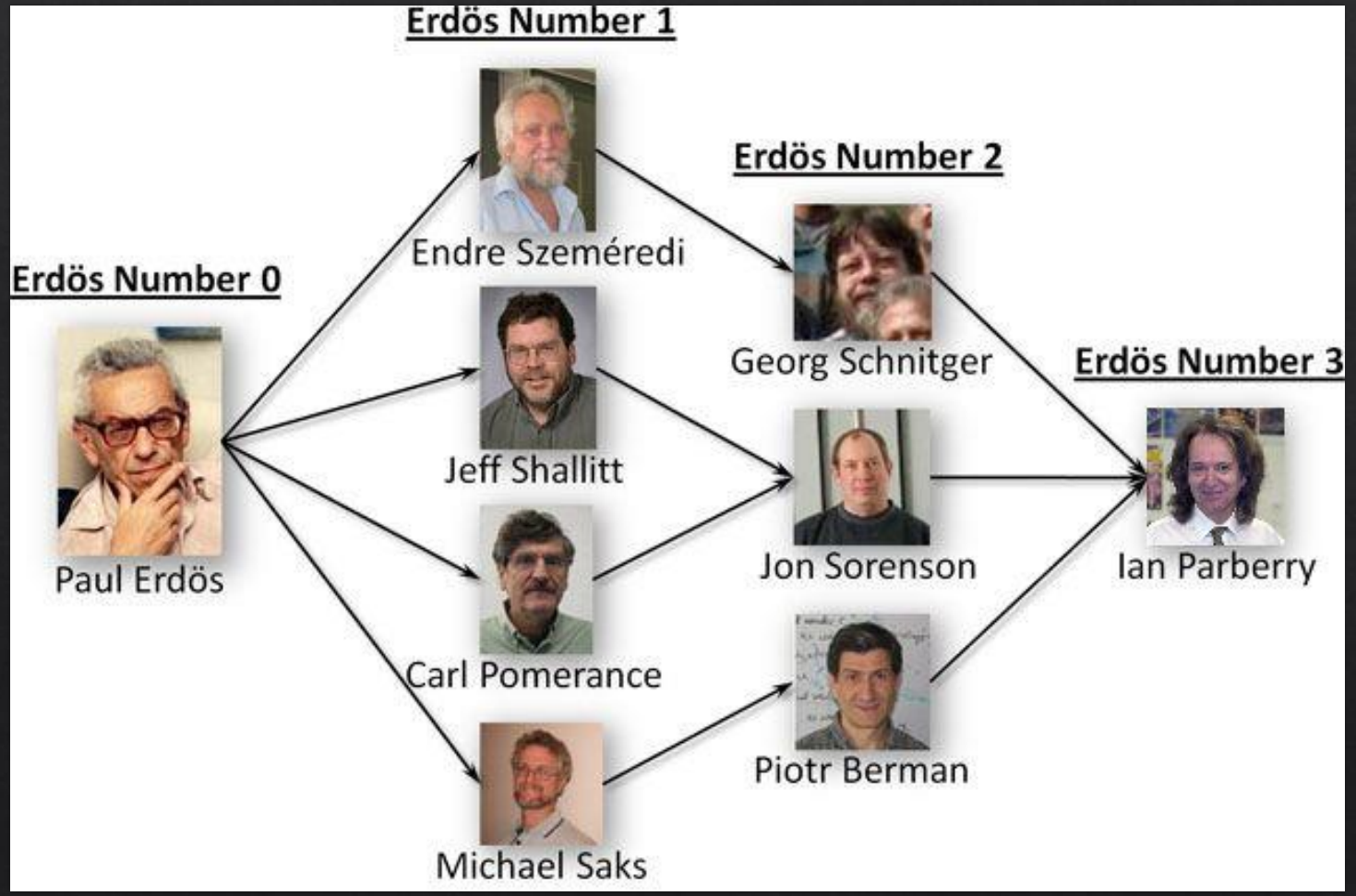
https://en.wikipedia.org/wiki/Six_degrees_of_separation

Bacon number



http://badegreedraza.blogspot.jp/2015/04/6-degrees-of-kevin-bacon.html

Erdős number



https://larc.unt.edu/ian/claimtofame.html

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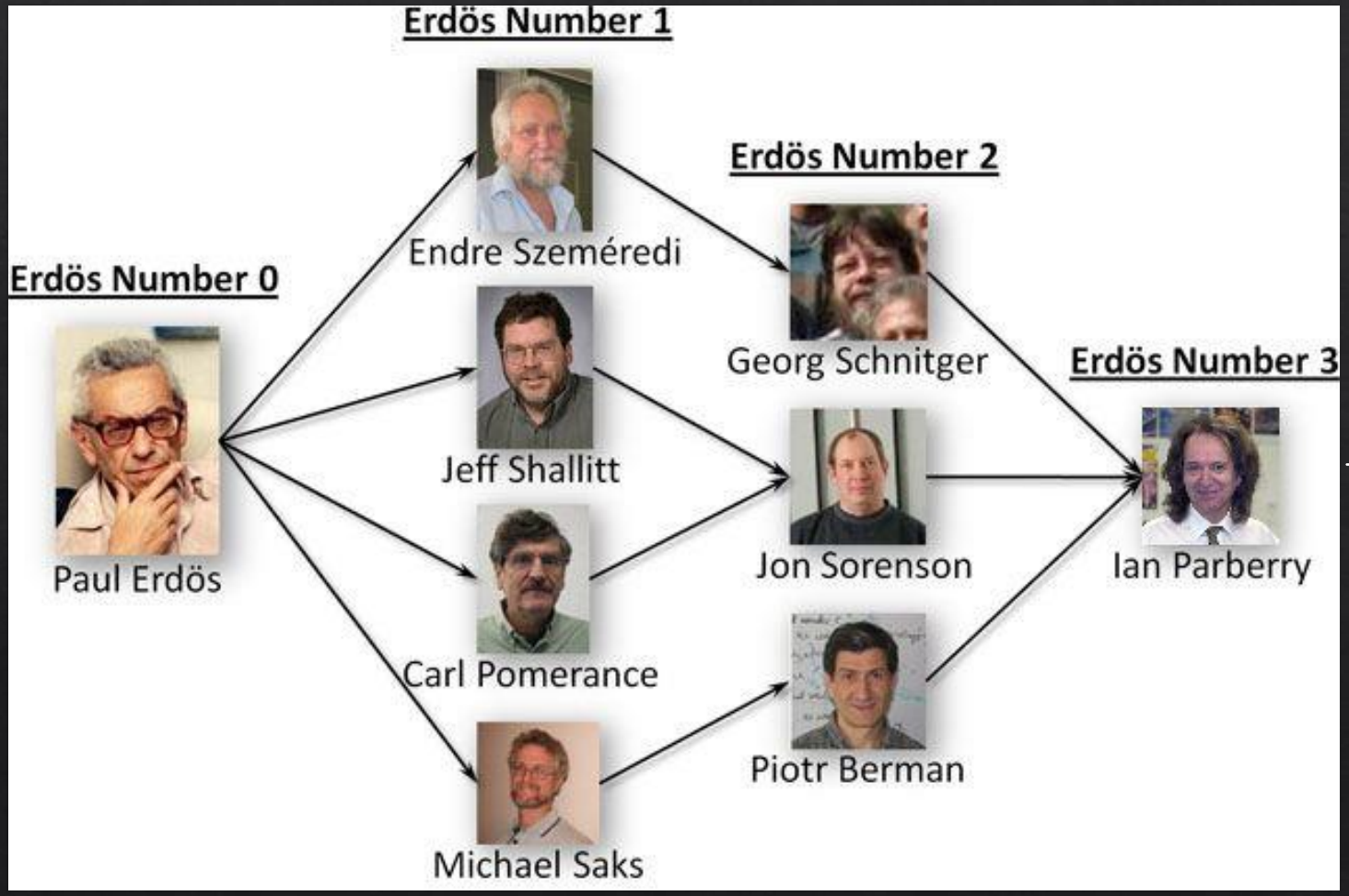

Erdős number 4

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  - Columbia professor Duncan Watts 2001
    - 19 email targets (157 countries) / 48,000 senders / 6
  - Microsoft researchers Jure Leskovec and Eric Horvitz 2007
    - 30 billion Skype messages / 240 million people / 6

https://en.wikipedia.org/wiki/Six_degrees_of_separation

Origin and development

- Six Degrees of Separation
- Big Data Area & Quantitative Method
  - UCINET (Borgatti et al. 2002)
  - PAJEK (Nooy et al. 2005)
  - NETDRAW (Borgatti 2002)
  - CYTOSCAPE (Shannon 2003)
  - …

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- Complex System

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    - Brain network, Nation network, Social network, Traffic network, Epidemic network…

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Origin and development (Language)

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  - Ramon Ferrer i Cancho & Ricard Solé

Origin and development (Language)

- Language is an ‘organic’ complex system
  - Ramon Ferrer i Cancho & Ricard Solé
- Different language networks
  - Syntactic dependency networks, language development or language evolution, language clustering and linguistic categorization, manual and machine translation, word sense disambiguation, communication and interaction, semantic networks, phonetics, morphology, parts of speech, knowledge networks, cognitive networks …

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1	Pricing	pricing	NN	_	2	NMOD
2	details	detail	NNS	_	3	SBJ
3	were	be	VBD	_	0	ROOT
4	n't	not	RB	_	3	ADV
5	immediately	immediately	RB	_	6	AMOD
6	available	available	JJ	_	3	PRD
7	.	.	.	_	3	P

1	She	she	PRP	_	2	SBJ
2	bought	buy	VBD	_	0	ROOT
3	a	a	DT	_	4	NMOD
4	car	car	NN	_	2	OBJ
5	.	.	.	_	2	P

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whole ≠ sum of parts

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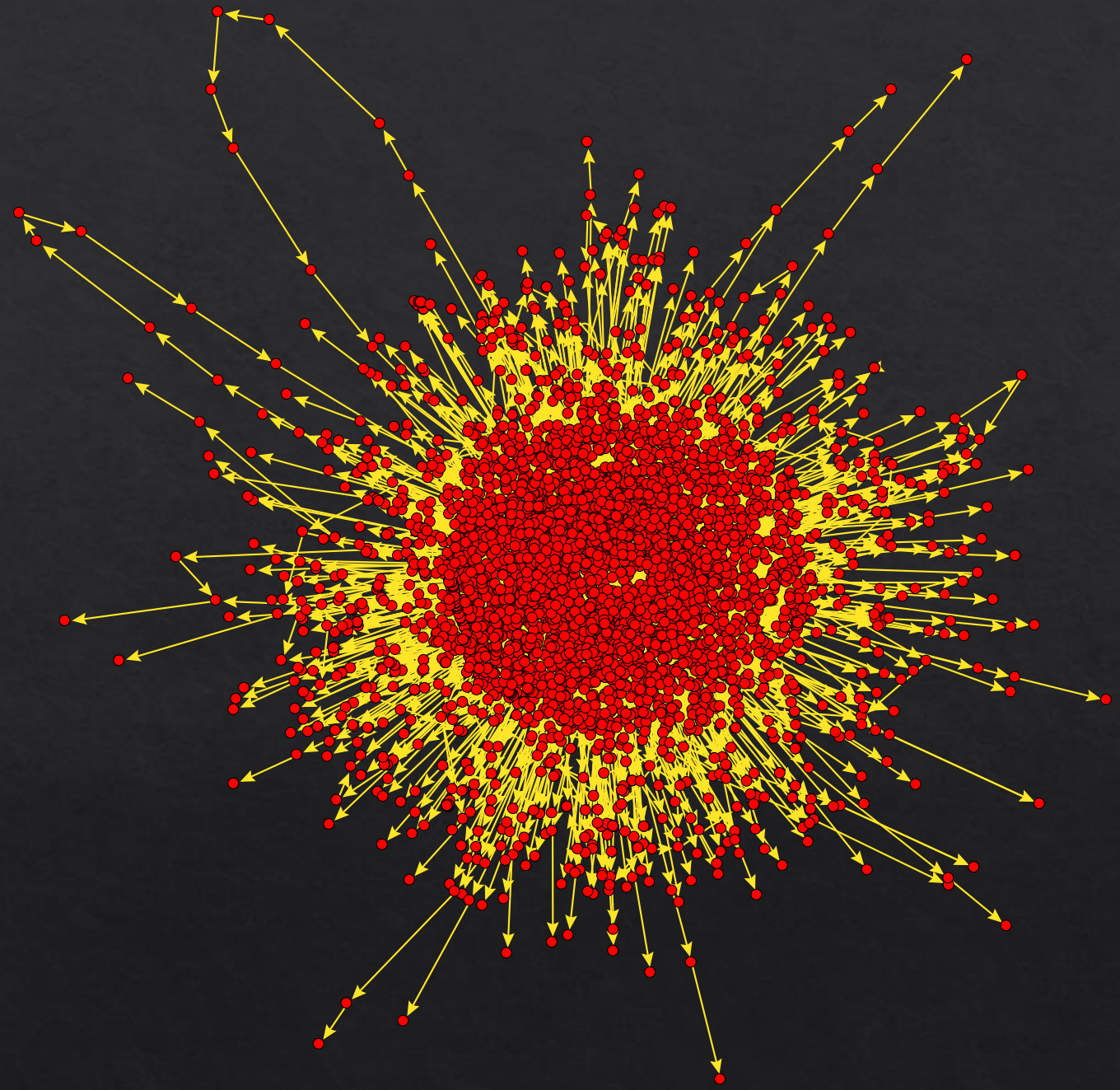

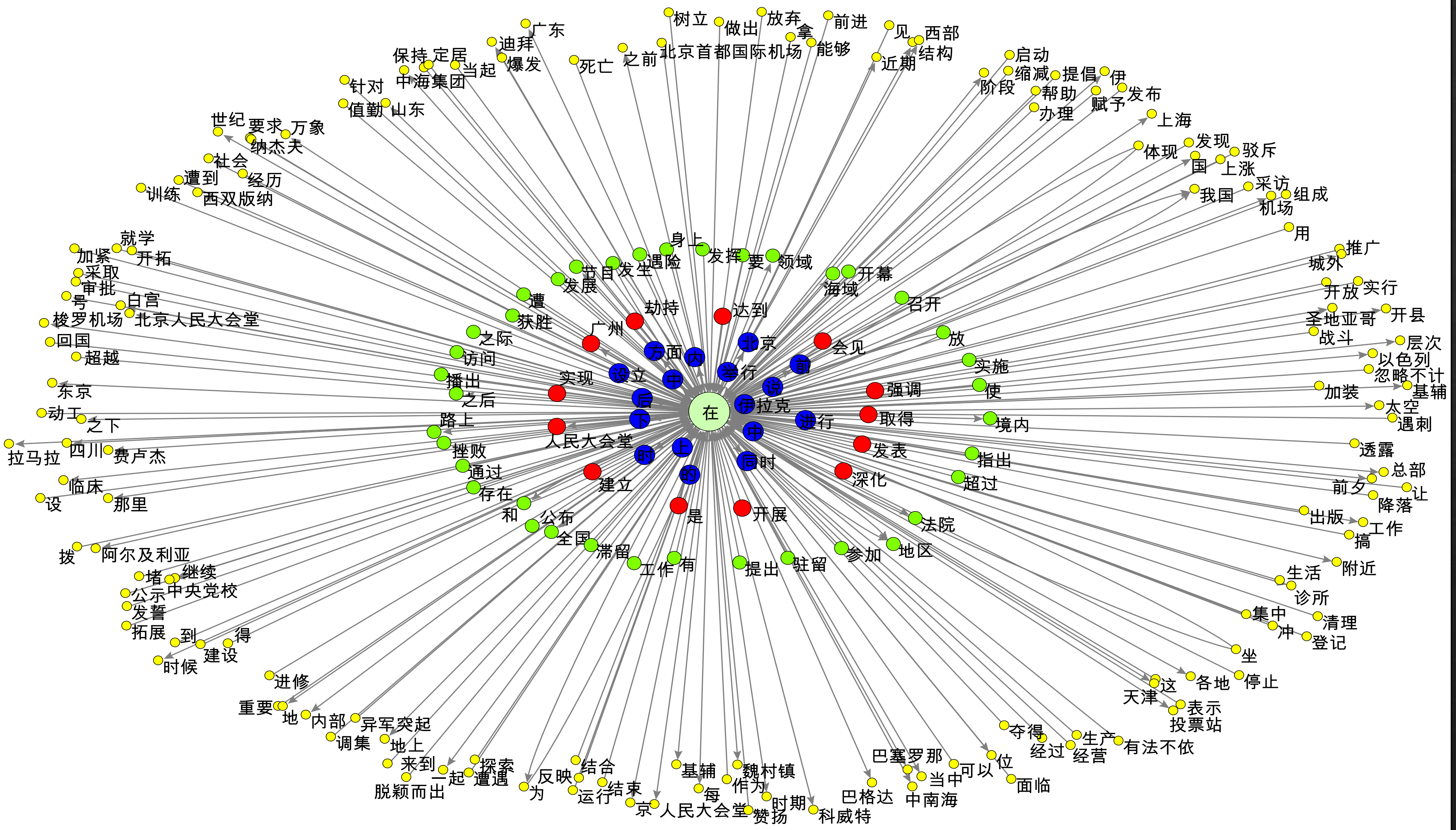

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迪拜
爆发
保持
定居
当起
中海集团
针对
值勤
山东
世纪
要求
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动工
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登记
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前夕
降落
让
总部
透露
遇刺
太空
基辅
加装
忽略不计
以色列
层次
战斗
圣地亚哥
开县
开放
实行
城外
推广
用
机场
组成
我国
采访
国
上涨
驳斥
体现
发现
上海
赋予
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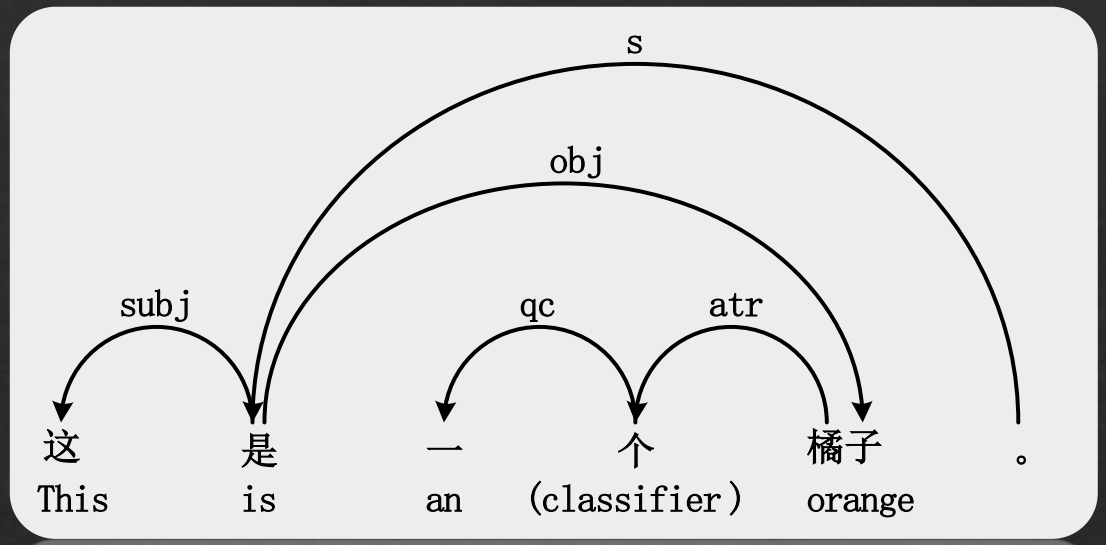
西部
结构

How to Build the Networks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This
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an
(classifier)
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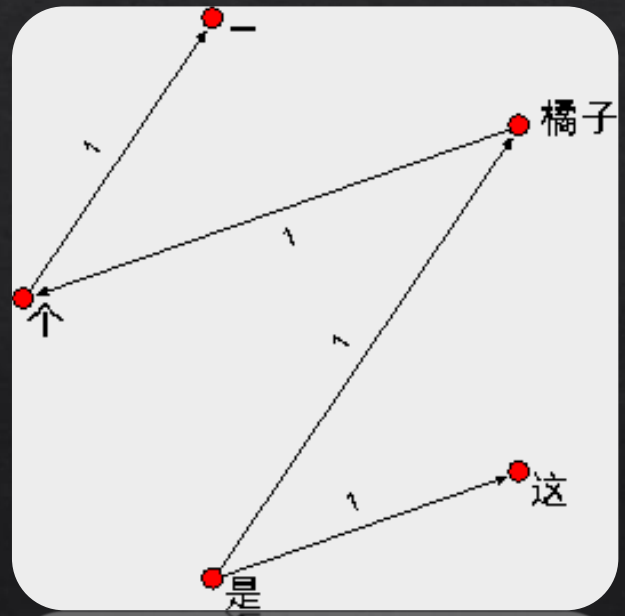
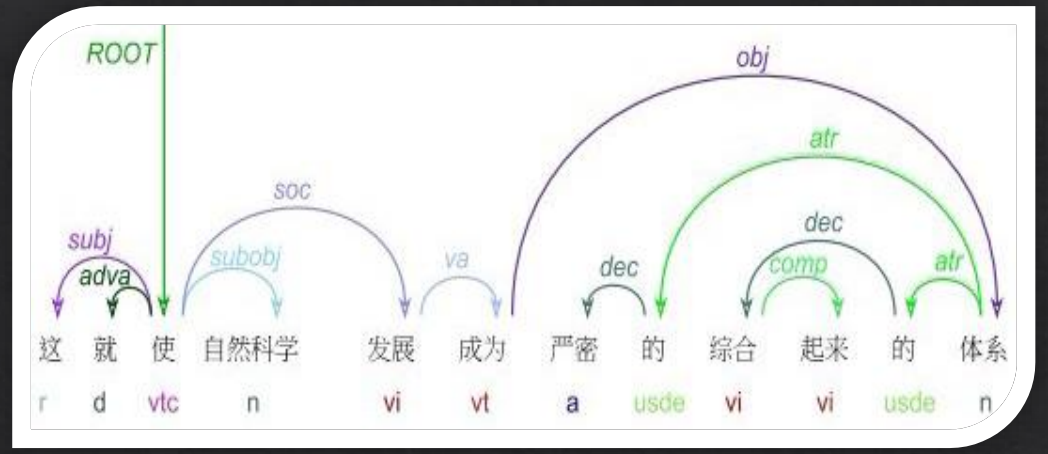
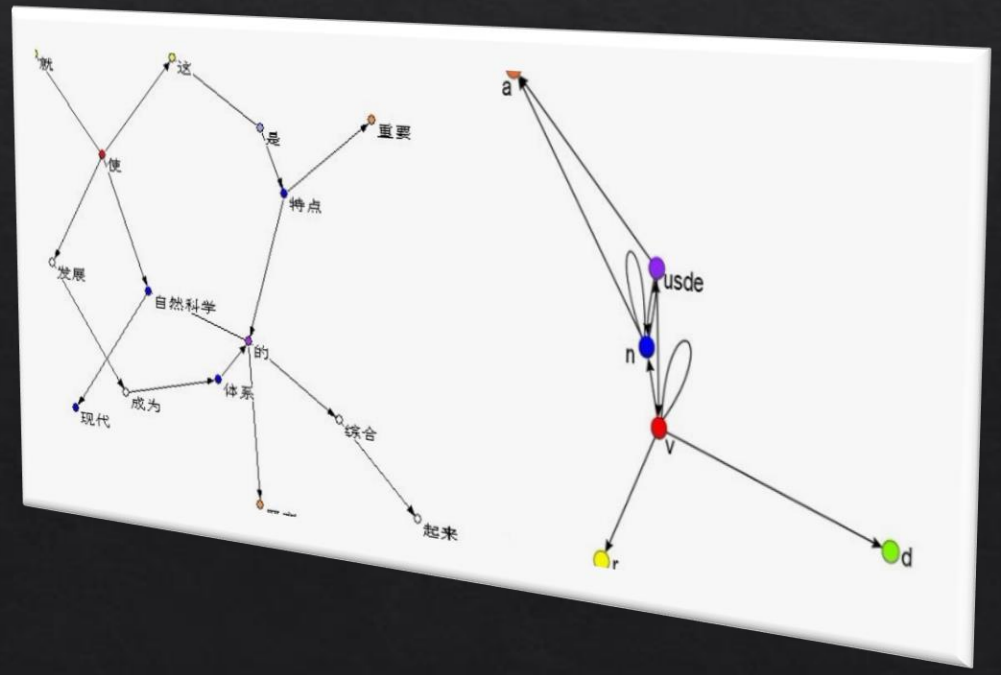

一
橘子
个
这
是
1
1
1
1

Annotation of a sample sentence in the Treebank.
这是一个橘子 *zhe-shi-yi-ge-ju-zi* 'this is an orange'

Sentence Order	Dependent			Governor			Dependency Type
	Order	Character	POS	Order	Character	POS	
S1	1	这 zhe	pronoun	2	是 shi	verb	Subject
S1	2	是 shi	verb	6	。	punctuation	main governor
S1	3	一 yi	numeral	4	个 ge	classifier	complement of classifier
S1	4	个 ge	classifier	5	橘子 juzi	noun	Attributer
S1	5	橘子 juzi	noun	2	是 shi	verb	Object
S1	6	。	punctuation				

sno	wno	wd	wtag	gno	gwd	gtag	syt
S1	1	这	r	3	使	vtc	subj
S1	2	就	d	3	使	vtc	adva
S1	3	使	vtc	0	s	s	s
S1	4	自然科学	n	3	使	vtc	subobj
S1	5	发展	vi	3	使	vtc	soc
S1	6	成为	vt	5	发展	vi	va
S1	7	严密	a	8	的	usde	dec
S1	8	的	usde	12	体系	n	atr
S1	9	综合	vi	11	的	usde	dec
S1	10	起来	vi	9	综合	vi	comp
S1	11	的	usde	12	体系	n	atr
S1	12	体系	n	6	成为	vt	obj
S2	1	这	r	2	是	vl	subj
S2	2	是	vl	0	s	s	s
S2	3	现代	n	4	自然科学	n	atr
S2	4	自然科学	n	5	的	usde	dec
S2	5	的	usde	7	特点	n	atr
S2	6	重要	a	7	特点	n	atr
S2	7	特点	n	2	是	vl	obj





Chinese Function Characters/Words Evolution

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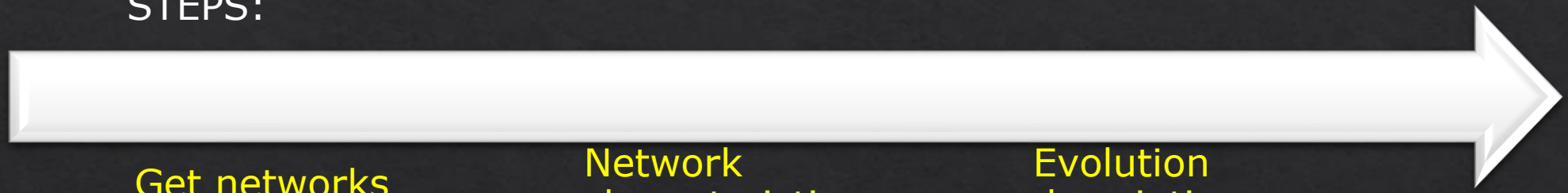
STEPS:



Get networks

- 4 periods
  - Ancient Chinese
  - Middle Ancient Times Chinese
  - Modern Times Chinese
  - Modern Chinese
- 2 single-character words
  - 在 zai ‘to exist, be living, to stay or remain, (to be located) in, at, ’
  - 人 ren ‘people’

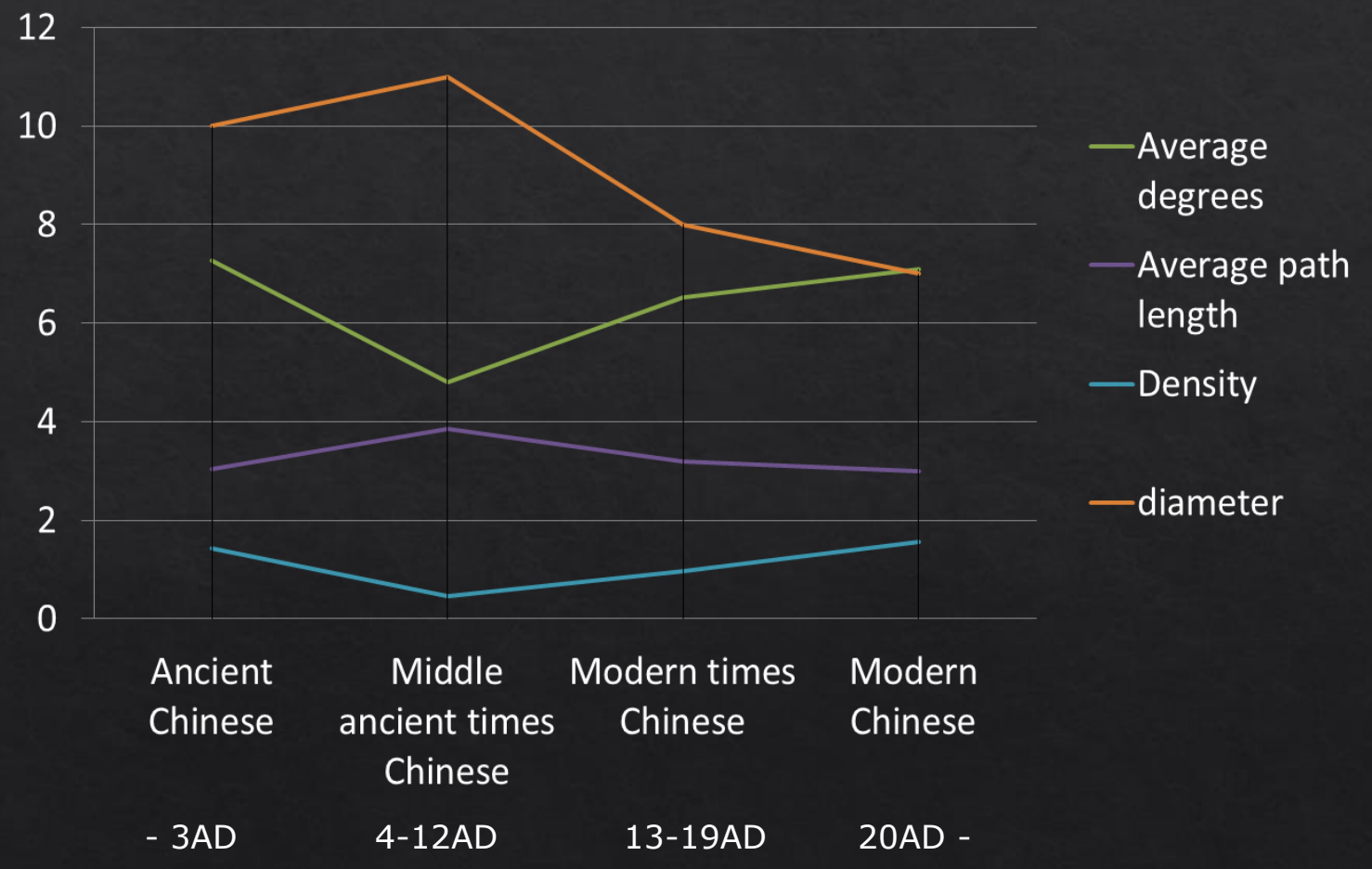
Network characteristics

- average degrees
- average path length
- density
- diameter
- degrees of ‘zai’
- degrees of ‘ren’

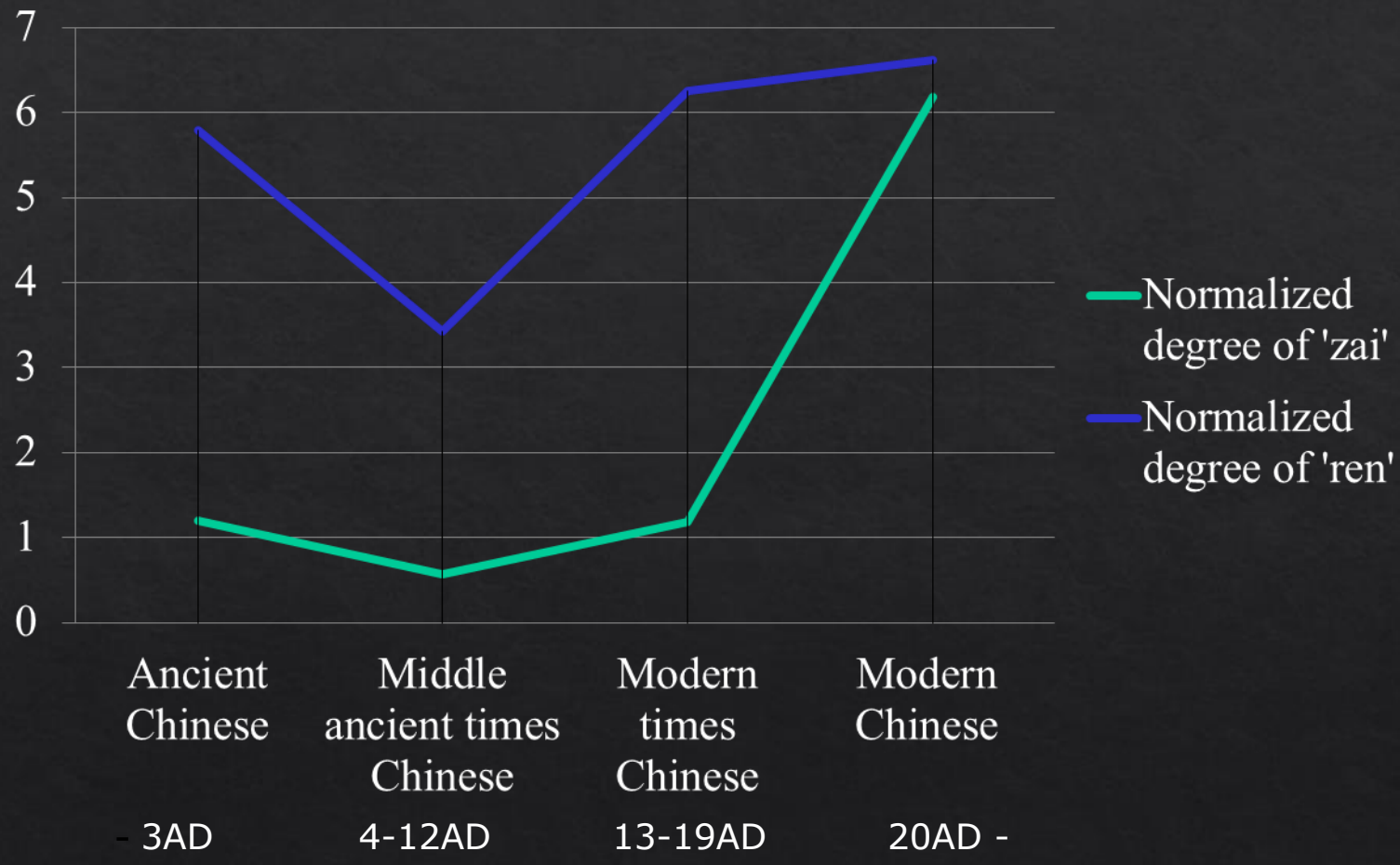
Evolution description

- quantitatively describe the evolution process of Chinese in 4 periods
- quantitatively describe the evolution process of 2 single-character words of Chinese in 4 periods

Co-occurrence Character Networks



Comparison of Single-character words



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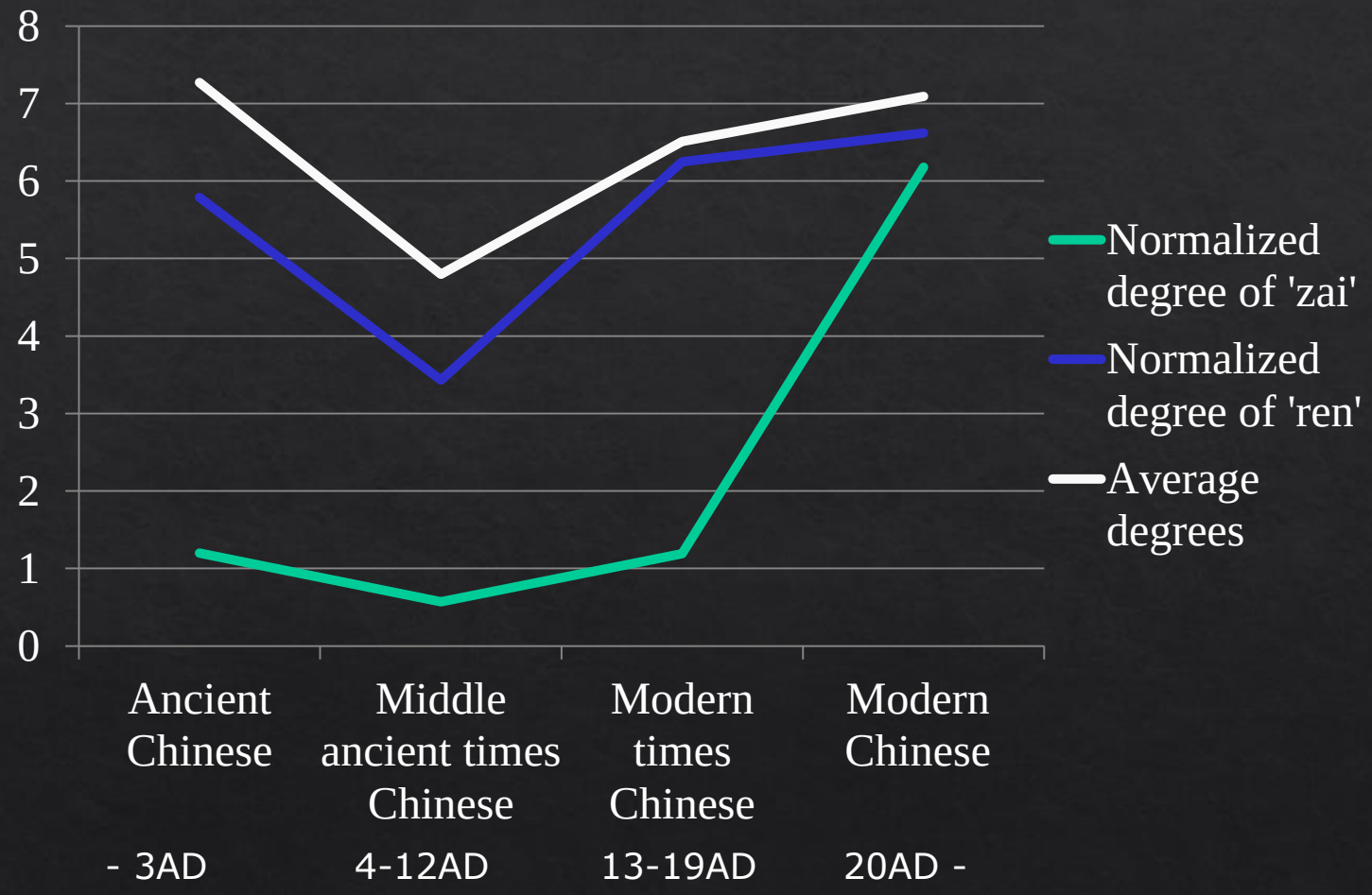
- 2 single-character words
  - Frequent characters/words both in the corpus and in general
  - zai underwent a grammaticalization process, whereas ren remains a content word
- Hubs could indicate the grammaticalization process and its starting points. Hubs could be functional or potential functional words to undergo future grammaticalization. (Solé et al. 2002)

Grammaticalization Process in Networks



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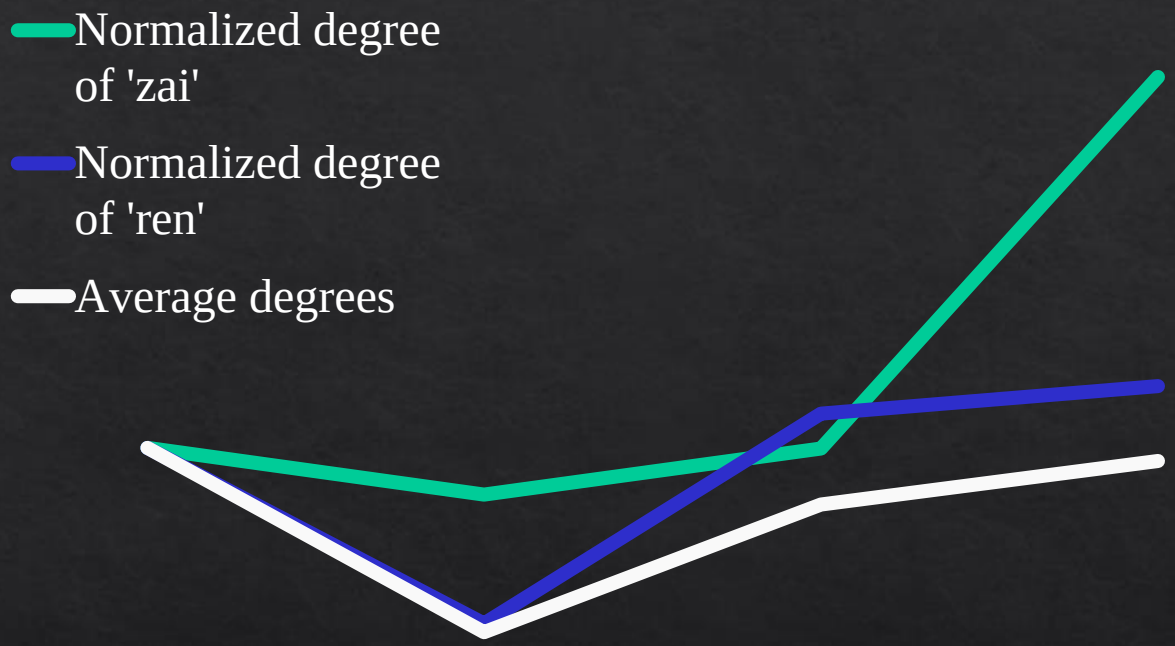

Conclusion

- The network features offer a new source of information to distinguish evolutions of different characters
- Observing evolution process in networks allows us to consider the evolutions of some specific units and the evolution of the whole system simultaneously.

Questions & Comments

Thank you ！