Disruptive lexical dynamics in the *Shangshu*

Persistence and change in cultural transmission

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Outline

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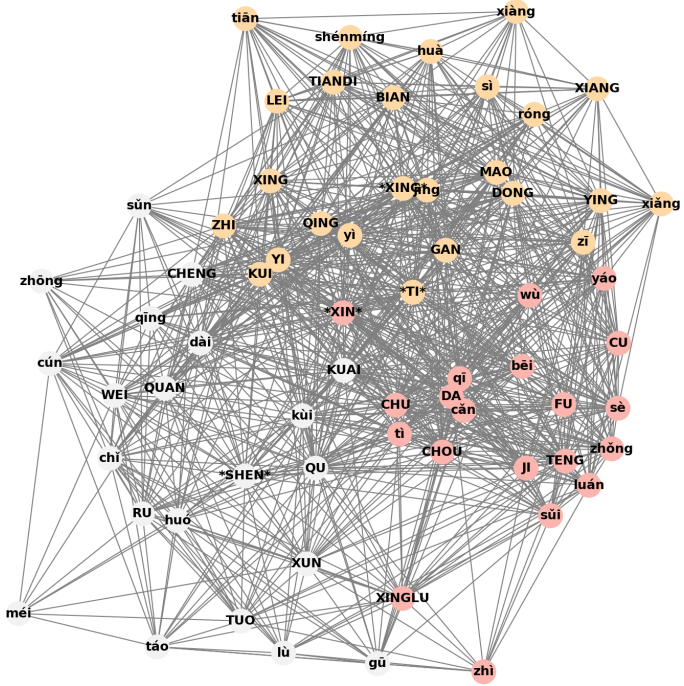
   - CTEXT database
2. Erroneous class
   - Classifier
   - Misclassification
   - Document distance
   - Erroneous features
3. Disruptive dynamics
   - Document representation
   - Qualitative similarities
   - Novelty & resonance
   - Results

CTEXT database

Corpus of 96 Classical Chinese texts from the CTEXT database
– $\sim$ 1000 BCE - 200 CE
– N tokens

Shangshu of 58 chapters:

Period	Chapters
Pre-Warring	10
Warring	16
Late Warring - Early Han	7
Han	25



Slingerland, E., Nichols, R., Nielbo, K., & Logan, C. (2017). The Distant Reading of Religious Texts: A Big Data Approach to Mind-Body Concepts in Early China. Journal of the American Academy of Religion, 85(4), 985–1016.

Nichols, R., Slingerland, E., Nielbo, K., Bergeton, U., Logan, C., & Kleinman, S. (2018). Modeling the Contested Relationship between Analects, Mencius, and Xunzi: Preliminary Evidence from a Machine-Learning Approach. The Journal of Asian Studies, 77(01), 19–57.

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Text-age (mis-)classifier

Train a simple and transparent learning model to explore the boundaries of age classification

- compare age-central to age-peripheral chapters of the *Shangshu*
- error semantics of the *Shangshu*

The probability of a document d being in class c, $P(c \mid d)$ is computed as:

$$P(c \mid d) \propto P(c) \prod_{i=1}^{m} P(t_i \mid c)$$

and the class of a document d is computed as:

$$c_{MAP} = arg\ max_{c \in \{c_1, c_2\}} P(c \mid d)$$

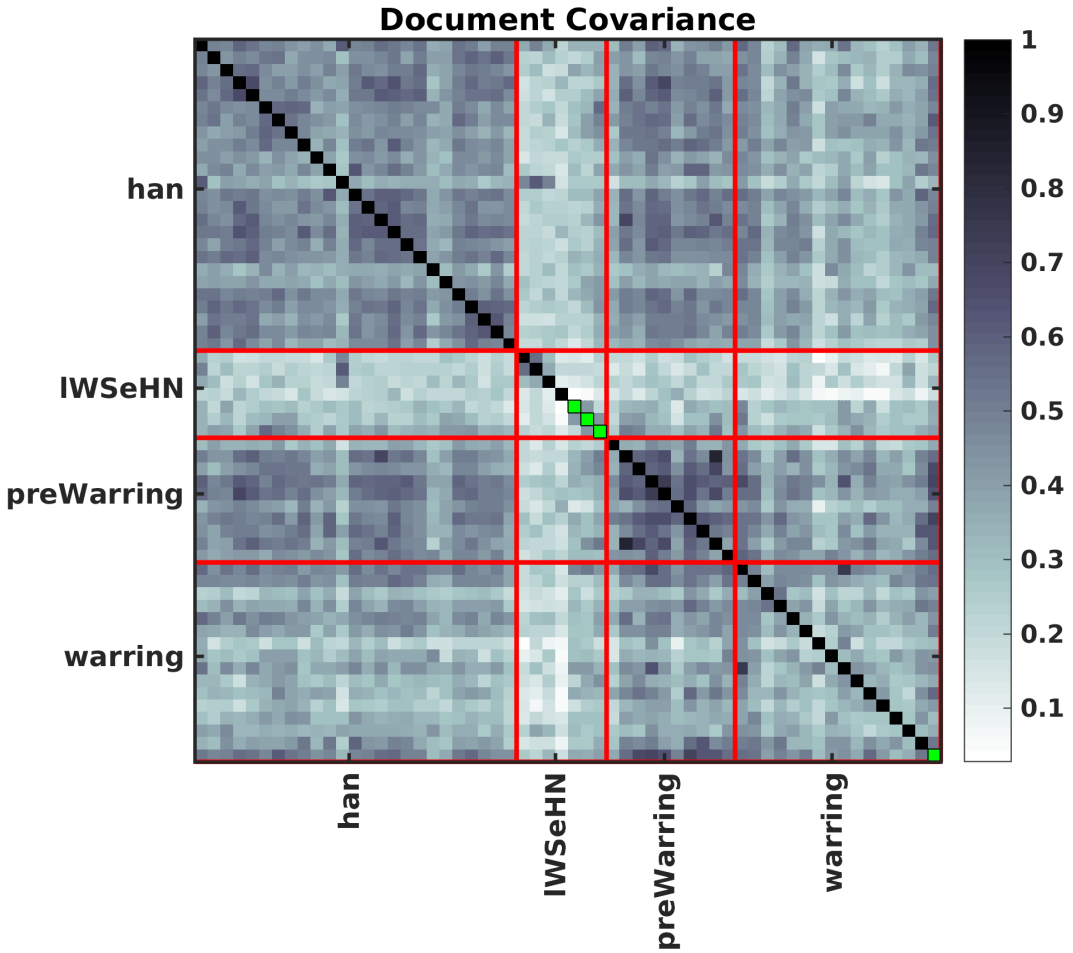

Figure 1: Documents covariance matrix for all chapters of the *Shangshu*

Three documents from the *Late Warring - Early Han* and one from *Han* are age ambiguous

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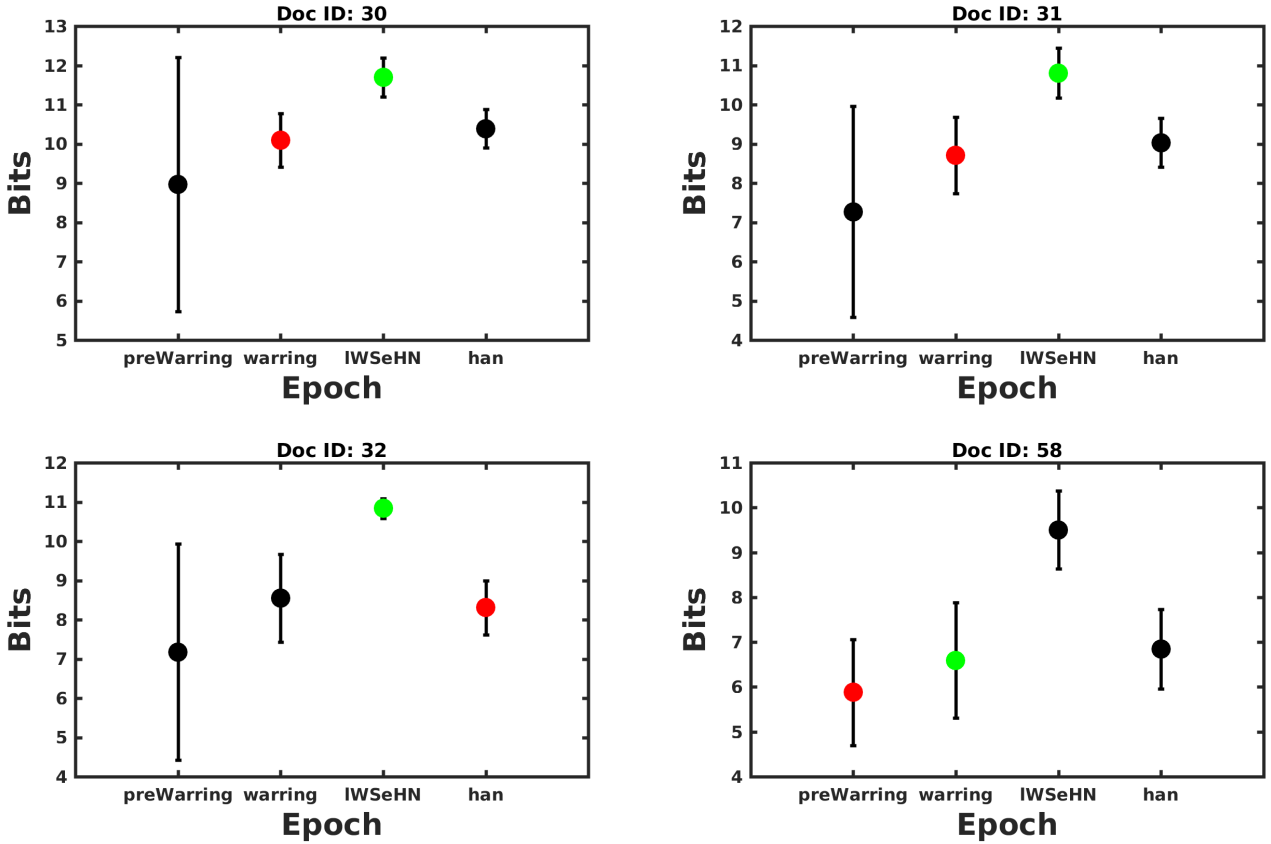

Figure 2: Average distance* to all classes show that the error class is closer to the document than the correct class

The distance between documents $s^{(1)}$ and $s^{(2)}$:

$$D_{KL}(s^{(1)} \mid s^{(2)}) = \sum_{i=1}^{K} s_i^{(1)} \times \log_2 \frac{s_i^{(1)}}{s_i^{(2)}}$$

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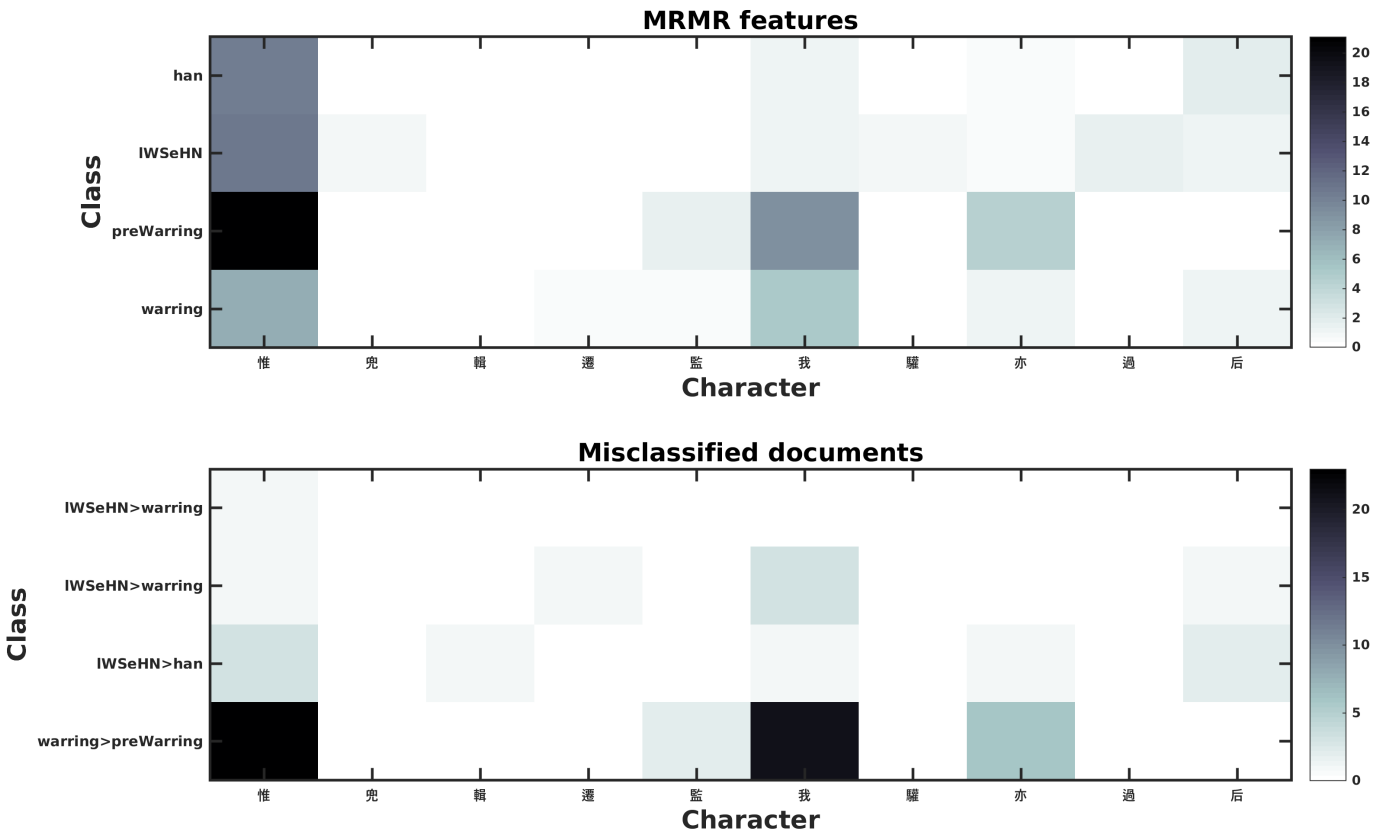

Figure 3: Features that collectively are most central for classification. Signal from feature one is sufficient to explain the error.

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Disruptive age effect

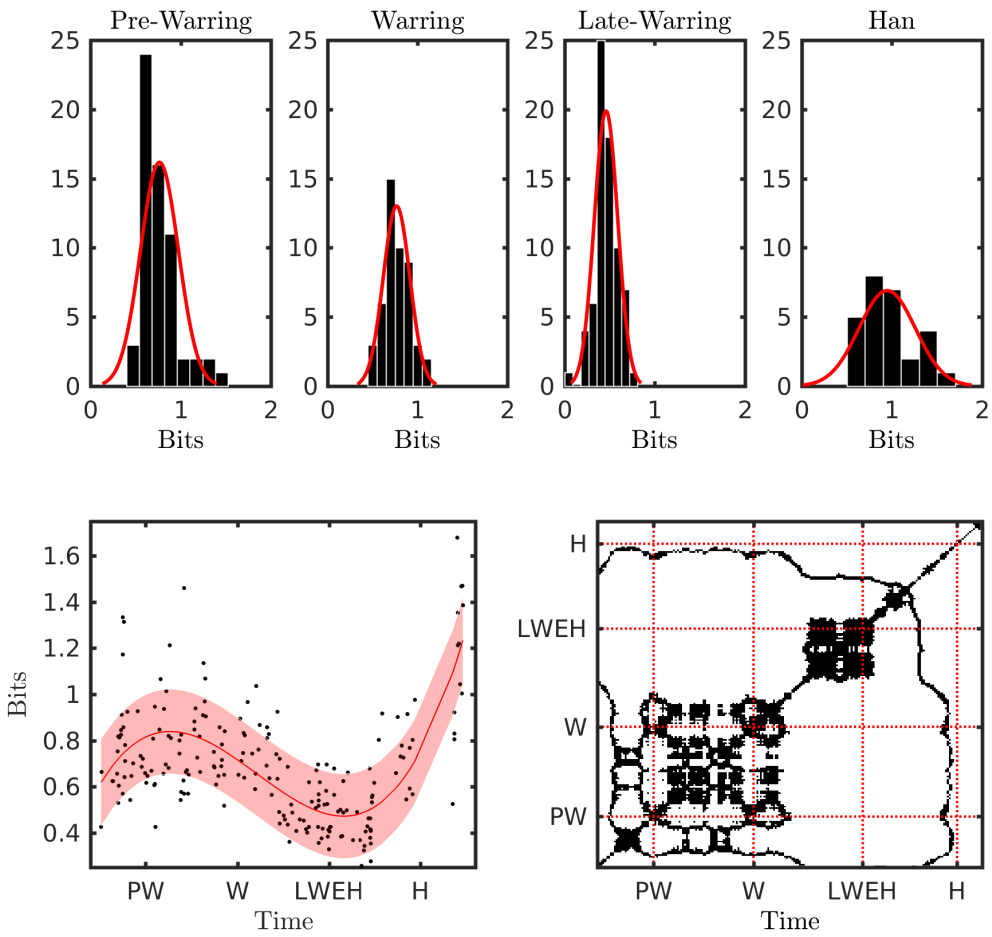

Figure 4: Length normalized lexical density over time for the Shangshu, notice the change points around and laminar region during *Late Warring* - *Early Han*

Dense document representation

– model semantic disruption as "variation on a theme" ⇒ use a simple Bayesian model to capture lexical semantics

– model each document as a distribution on lexical topics (e.g., $P_1 = [0\ .09\ .78\ .11\ .2]$), where each 'topic' is a distribution on words, and compare document similarity as the distance between any two documents with *chapter* – *index* j and k:

$$D_{KL}(s^{(j)} \mid s^{(k)}) = \sum_{i=1}^{K} s_i^{(j)} \times \log_2 \frac{s_i^{(j)}}{s_i^{(k)}}$$

– bracket concrete semantics (∼ reduce interpretive load) and only compare relative entropy between documents on topics ("variation on a theme")

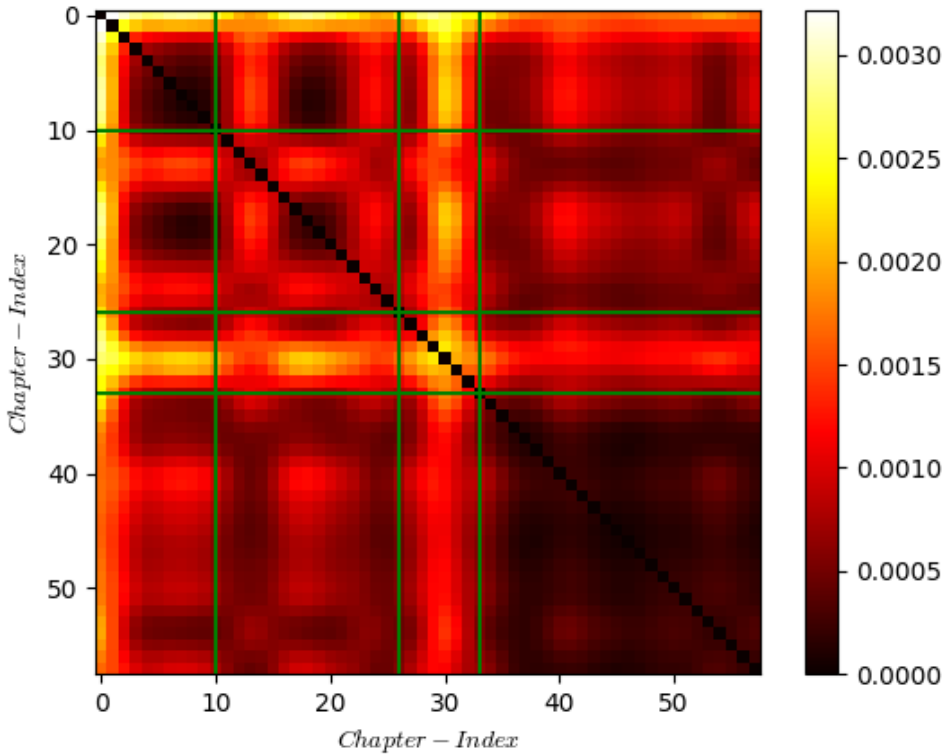

Figure 5: Distance matrix indicate some similarities with the sparse model (Fig. 1), notice the disruptive effect of *Late Warring* - *Early Han* centered on $i = 30$.

Disruptive dynamics

Compute disruption as a combination of resonance on novelty: $\mathbb{N}$ovelty over window w:

$$\mathbb{N}_w(j) = \frac{1}{w} \sum_{d=1}^{w} D_{KL}(s^{(j)} \mid s^{(j-d)})$$

with $\mathbb{T}$ransience:

$$\mathbb{T}_w(j) = \frac{1}{w} \sum_{d=1}^{w} D_{KL}(s^{(j)} \mid s^{(j+d)})$$

for $\mathbb{R}$esonance

$$\mathbb{R}_w(j) = \mathbb{N}_w(j) - \mathbb{T}_w(j)$$

s

Murdock, J., C. Allen, S. DeDeo. 2015. Exploration and Exploitation of Victorian Science in Darwin's Reading Notebooks. arXiv:1509.07175 .

Nielbo, K.L., M.L. Perner, C Larsen, J Nielsen, Laursen D. 2019. Automated Compositional Change Detection in Saxo Grammaticus' Gesta Danorum. hal-02084682

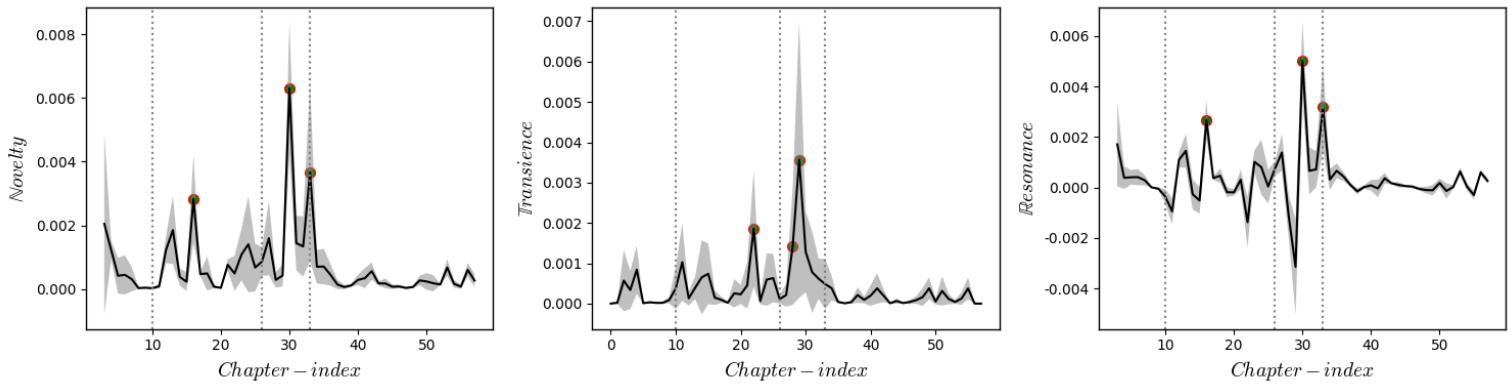

Figure 6: *Shangshu* Chapters' $\mathbb{N}$ovelty, $\mathbb{T}$ransience, and $\mathbb{R}$esonance for $w = 3$

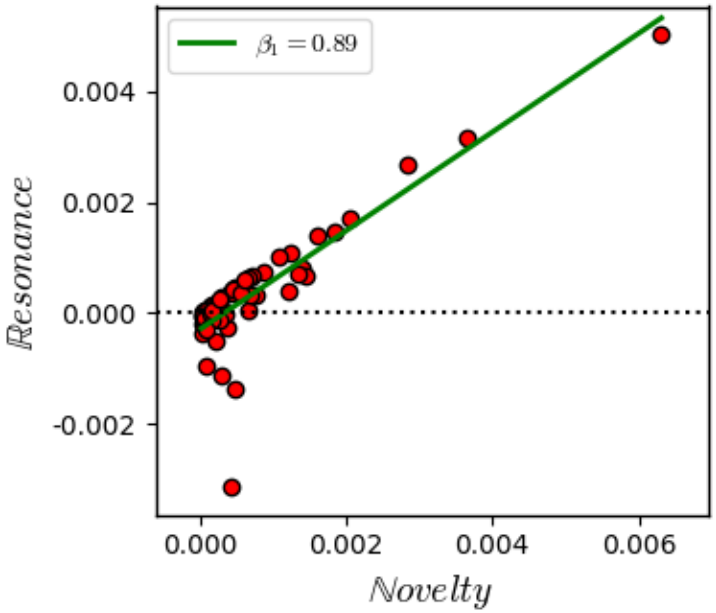

Figure 7: *Shangshu* Chapters' $\mathbb{R}$esonance on $\mathbb{N}$ovelty for $w = 3$

in conclusion

– *Late Warring - Early Han* display age class atypical behavior

– lexical density shows global minimum and laminar behavior during *Late Warring - Early Han*

– two disruptive maxima are located in *Late Warring - Early Han*

– saturation followed by innovation

– class-dependent findings (study 1) confirmed by class-independent model (study 2)

Thank you for your attention

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slides: http://knielbo.github.io/files/kln_shangshu.pdf