Disruptive lexical dynamics in the *Shangshu*

Persistence and change in cultural transmission

Kristoffer L Nielbo
kln@cas.dk
knielbo.github.io
chcaa.io

Center for Humanities Computing
Aarhus University, Denmark

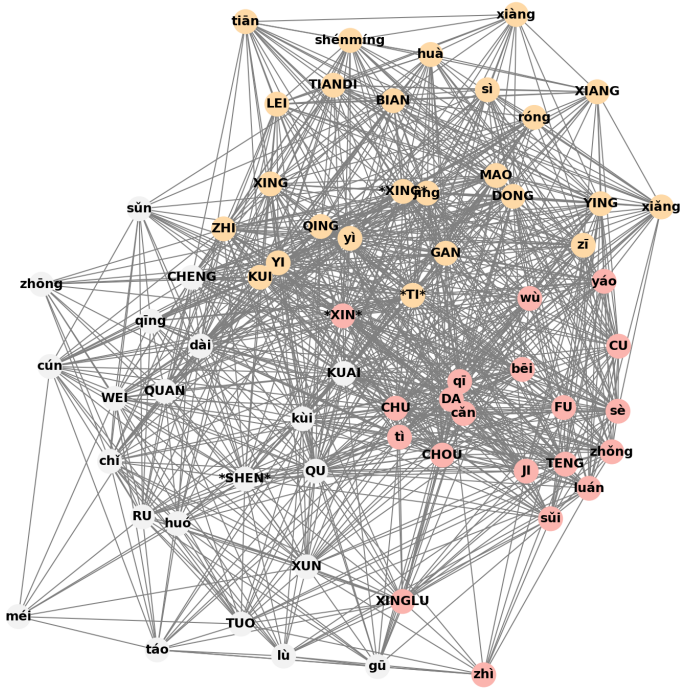
Outline

CTEXT database

Corpus of 96 Classical Chinese texts from the CTEXT database
– $\sim$ 1000 BCE - 200 CE
– $\sim$ 6M tokens on $\sim$ 16K types

Shangshu of 58 chapters:

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



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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:

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

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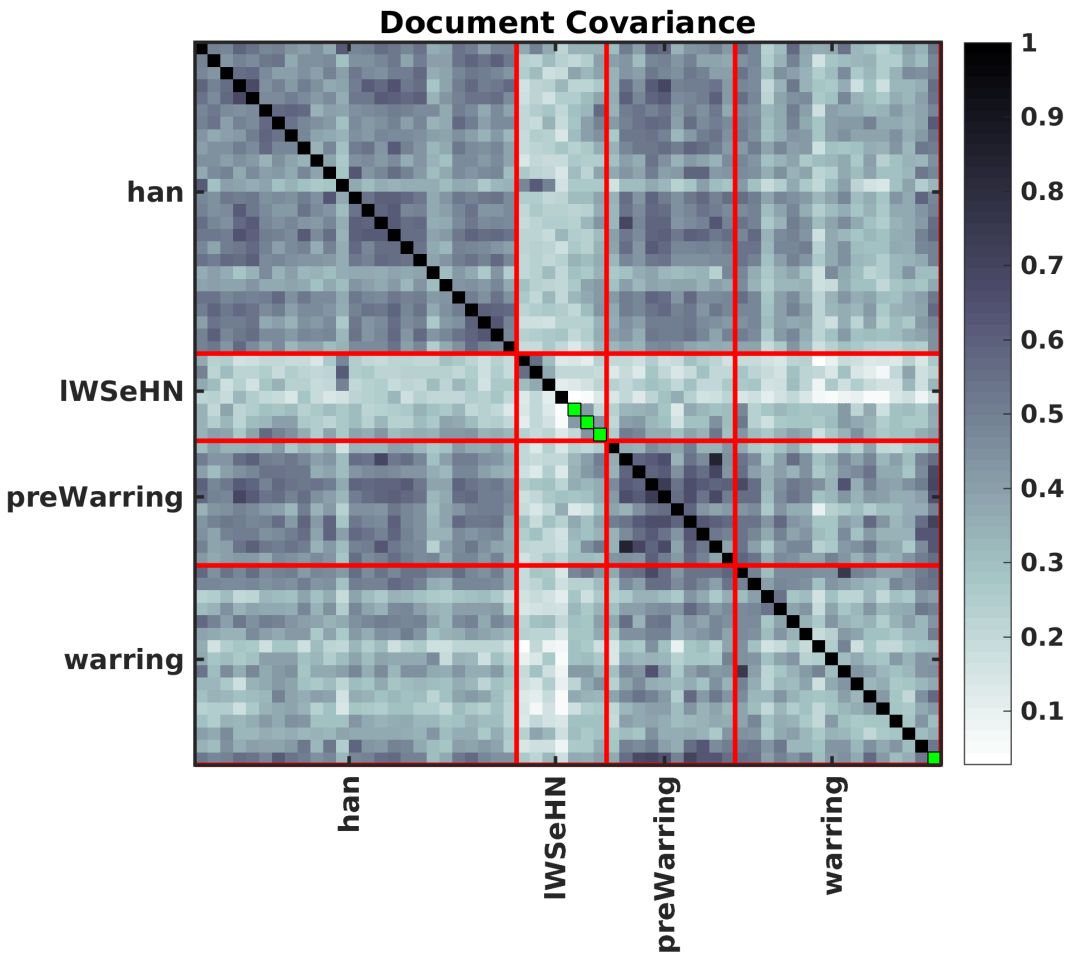

Figure 1: Documents covariance matrix for all chapters of the *Shangshu*

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

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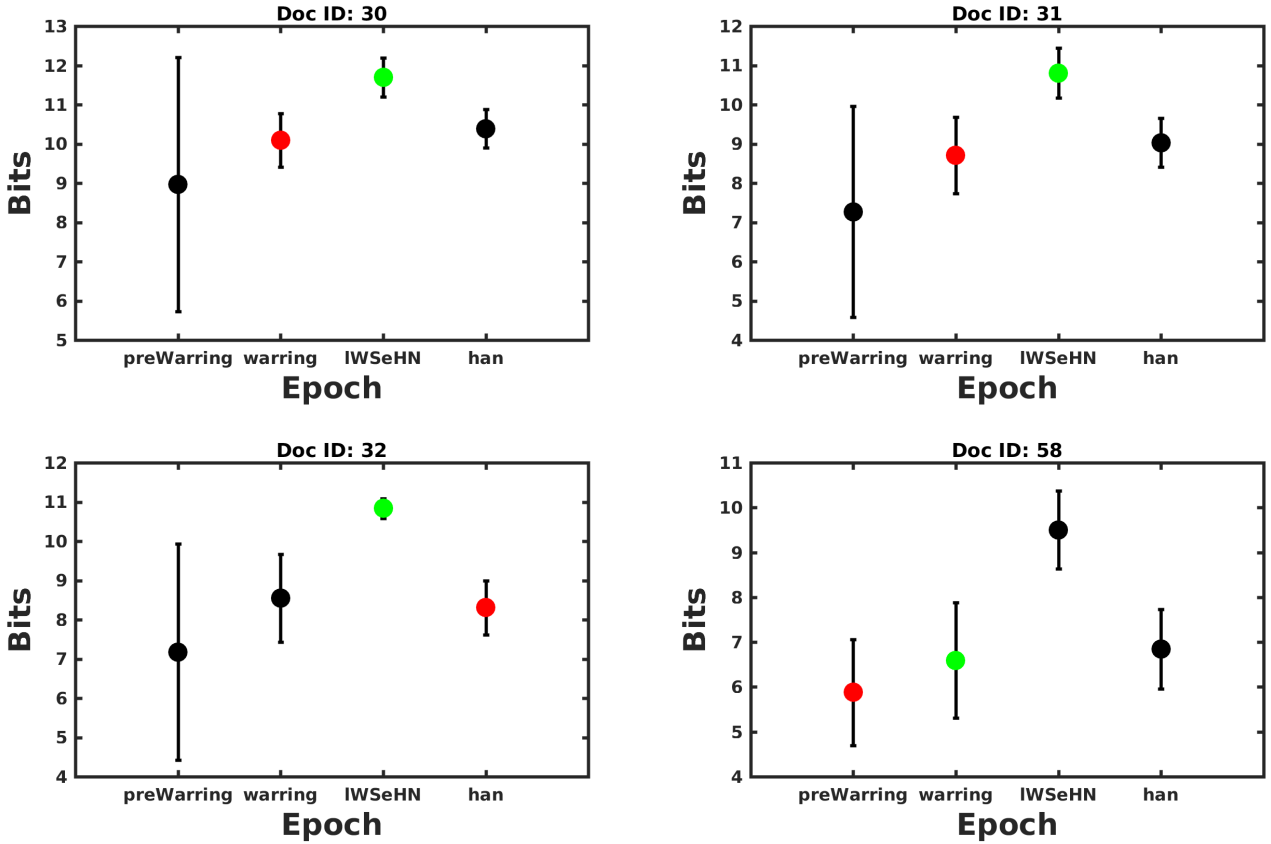

Figure 2: Average distance* to all classes show that the error class is closer to the document than the correct class

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

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

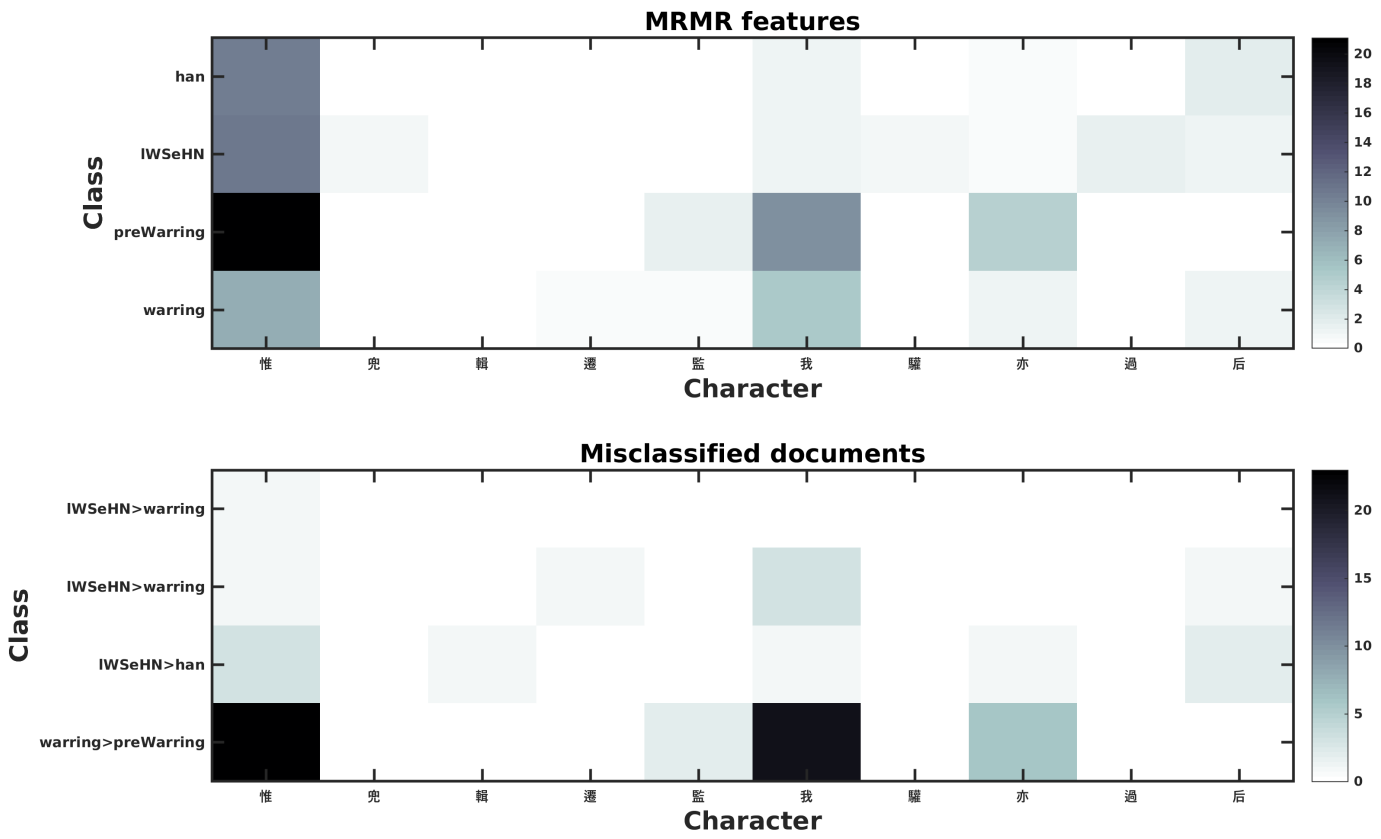

Figure 3: Features that collectively are most central for classification. Signal from feature one is sufficient to explain the error.

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Disruptive age effect

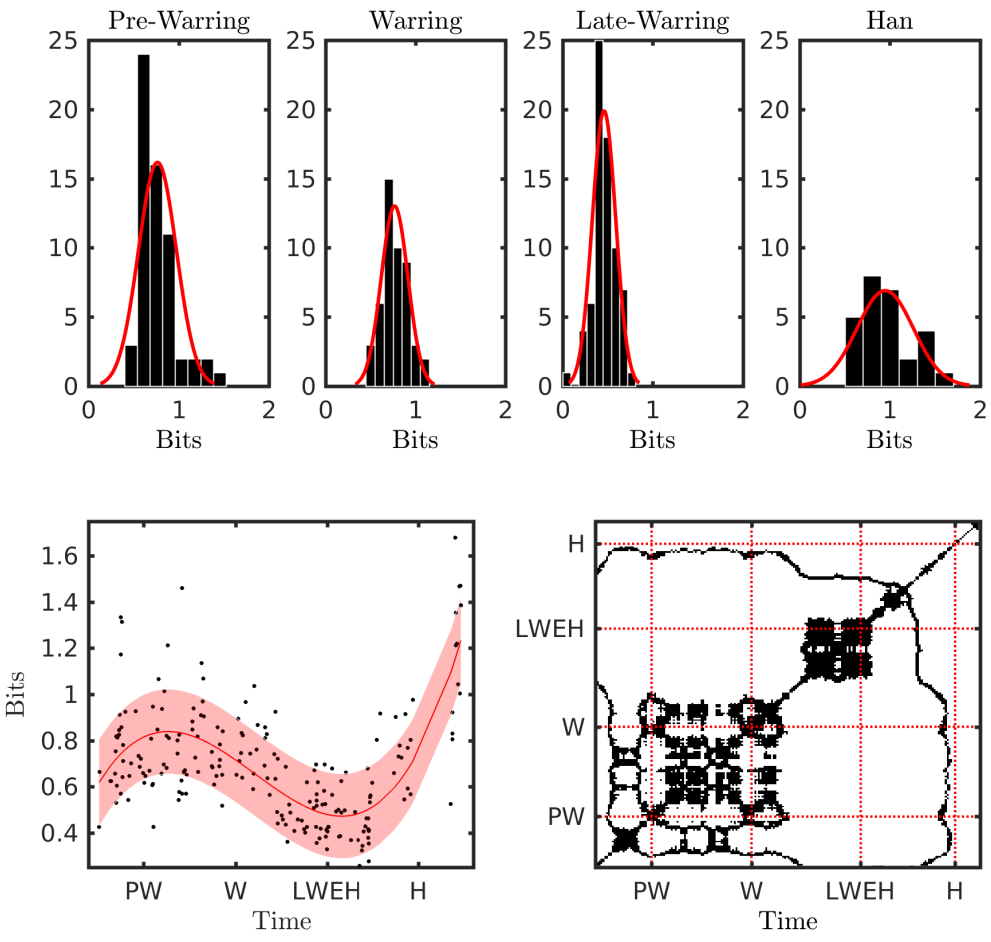

Figure 4: Length normalized lexical density over time for the Shangshu, notice the change points around and laminar region during *Late Warring - Early Han*

Dense document representation

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

– model each document as a distribution on lexical topics, e.g., $s = [0\ .09\ .78\ .11\ .2]$, 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 ($\sim$ reduce interpretive load) and only compare relative entropy between documents on topics ("variation on a theme")

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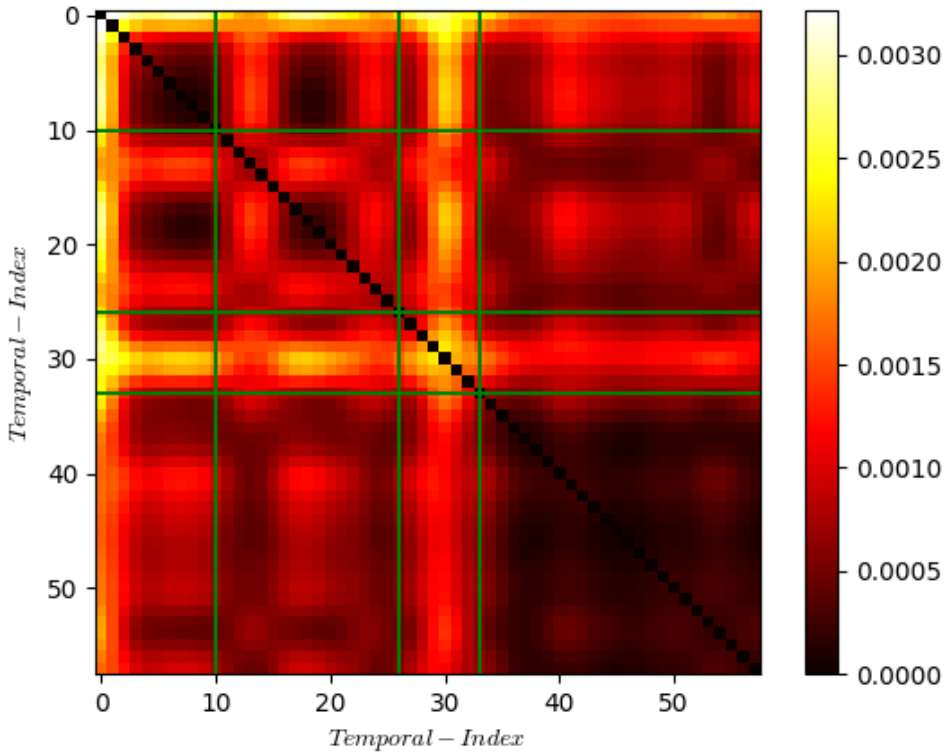

Figure 5: Distance matrix indicate some similarities with the sparse model (Fig. 1), notice the disruptive effect of *Late Warring* - *Early Han* centered on $i = 30$.

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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

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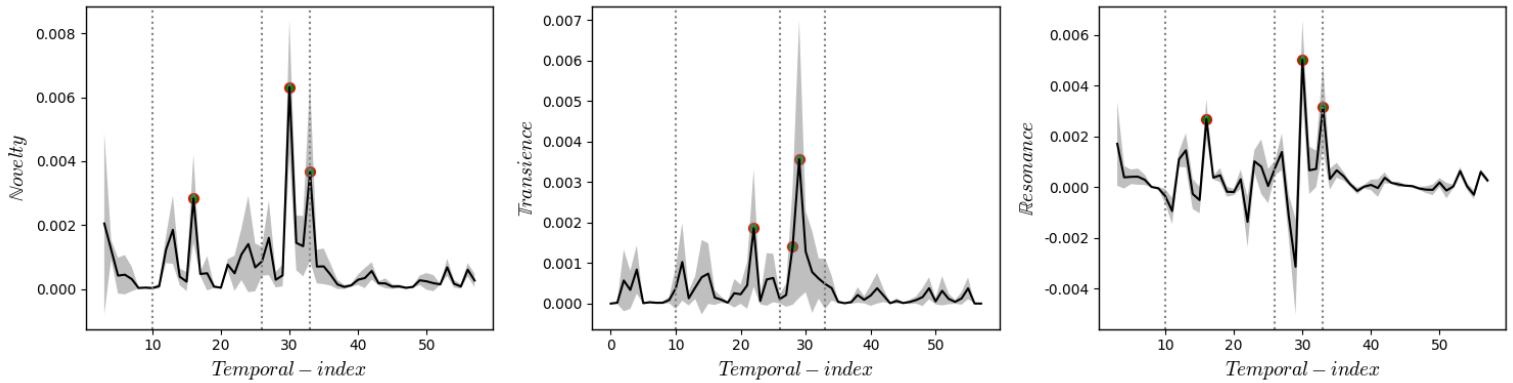

Figure 6: *Shangshu* Chapters' $\mathbb{N}$ovelty, $\mathbb{T}$ransience, and $\mathbb{R}$esonance for $w = 3$

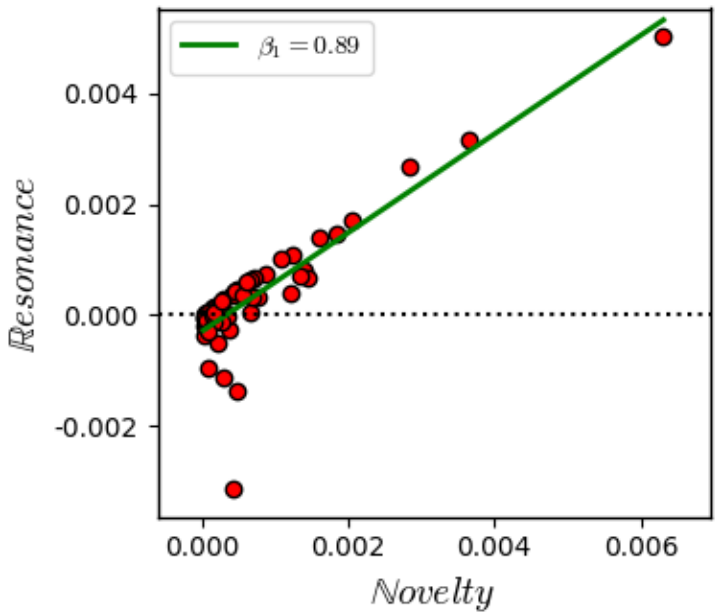

Figure 7: *Shangshu* Chapters' $\mathbb{R}$esonance on $\mathbb{N}$ovelty for $w = 3$

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

kln@au.dk
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chcaa.io

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