Play it again, Sam(ple) - Trends in the prevalence of repetition and audio self-similarity in German chart songs

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Background

Music is fundamentally characterized by an ubiquity of **repetitive elements** which are assumed to play an important role in its cognitive processing, social functions, and liking (Margulis, 2014). Those elements can range from fully recurring sections, smaller repeated background riffs to overall timbral self-similarities across a track. Due to higher **processing fluency**, higher *lyrical* repetition supposedly increases the likelihood of a song to reach **top chart positions** (Nunes et al., 2015). Chart songs have been systematically analyzed for **acoustic trends** (e.g. Schellenberg & von Scheve, 2012) and, on a smaller scale, specifically for **repetitive motifs** (e.g. Yu & Ying, 2015), however the overall chronological trend regarding audio repetition/self-similarity in chart music remains unclear.

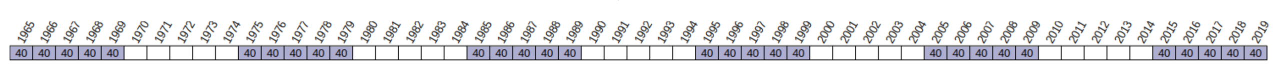
Aim

Therefore, the aim is to investigate:

1. whether an increase or decrease in **repetitive elements/self-similarity** from an acoustic perspective can be observed in **German chart songs** over the past decades, and how this might be reflected in different possible measures of repetition and self-similarity within the music signal.
2. whether songs at **higher chart positions** are characterized by a higher amount of repetition.

Methods

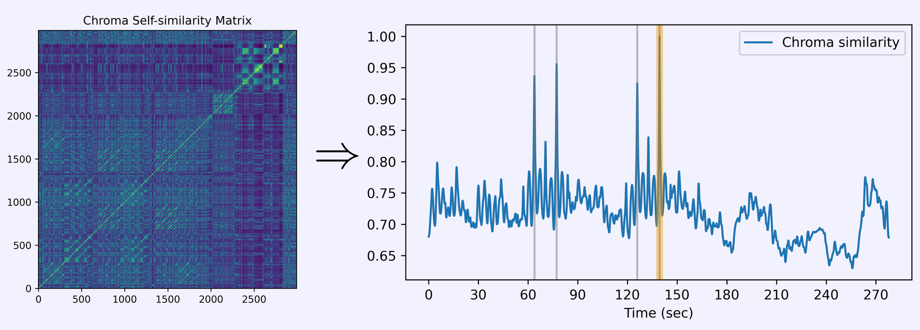
The **top 40** recordings of the year-end music charts in Germany were collected for five-year blocks over six decades (similar to Schellenberg & von Scheve, 2012) from **1965** to **2019** – resulting in a total of **1200 songs**.



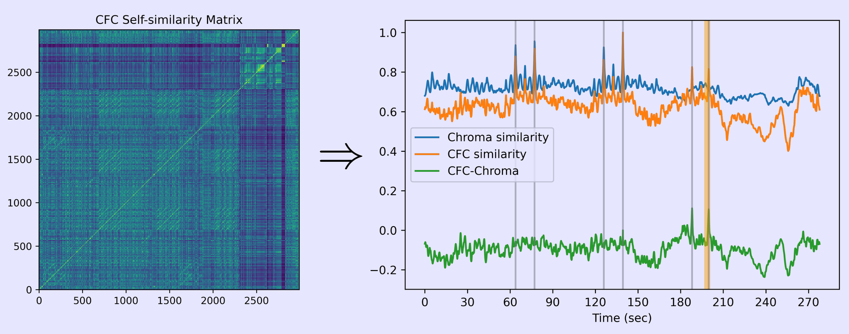
The audio signals were analyzed for three main **different measures** of repetition and self-similarity:

Repetitions per Minute (RPM)

The most saliently/often **repeated section** was extracted and its occurrences counted based on Chroma similarity via `LibROSA` (McFee et al., 2015) and **pychorus** (based on Goto, 2006).

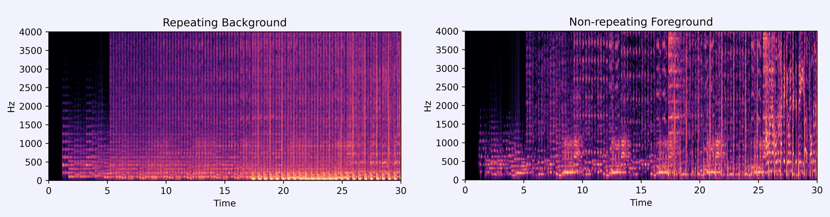


In order to account for *transposed repetitions* as well, a different signal representation is proposed - *Chroma Fourier Coefficients (CFC)*, obtained by applying a Fourier transform to the Chroma vector.



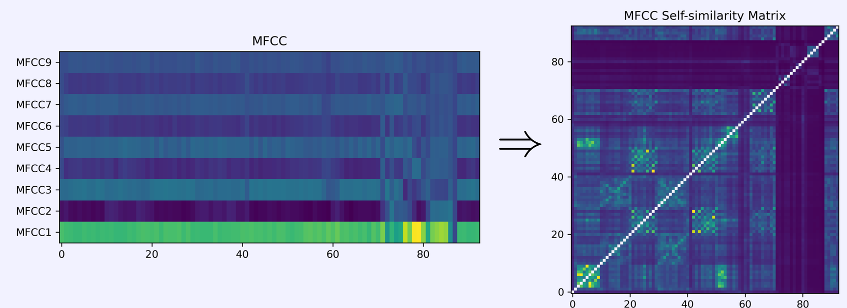
Repetitive Background Ratio (RBR)

The ratio of **repetitive background elements** in relation to the non-repeating foreground was extracted using the `REPET` algorithm (Rafii & Pardo, 2012).



Timbral Self-similarity (TSS)

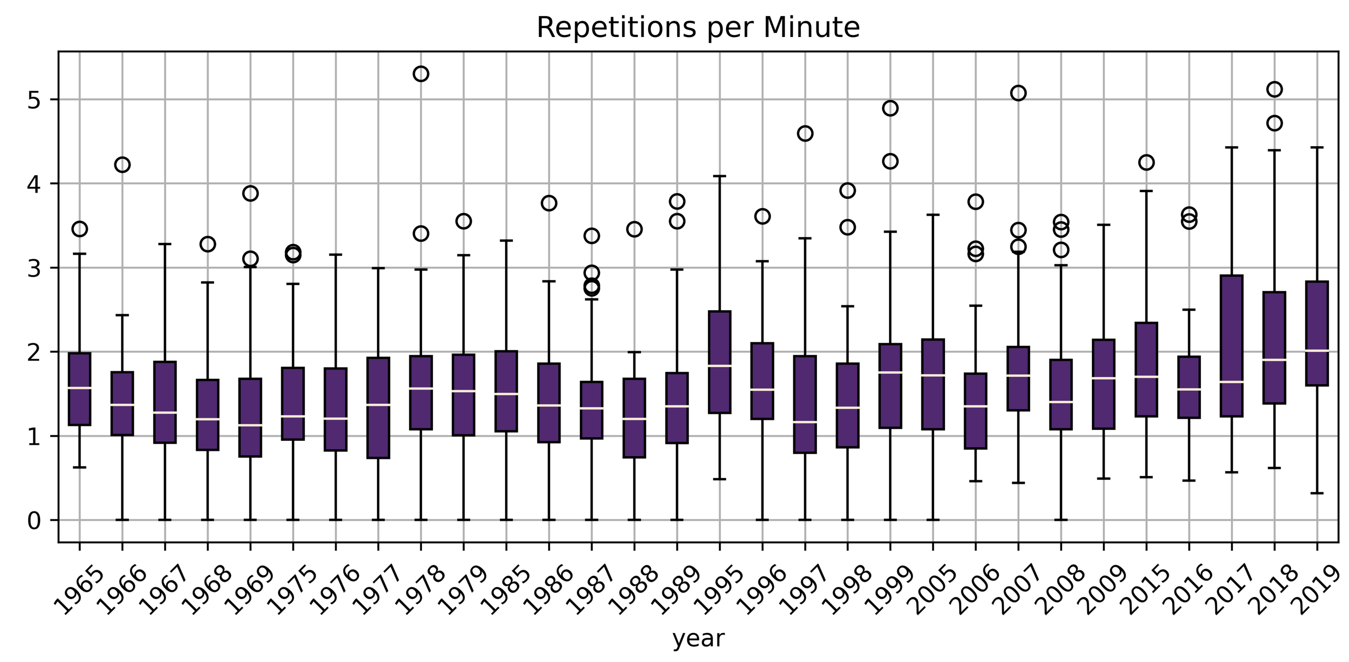
As a measure of timbral self-similarity, the average **pairwise MFCC similarity** was calculated across 3-second windows (excluding the main diagonal). Extraction of the first 20 MFCCs was done via `LibROSA`.



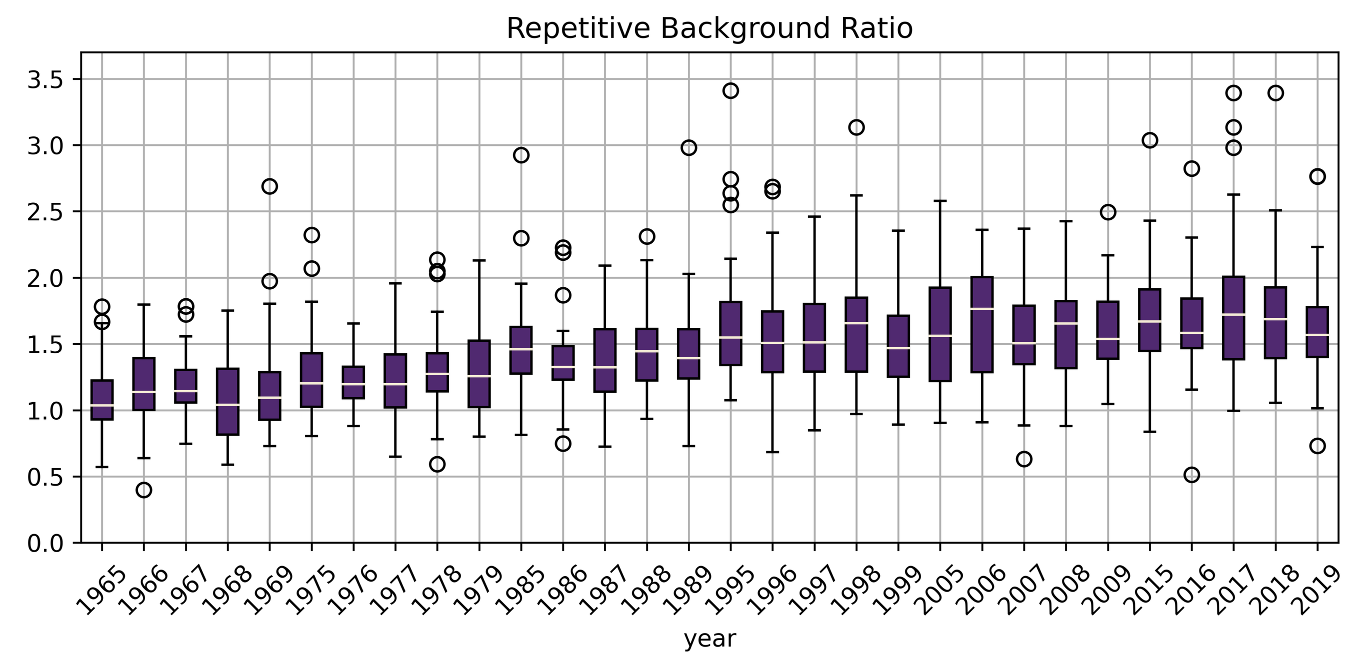
The extracted measures were analyzed for possible trends over the years using **Mann-Kendall trend test**. The relation to the chart position was investigated via **Pearson correlation**.

Results

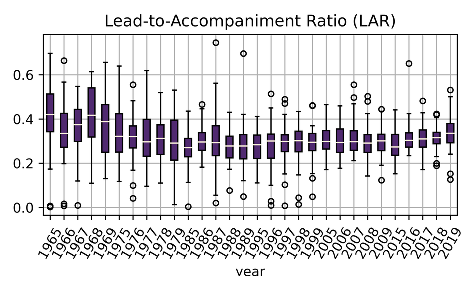
According to a Mann-Kendall trend test, the detected number of **repetitions per minute** shows a significant **increase** in the observed years ($p = 0.003$). This is also the case when considering transposed repetitions via CFC ($p < 0.001$). An increase can still be observed when controlling for duration and recognized tempo.



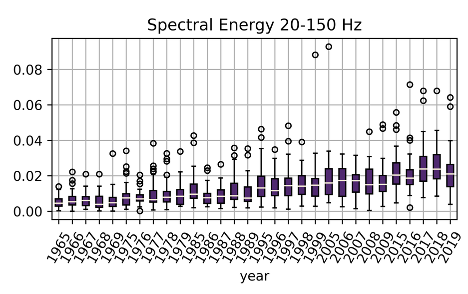
A steady **increase** over the decades can also be observed in case of the **repetitive background ratio** (RBR) ($p < 0.001$).



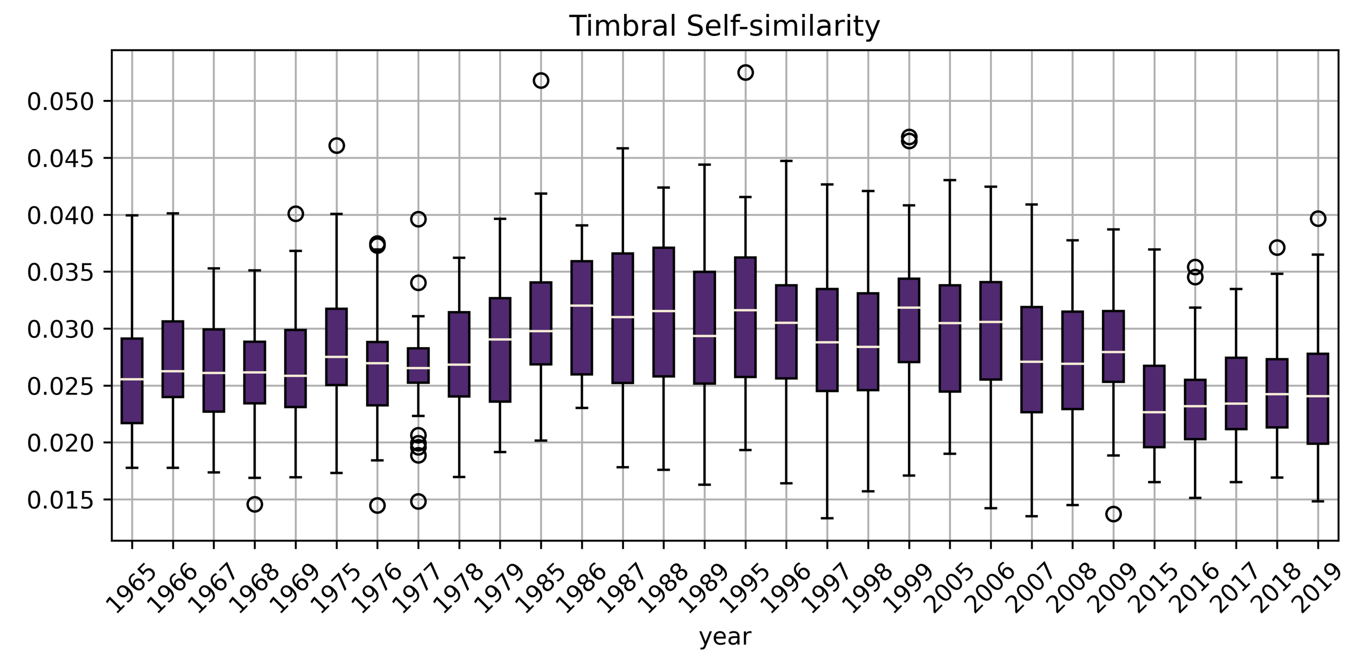
This holds true when controlling for the *Lead-to-Accompaniment Ratio (LAR)*. The LAR shows a decrease until the end of the 1970s (as was also observed for the Billboard charts by Gerdes & Siedenburg, 2023).



However, RBR increase seems to be driven by the higher level of (repetitive) *bass components* (which show a strong increase over the years - see also Hove et al. 2019).



Timbral self-similarity increases until 1990 but decreases in the years after ($<$ **1990**: $incr., p < 0.001$; $>=$ **1990**: $decr., p = 0.002$).



No significant correlations were found between the **chart position** and any of the investigated measures.

Feature	r	p
RPM	0.034	0.833
RBR	0.095	0.561
TSS	0.079	0.630

Conclusion & Outlook

Multiple measures were included in order to reflect different aspects of repetition and self-similarity in the analyzed music corpus. Overall, the results indicate an **increase of repetitive elements** – possibly enabling higher processing fluency – in German chart songs over the past decades, especially from 1965–1990. In order to get a more comprehensive picture, repetition should be considered at different time spans and with various degrees of variation in different musical parameters. A software tool is being developed that enables interactive exploration and visualization of self-similarity across different audio dimensions (see below).

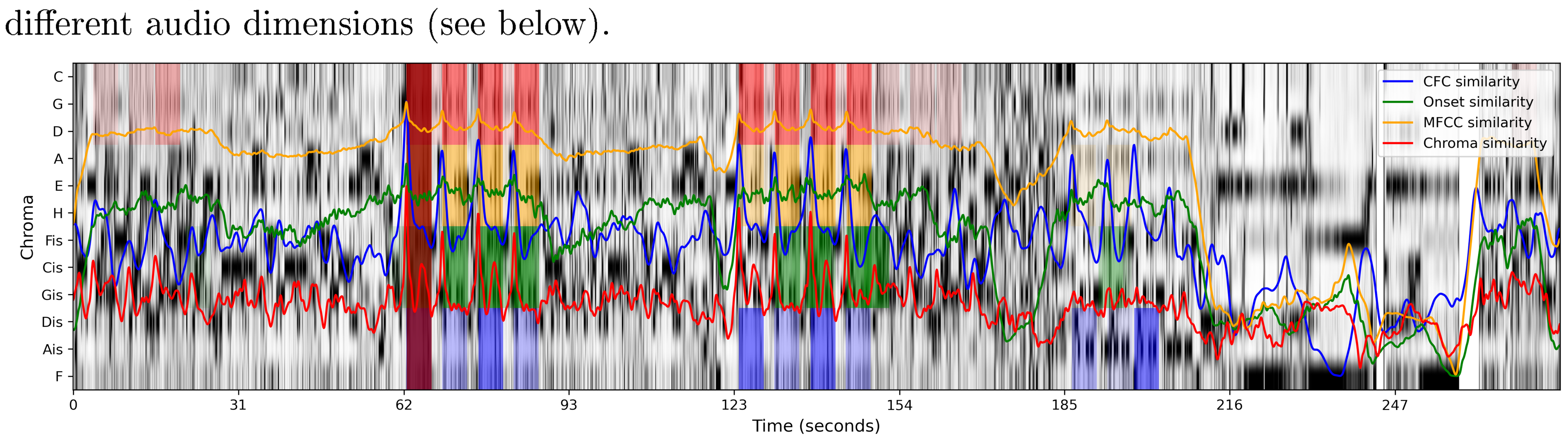


Figure 1: Identification of similar sections across different representations of the audio signal.

References

Gerdes, K., & Siedenburg, K. (2023). Lead-vocal level in recordings of popular music 1946–2020. *JASA Express Letters*, 3(4). | **Goto, M. (2006).** A chorus section detection method for musical audio signals and its application to a music listening station. *IEEE Transactions on Audio, Speech, and Language Processing, 14*, 1783-1794. | **Hove, M. J., Vuust, P., & Stupacher, J. (2019).** Increased levels of bass in popular music recordings 1955–2016 and their relation to loudness. *The Journal of the Acoustical Society of America*, 145(4), 2247-2253. | **Margulis, E. H. (2014).** *On repeat: How music plays the mind.* Oxford University Press. | **McFee, B., Raffel, C., Liang, D., Ellis, D. P., McVicar, M., Battenberg, E. & Nieto, O. (2015).** librosa: Audio and music signal analysis in python. *Proceedings of the 14th python in science conference.* | **Nunes, J. C., Ordanini, A., & Valsesia, F. (2015).** The power of repetition: Repetitive lyrics in a song increase processing fluency and drive market success. *Journal of Consumer Psychology, 25(2)*, 187-199. | **Rafii, Z., & Pardo, B. (2012).** Repeating pattern extraction technique (REPET): A simple method for music/voice separation. *IEEE transactions on audio, speech, and language processing, 21(1)*, 73-84. | **Schellenberg, E. G., & von Scheve, C. (2012).** Emotional cues in American popular music: Five decades of the Top 40. *Psychology of Aesthetics, Creativity, and the Arts, 6(3)*, 196-203. | **Yu, G. C. J., & Ying, L. F. (2015).** An analysis of repetitive motifs and their listening duration in selected western popular songs from 2000 to 2013. *Procedia-Social and Behavioral Sciences, 185*, 18-22.