Third International Conference on Computational and Cognitive Musicology
Aalborg University, Aalborg, Denmark, 8-10 October 2025

Modelling the Evolution of Tonal Complexity

A Statistical Analysis from Renaissance to Baroque

Charlotte van Roijen, MA, MSc
Drs. Mirjam Visscher

What is the trend in tonal complexity from the Renaissance to the Baroque?

Background

Studying musical evolution using time-consuming traditional methods is a nearly impossible task due to the large datasets required. Computational methods provide a useful alternative as large amounts of data can be processed in a short time. The current study is inspired by Weiß et al. (2019), who investigated the stylistic evolution of Western classical music from the Baroque to Modern periods in terms of tonal complexity.

Tonal Complexity

Tonal complexity is a measure that quantifies how pitch class content is distributed along the circle of fifths (Weiß and Müller, 2014). The more uniform the distribution of the chroma values in this reordered space, the higher the tonal complexity. It is calculated based on the length of the mean resultant vector.

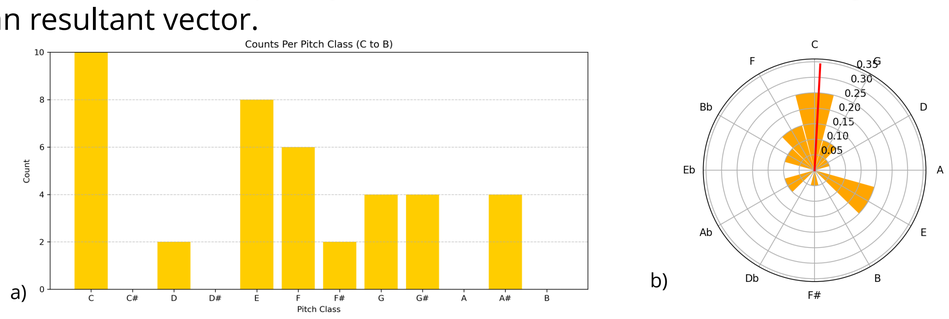


Figure 1. a) a pitch class profile, b) a circular interpretation of the respective reordered pitch class profile.

Tonal complexity per composition was calculated using three temporal resolutions:

complexity feature	window size
global tonal complexity	entire composition
medium tonal complexity	8 s
local tonal complexity	1/86 s

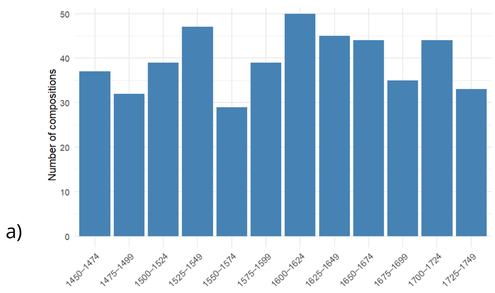
To calculate medium and local tonal complexity, a sliding window with stride 1/86 s was used, which was then averaged.

Pitch extraction

Pitch information from audio was extracted with the multiple f0 estimation method by Cuesta et al. (2020), which outperforms other state-of-the-art models (Visscher & Wiering, 2025).

Corpus

The corpus comprised of 469 compositions from 1450 to 1750 by a total of 148 composers. If the year of composition was unknown, it was estimated by taking the midlife year of the composer. Compositions were distinguished based on musical function (*sacred* vs. *secular*) and performance type (*vocal* vs. *instrumental* vs. *mixed*).



b)

	sacred	secular	total
vocal	115	44	159
instrumental	20	174	194
mixed	84	32	116
total	219	250	469

Figure 2. a) the number of compositions per 25-year bin, b) the number of compositions split by musical function and performance type.

Statistical analysis

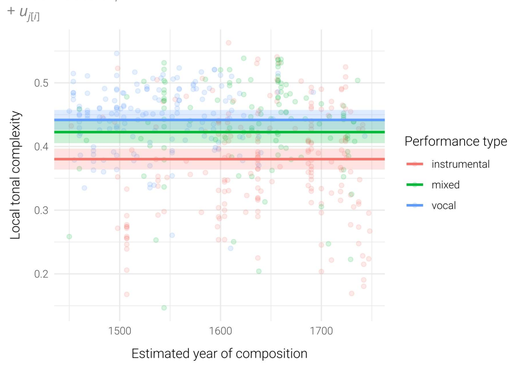
Regression analysis with beta GLMMs was employed. Model selection was done with AIC and BIC.

Results

for observation i, composer j, work k and random intercept u

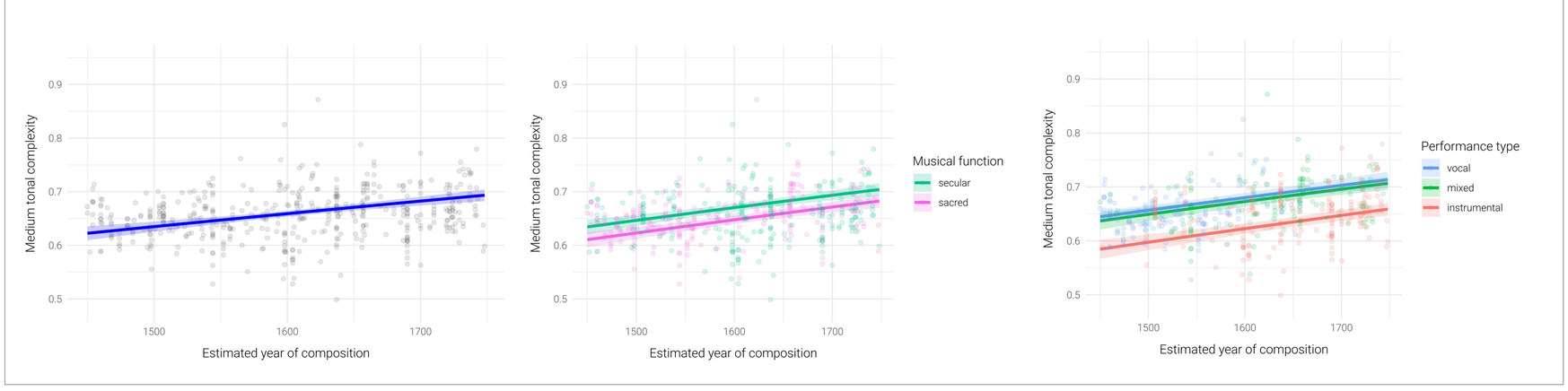
Local tonal complexity

$\text{logit}(\text{local tonal complexity}_i) = -0.47 + 0.18 * \text{mixed}_i + 0.25 * \text{vocal}_i - 0.03 * \text{secular}_i + u_{j[i]}$



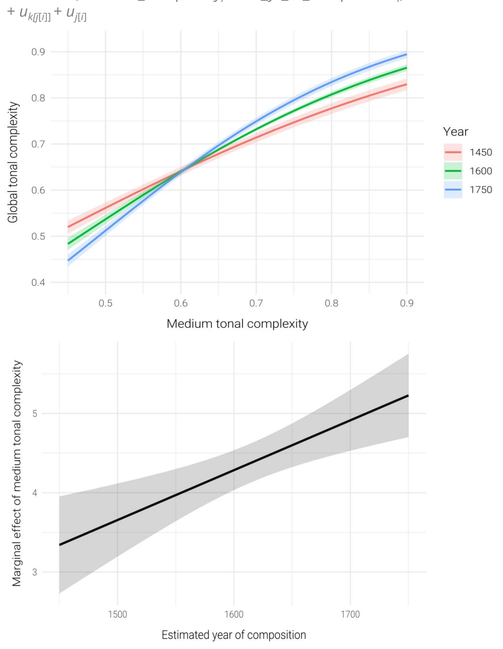
Medium tonal complexity

$\text{logit}(\text{medium tonal complexity}_i) = 0.29 + 0.001 * \text{est\_yr\_of\_composition}_i + 0.22 * \text{mixed}_i + 0.25 * \text{vocal}_i + 0.10 * \text{secular}_i + u_{j[i]}$



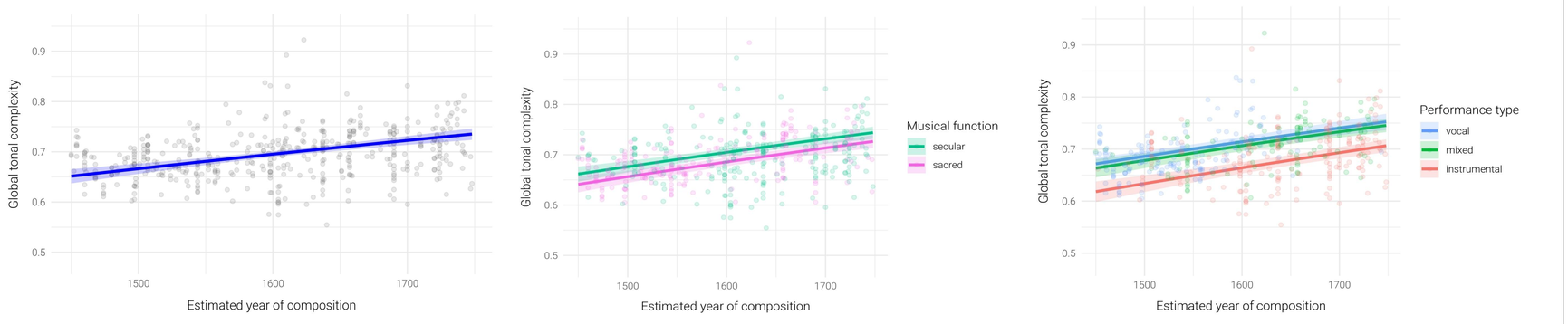
Medium vs. global tonal complexity

$\text{logit}(\text{global tonal complexity}_i) = -1.42 + 3.34 * \text{medium\_complexity}_i - 0.004 * \text{est\_yr\_of\_composition}_i + 0.006 * (\text{medium\_complexity}_i \times \text{est\_yr\_of\_composition}_i) + u_{k|j[i]} + u_{j[i]}$



Global tonal complexity

$\text{logit}(\text{global tonal complexity}_i) = 0.44 + 0.001 * \text{est\_yr\_of\_composition}_i + 0.20 * \text{mixed}_i + 0.23 * \text{vocal}_i + 0.09 * \text{secular}_i + u_{j[i]}$



Findings

- Local tonal complexity showed no clear trend over time.
- Medium and global tonal complexity increased over time.
  - Global tonal complexity showed a stronger increase.
  - Tonal complexity was higher for secular, vocal and mixed compositions.
- Musical function and performance type are associated with differences in the overall level of tonal complexity, but do not account for its historical development from the Renaissance to the Baroque.

References

Cuesta, H., McFee, B., & Gómez, E. (2020). Multiple f0 estimation in vocal ensembles using convolutional neural networks. Proceedings of the 21st International Society for Music Information Retrieval Conference (ISMIR).
Visscher, M., & Wiering, F. (2025a). Fuzzy frequencies: Finding tonal structures in audio recordings of renaissance polyphony. Heritage, 8 (5), 164.
Weiß, C., Mauch, M., Dixon, S., & Müller, M. (2019). Investigating style evolution of Western classical music: A computational approach. Musicae Scientiae, 23 (4), 486–507.
Weiß, C., & Müller, M. (2014). Quantifying and visualizing tonal complexity. In T. Klouche & E. R. Miranda (Eds.), Proceedings of the 9th conference on interdisciplinary musicology (cim) (pp. 184–187).

charlottevanroijen@gmail.com