Decoding the sound of 'hardness' and 'darkness' as perceptual dimensions of music

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Hardness

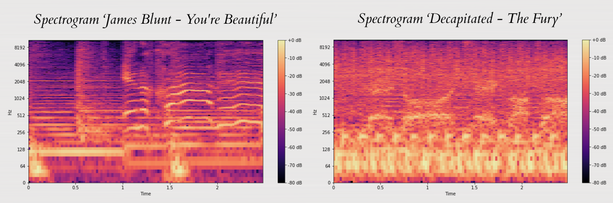
'Hardness' is often considered a distinctive feature of (heavy) metal music, as well as in genres like hardcore techno or 'Neue Deutsche Härte'. In a previous investigation the concept of 'hardness' in music was examined in terms of its acoustic correlates and suitability as a descriptor for music [Czedik-Eysenberg et al. 2017].

Sound Features

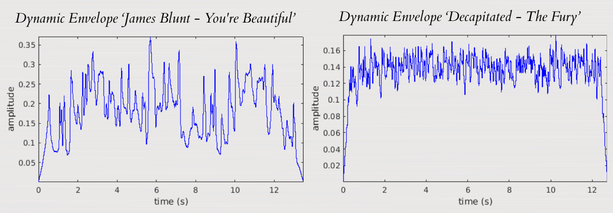
Considering Bonferroni correction, 65 significant feature correlations were found for the concept of 'hardness'.

The characterizing attributes of 'hardness' include **high tempo** and **sound density**, less focus on clear melodic lines than **noise-like** sounds and especially the occurrence of strong **percussive** components.

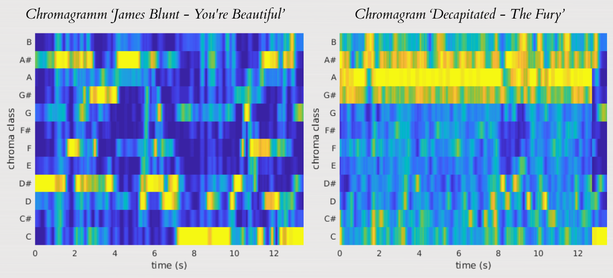
1. percussive energy / rhythmic density



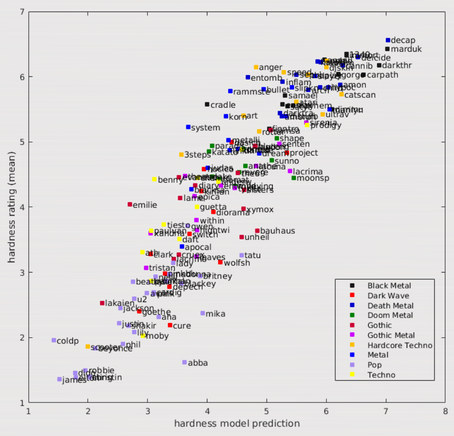
2. dynamic distribution



3. melodic content / harmonic entropy



Model



Sequential feature selection
↓
set of 5 features
↓
predictive linear regression model

RMSE	R^2	MSE	MAE	r
0.64	0.80	0.40	0.49	0.90

Rater Agreement

Intraclass Correlation Coefficient (Two-Way Model, Consistency): **0.653**

Aims

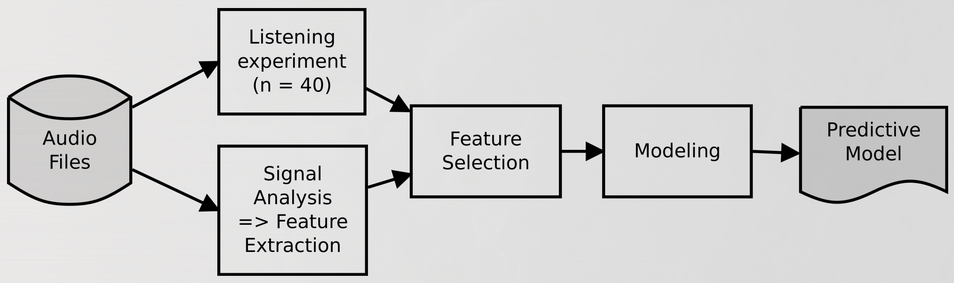
The semantic concepts of 'hardness' and 'darkness' in music are analyzed in terms of their corresponding sound attributes. Based on listening test data, predictive models for both dimensions are created and compared.

Method

Based on last.fm listener statistics, 150 pieces of music were selected from 10 different subgenres of metal, techno, gothic and pop music.

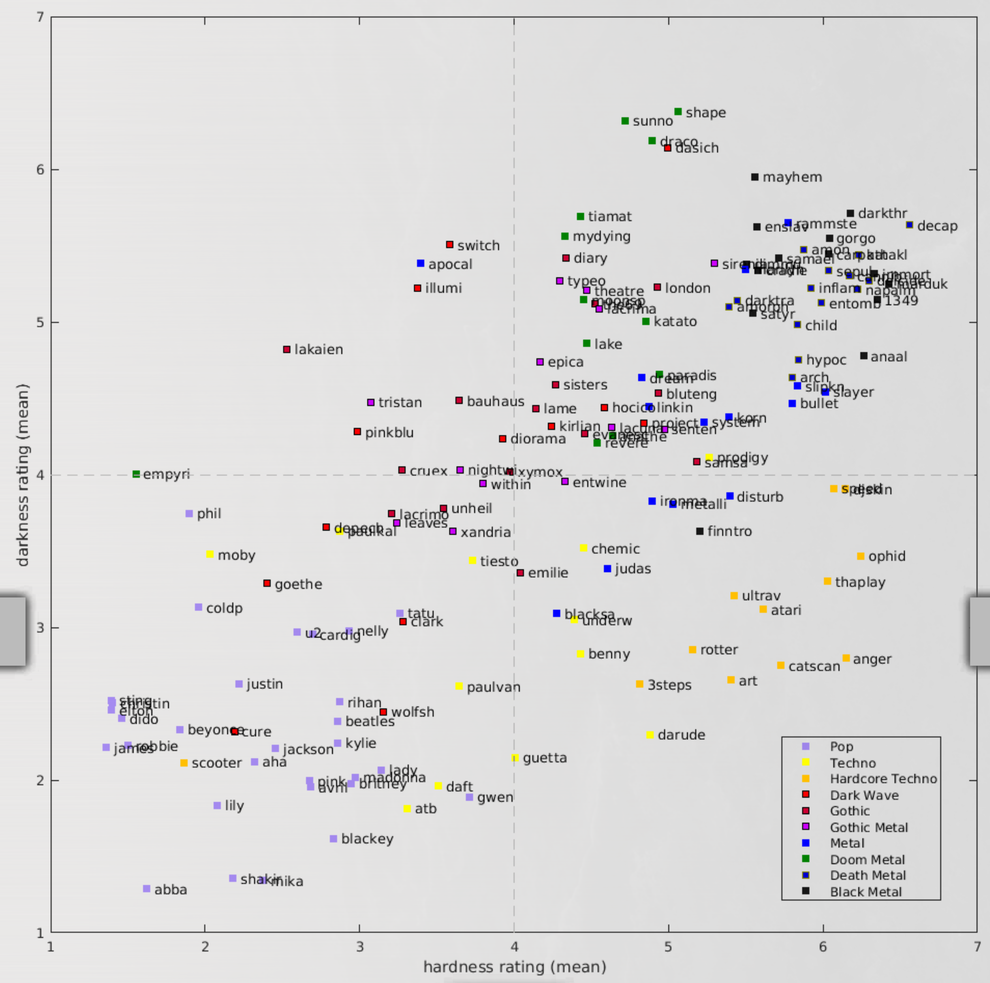
last.fm

In an online listening test, 40 participants were asked to rate the refrain of each example in terms of 'hardness' and 'darkness'. These ratings served as a ground truth for examining the two concepts using a machine learning approach:



Taking into account 230 features describing spectral distribution, temporal and dynamic properties, relevant dimensions were investigated and combined into models. Predictors were trained using five-fold cross-validation.

Data



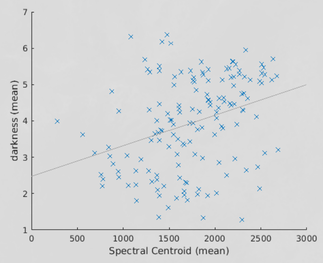
Darkness

Certain kinds of music are sometimes described as 'dark' in a metaphorical sense, especially in genres like gothic or doom metal. According to musical adjective classifications 'dark' is part of the same cluster as 'gloomy', 'sad' or 'depressing' [Hevner 1936], which was later adopted in computational musical affect detection [Li & Oghihara 2003]. This would suggest the relevance of sound attributes that correspond with the expression of sadness, e.g. lower pitch, small pitch movement and 'dark' timbre [Huron 2008]. In timbre research 'brightness' is often considered one of the central perceptual axes [Grey 1975; Siddiq et al. 2014], which raises the question if 'darkness' in music is also reflected as the inverse of this timbral 'brightness' concept.

Sound Features

Considering Bonferroni correction, 35 significant feature correlations were found for the 'darkness' ratings.

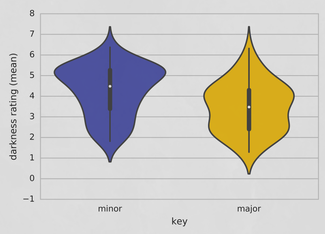
While a suspected negative correlation with **timbral 'brightness'** can **not** be confirmed, 'darkness' appears to be associated with a high **spectral complexity** and harmonic traits like **major or minor mode**.



No evidence for negative correlations between darkness rating and measures for brightness:

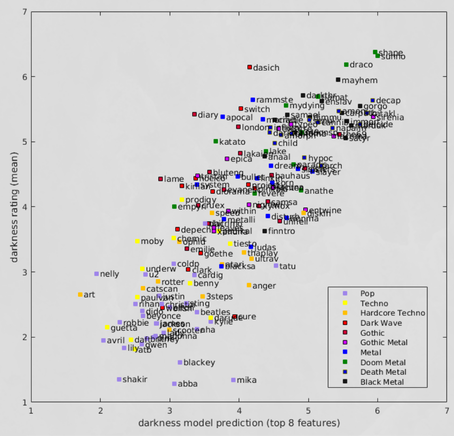
Feature	r	p
Spectral centroid	0.334	<0.01
High frequency content	0.153	0.063

Musical excerpts in minor mode were significantly rated as 'harder' than those in major mode. ($p < 0.01$ according to t-test)



Model

Sequential feature selection
↓
set of 8 features
↓
predictive linear regression model



RMSE	R^2	MSE	MAE	r
0.81	0.60	0.65	0.64	0.798

Rater Agreement

Intraclass Correlation Coefficient (Two-Way Model, Consistency): **0.498**

Further Results & Conclusions

Comparison

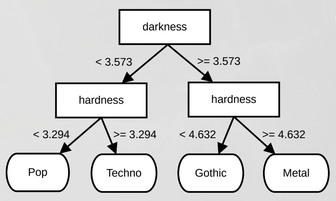
When comparing 'darkness' and 'hardness', the results indicate that the latter concept can be more efficiently described and modeled by specific sound attributes:

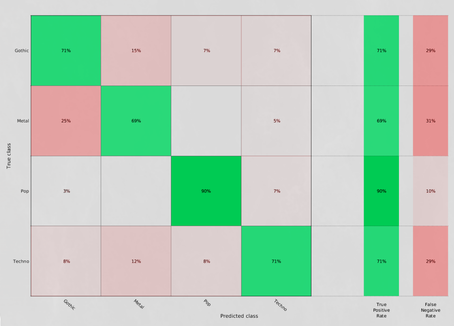
- The consistency between ratings given by different raters is higher for 'hardness' (see Intraclass Correlation Coefficients)
- For the 'hardness' dimension, a model can be based on a more compact set of features and at the same time leads to a better prediction rate

Further application

Although a considerable linear relation ($r = 0.65$, $p < 0.01$) is present between the two dimensions within the studied dataset, the concepts prove to be useful criteria for distinguishing music examples from different genres.

E.g. a simple tree can be constructed for classification into broad genre categories (Pop, Techno, Metal, Gothic) with an accuracy of 74 %.





Conclusion

'Hardness' and 'darkness' constitute perceptually relevant dimensions for a high-level description of music. By decoding the sound characteristics associated with these concepts, they can be used for analyzing and indexing music collections and e.g. in a decision tree for automatic genre prediction.

References

Czedik-Eysenberg, I., Knauf, D., & Reuter, C. (2017) 'Hardness' as a semantic audio descriptor for music using automatic feature extraction. Gesellschaft für Informatik, Bonnhttps://doi.org/10.18420/in2017_06 || Grey, J.M. (1975) An Exploration of Musical Timbre. Stanford University, CCRMA Report No.STAN-M-2 || Li,T., Ogihara,M. (2003) Detecting emotion in music. 4th ISMIR Washington & Baltimore; S. 239-240 || Huron, D. (2008) A comparison of average pitch height and interval size in major-and minor-key themes. Empirical Musicology Review, 3; S. 59-63 || Siddiq,S. et al. (2014) Kein Raum für Klangfarben - Timbre Spaces im Vergleich. 40. DAGA; S. 56-57