



# Information theoretic historical morphology: A case study of High German adjectives

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## Goals

To use the tools from information theory to:

- Assess claims about New High German adjectival system
- Provide a methodology to quantify simplification and complexity in language change

## Background on High German adjectives

### Middle High German (MHG)

Two paradigms:

- Weak**, used with definite articles
- Strong**, used with indefinite articles, or no article

(1) einer **guter** vrau  
a good.STR woman  
“of a good woman”

### New High German (NHG)

Three paradigms:

- Weak**, used with definite articles
- Mixed**, used with indefinite articles
- Strong**, used when no article present

(2) einer **guten** Frau  
a good.MX woman  
“of a good woman”

- NHG, Durrell (2002:118): Trade off between “fuller” strong endings and clarity of determiners

## Information theory

- Branch of mathematics concerned with representation and transmission of signals (Shannon 1948); applied in studies of linguistic complexity.
- Entropy** is a measure of uncertainty based on the frequency of signals and is measured in bits.

### Key for $H(A|B)$

Higher entropy → Less informative

Lower entropy → More informative

Table 1 : Informativeness of  $B$  w.r.t.  $A$

## Methodology

### Calculations

- Measure the conditional entropy of the adjective form given the article inflection (i.e.,  $H(\text{ADJ}|\text{ART})$ ) in both MHG and NHG.
- Measure the conditional entropy of the article inflection given the adjective form (i.e.,  $H(\text{ART}|\text{ADJ})$ ) in both MHG and NHG.

### Synchronic Predictions

**Strong**  $H(\text{ADJ}|\text{ART}) > H(\text{ART}|\text{ADJ})$

**Weak**  $H(\text{ADJ}|\text{ART}) < H(\text{ART}|\text{ADJ})$

Table 2 : Relations between the entropy calculations suggested by Durrell's (2002) claims

### Simulations

- Generate alternative mixed paradigms to compare the attested systems to an alternative tripartite system
- Generate possible single paradigm systems to compare the attested systems to an alternative system where the paradigms collapsed

## Entropy of the MHG and NHG adjective paradigms

Q1: Does the adjective compensate for a lack of information on the article?

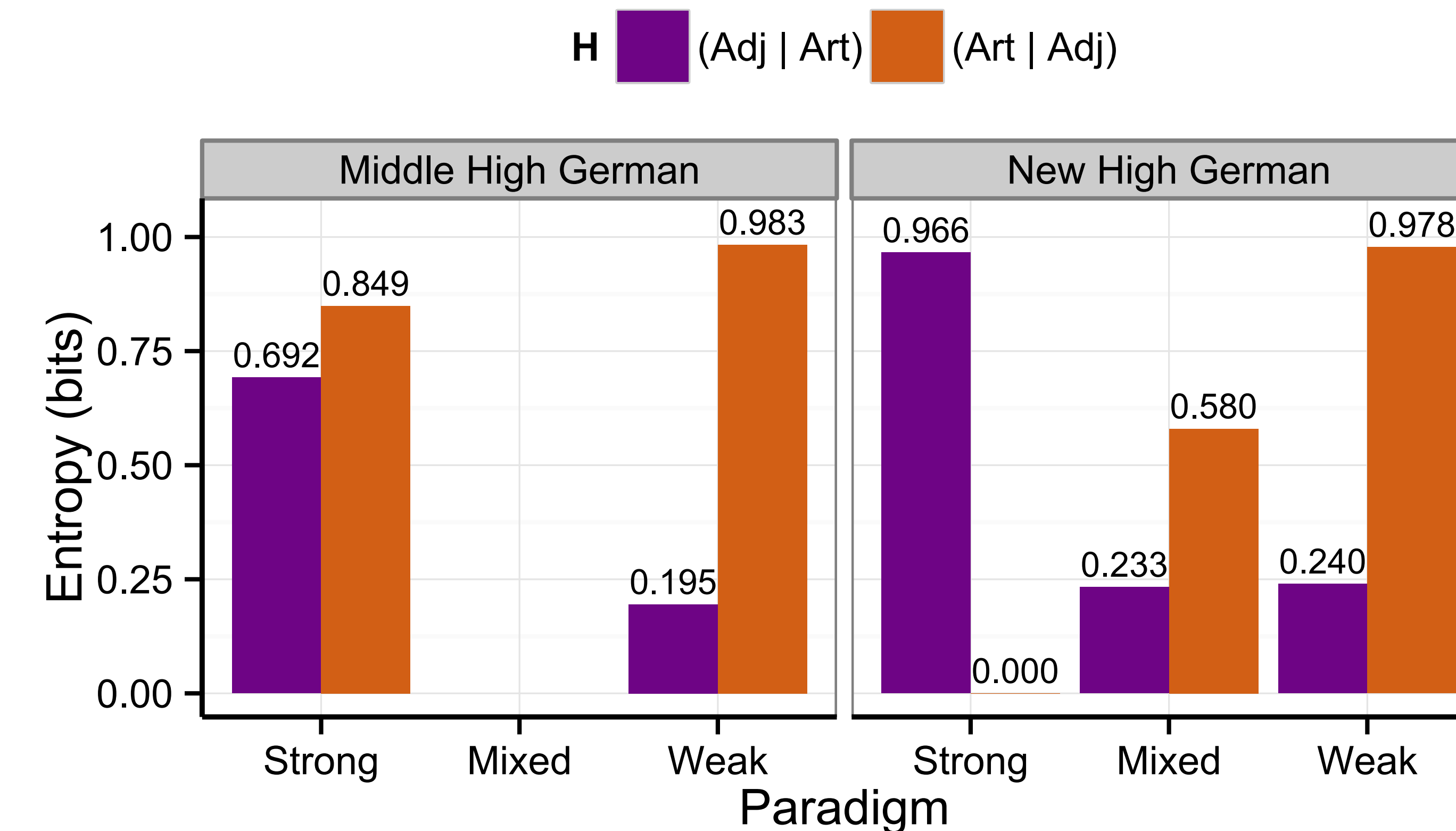


Figure 1 : Relative conditional entropy for distinct paradigms in MHG and NHG

- In MHG, the article is more informative about the adjective than vice versa.
- In NHG, strong adjective given the article is more informative than article given the strong adjective, and vice versa for weak adjective.
- This result supports Durrell's (2002) claims.

Q2: How does the MHG system compare to the NHG system?

Overall relative entropy for:

MHG 0.658

NHG 0.537

- NHG has lower entropy compared to MHG.
- I.e., the adjective form has become more predictable based on the preceding article.

## Simulating alternative mixed paradigms

Q3: How does NHG compare to systems with alternative mixed paradigms?

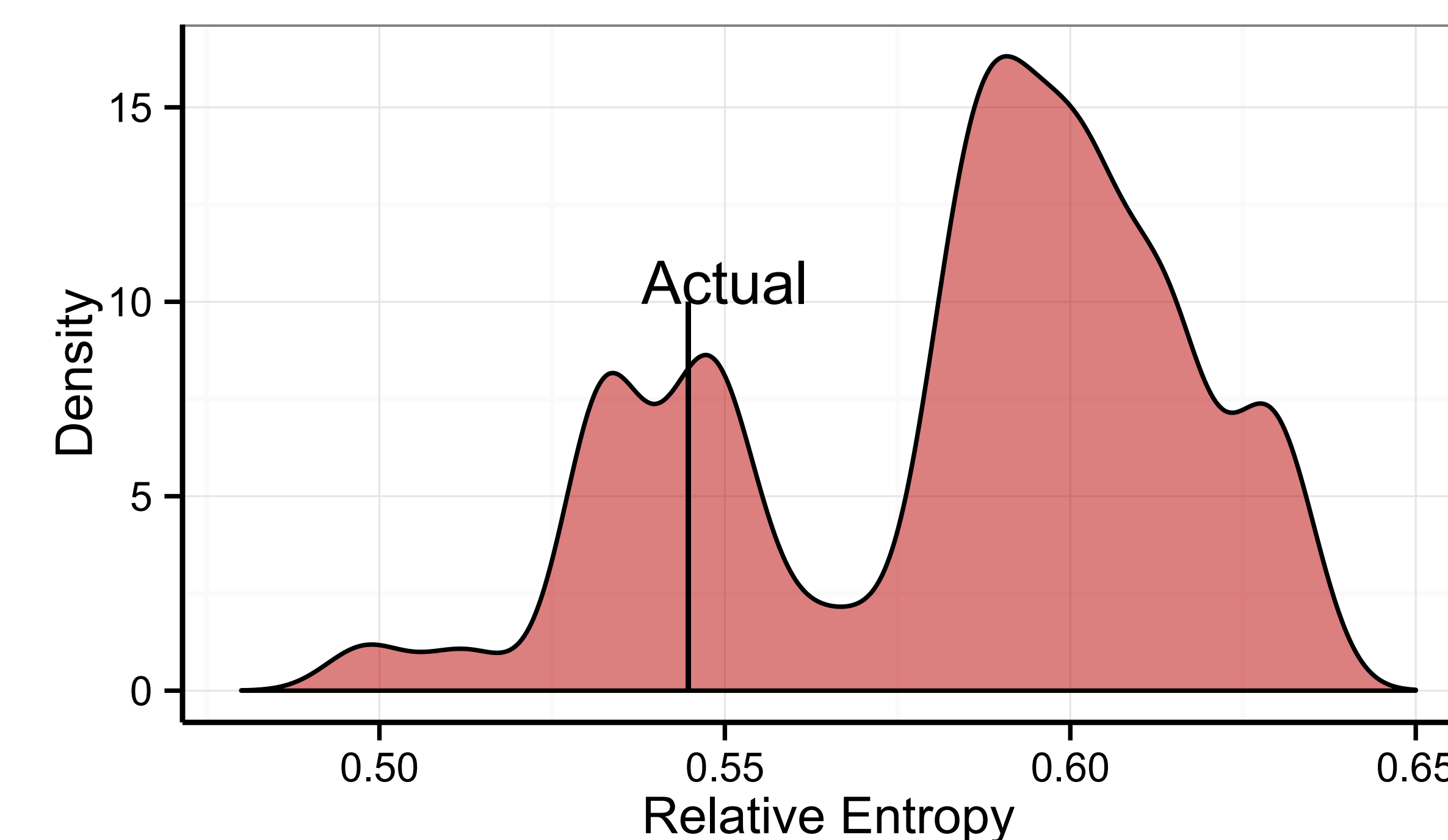


Figure 2 : Varying the mixed paradigm in a tripartite system

NHG system at a lower, but not lowest, end of the possible entropy space .

## Simulating a single paradigm

- Language change can move in different directions.
- Other languages descended from Middle High German have a single paradigm (cf. Yiddish, Luxembourgish).
- Intuitively, one might assume a single paradigm is “simpler”.

Q4: How does the NHG system compare to possible single paradigm systems?

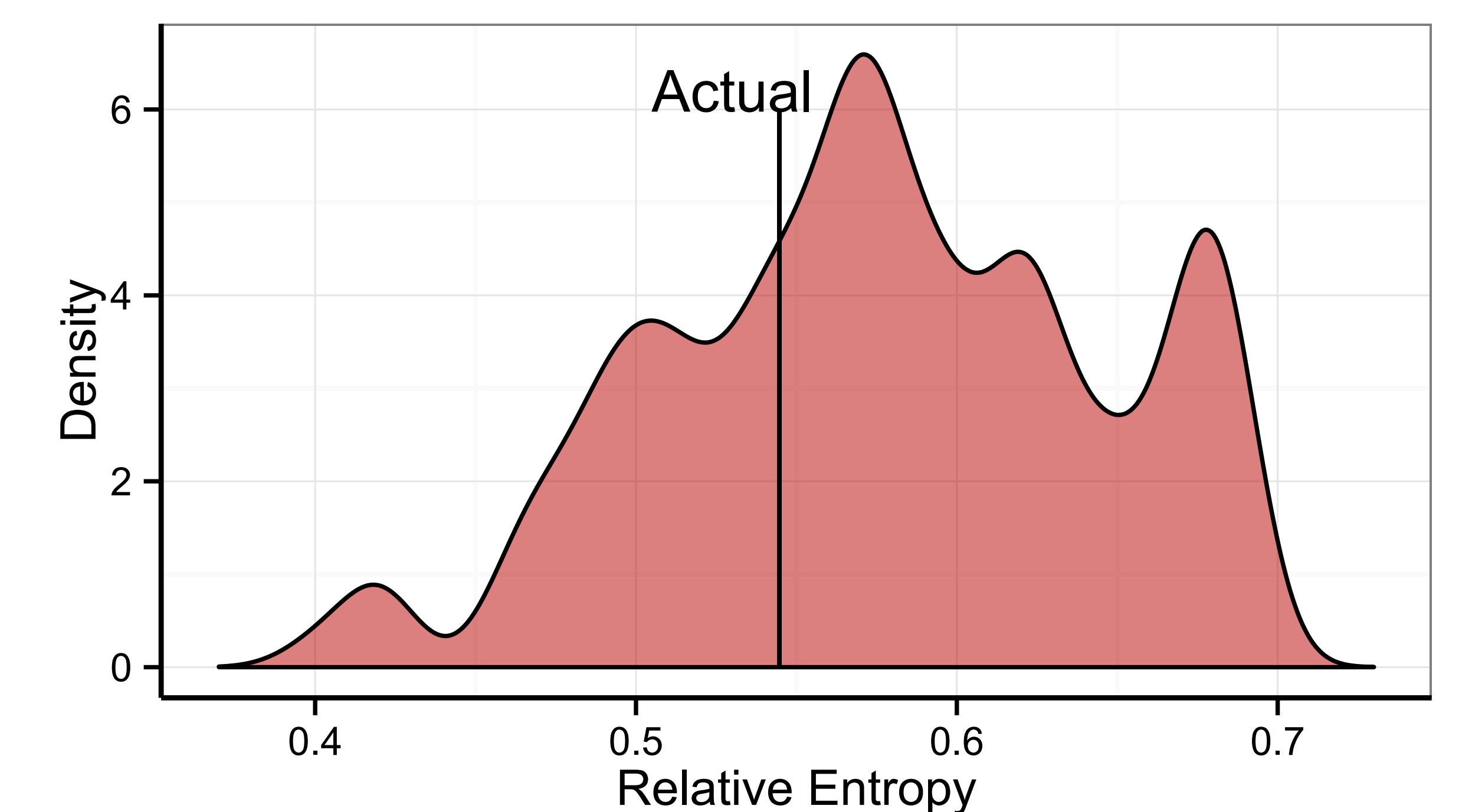


Figure 3 : Varying the composition of a one paradigm system

- Attested NHG system has relative entropy comparable to a system with a single paradigm
- Some possible single paradigm systems have higher entropy than the NHG system

## Discussion & Conclusions

- Intuitionistic claims are correct** that NHG strong forms compensate for a lack of information on the article.
- NHG system is ‘simpler’**, but unclear what this means in the language as a whole.
- NHG system has relatively low entropy**, compared to other possible tripartite systems.
- Attested tripartite system has entropy comparable to a collapsed system** with only one paradigm for adjectives.
- Relative entropy decreased from MHG to NHG**, suggesting that the NHG system is easier for listeners to process.

Methodology from information theory allows for a more refined discussion of processes like ‘simplification’ and notions of ‘clarity’ in language change

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### Works Cited

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