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“Heaviness” and the metal music guitar. Interactions between harmonic structure and sound from acoustic and perceptual perspectives

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Background

In the metal music studies discipline, "heaviness" is considered the determining criterion of the genre. On the ground of Berger's (1999) work on death metal, heaviness has been associated with the sound of the electric guitar until today. Berger and Fales (2005) claimed the dominance of treble frequencies, high loudness and harmonic dissonance to constitute heaviness. Since it greatly affects these parameters, Berger and Fales concluded guitar distortion to be the primary acoustic phenomenon of heaviness in metal music. The list of research on heaviness and the distorted electric guitar is short. From a music theory perspective, perfect intervals and chords of little structural complexity produce a more consonant sensation because more of the partials intensified by distortion coincide (Lilja, 2015; Herbst, 2017).
Recent work by Czedik-Eysenberg, Knauf and Reuter (2016, 2017) showed that musical heaviness can be quantified with acoustic features. Accordingly, percussive elements, a flat envelope, high loudness and intensive treble frequencies increase the sensation of heaviness irrespective of any musical genre.

Research interest and method

This study explored the interaction between the electric guitar's sounds and chord structures acoustically and perceptually. Based on findings in music theory, metal music studies and the author's experience as a guitar player, playing complex chords with overdriven and distorted sounds was expected to diminish sensory pleasantness. This sensation was assumed part of what constitutes the feeling of heaviness. Moreover, the reasons for this perception such as acoustic features and personal factors were of interest. The research followed a two-phase design with subsequent triangulation.

1. *Acoustic experiment*: Power chords (fifth interval), major, minor and altered dominant chords were recorded with three guitars, five valve amplifiers and three sounds (clean, overdrive, distortion). The 270 samples were analysed with music information retrieval technology (Lartillot & Toiviainen, 2007), following a design similar to Czedik-Eysenberg, Knauf and Reuter's (2016, 2017) work. The sensory pleasantness was operationalised with Terhardt's (1984) and Aures' (1985) model that considers both musical harmony and sensorial consonance. Roughness, spectral fluctuation, sharpness, loudness and tonalness served as key parameters.
2. *Listening experiment*: Chords with the three different sounds taken from the acoustic experiment were rated by 171 respondents (mean age 22.06 years; SD = 3.33; 53% women) on a 10-point scale (1 = very unpleasant, 10 = very pleasant). Every chord was rated three times to reduce order effects. The mean ratings were transformed into scales for the sounds with excellent reliability (clean α = .92, overdrive and distortion α = .97) and explained variance (clean 67%, overdrive 82%, distortion 88%).

Results

Acoustic experiment

As the different guitars and amplifiers did not significantly affect the five acoustic parameters, they were not taken into account further. This result and the descriptive statistics (Table 1) indicate structure and sound to influence the features of the audio samples primarily. Regression analyses (Table 2) highlight the influence of structure and sound. The structural complexity was much more relevant than the sound in the case of tonalness. All other parameters however reacted to the sound more, even if to a different degree.

Table 1: Descriptive statistics of the parameters of sensory pleasantness

	Clean *M (SD)*	Overdrive *M (SD)*	Distortion *M (SD)*
Roughness	576 (330)	2,234 (1,157)	2,695 (1,338)
Spectral flux	19.51 (6.51)	53.45 (26.08)	83.42 (29.55)
Spectral centroid	1,168 (253)	1,512 (351)	2,322 (265)
Loudness	309 (38)	447 (33)	516 (51)
Tonalness	0.667 (0.098)	0.612 (0.122)	0.577 (0.116)

Table 2: Categorical regression models of the parameters of sensory pleasantness

		Regression				ANOVA	
		Beta	*F*	Sig.	adj. R^2	*F*	Sig.
Roughness	Structure	.48	126.84	< .001	.66	131.73	< .001
	Sound	.66	455.89	< .001			
Spectral flux	Structure	.50	358.10	< .001	.85	221.26	< .001
	Sound	.78	684.55	< .001			
Spectral centroid	Structure	.26	73.29	< .001	.78	192.61	< .001
	Sound	.85	1857.07	< .001			
Loudness	Structure	.10	11.15	.001	.81	285.17	< .001
	Sound	.90	4448.84	< .001			
Tonalness	Structure	–.84	1046.01	< .001	.81	191.73	< .001
	Sound	–.32	89.36	< .001			

Listening experiment

The descriptive values (Table 3) and the Figure of the listeners' ratings demonstrate the highest liking of major and power chords irrespective of the sound. Adding overdrive and distortion affected the rating of the least complex power chord least.
A MANOVA with repeated measures revealed a large effect on sound, $F(2)$ = 150.67, p < .001, η^2_p = .47 and an even larger effect on structure, $F(3)$ = 267.22, p < .001, η^2_p = .61. Both variables interacted with a medium to large effect, $F(6)$ = 53.38, p < .001, η^2_p = .24.

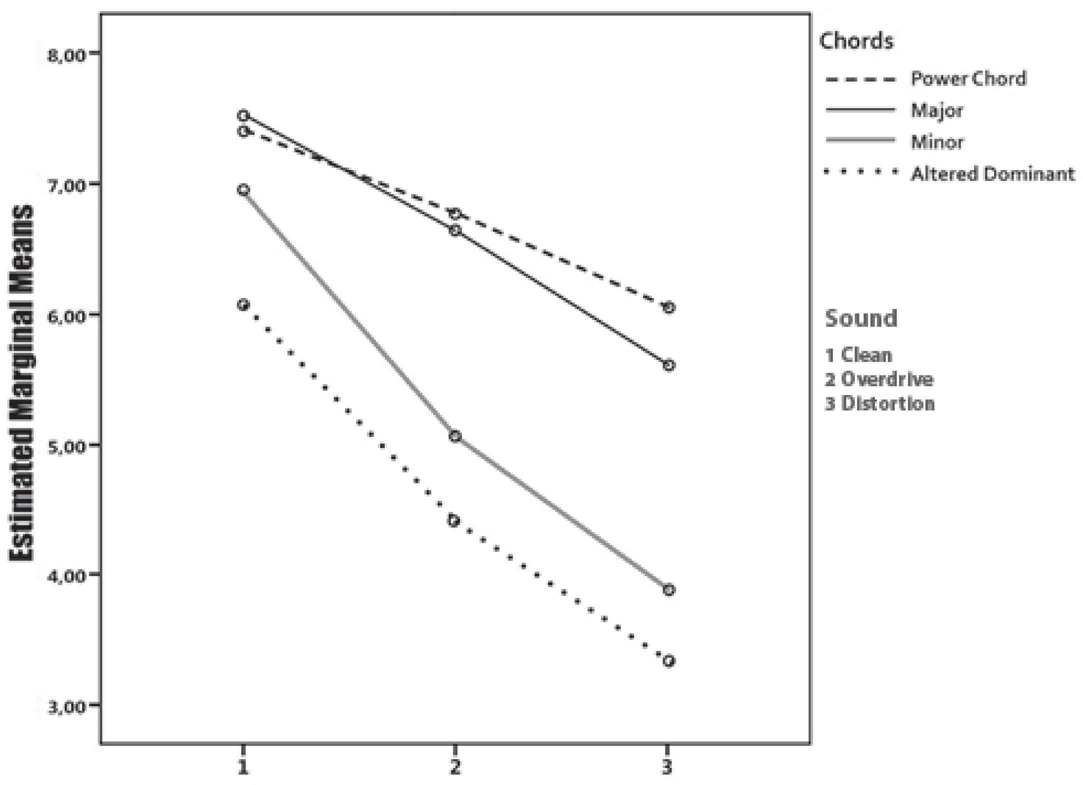

Figure 1: Influence of sound on the chord ratings

The tests of between-subjects' effects (Table 4) demonstrated a larger effect between overdriven and distorted sounds than these did between clean and overdriven sounds. The harmonically neutral power chord and the major chord differed only with a small effect. The ratings between all other chords differed much more. Overall, the differences between the chord ratings were greater when adding overdrive to a clean signal than when shifting from overdrive to distortion.

Table 3: Descriptive statistics of chord ratings with different sounds

	Power chord *M (SD)*	Major *M (SD)*	Minor *M (SD)*	Altered dominant *M (SD)*
Clean	7.40 (1.48)	7.52 (1.46)	6.96 (1.60)	6.06 (2.04)
Overdrive	6.76 (1.97)	6.64 (2.03)	5.05 (2.22)	4.40 (2.26)
Distortion	6.06 (2.48)	5.61 (2.59)	3.89 (2.52)	3.35 (2.46)

Table 4: Tests of Between-Subjects Effects of structure and sound

Effect			MS	F	Sig.	η^2_p
Sound	clean vs. overdrive		276.33	98.13	< .001	.37
	overdrive vs. distortion		166.45	178.78	< .001	.51
Structure		power chord vs. major	3.89	10.66	.001	.06
		major vs. minor	283.90	237.66	< .001	.58
		minor vs. dominant	83.59	99.90	< .001	.37
Sound * Structure	clean vs. overdrive	power chord vs. major	9.12	10.68	.001	.06
		major vs. minor	180.46	91.34	< .001	.35
		minor vs. dominant	10.48	6.63	.011	.04
	overdrive vs. distortion	power chord vs. major	19.56	28.15	< .001	.14
		major vs. minor	2.75	2.05	.154	.01
		minor vs. dominant	2.04	2.27	.134	.01

Table 5: Tests of Between-Subjects Effects for the distorted sound

	SS	df	MS	F	Sig.	η^2_p
Corrected Model	530.30[a]	18	29.46	11.41	.000	.59
Intercept	11.03	1	11.03	4.27	.041	.03
Age (A)	27.72	1	27.72	10.74	.001	.07
Gender (G)	1.21	1	1.21	.47	.495	.00
Music_Preference (MP)	109.41	4	27.35	10.59	.000	.23
E-Guitar (EG)	23.69	1	23.69	9.18	.003	.06
G * MP	19.33	4	4.83	1.87	.119	.05
G * EG	5.27	1	5.27	2.04	.155	.01
MP * EG	14.81	4	3.70	1.43	.226	.04
Ge * MP * EG	15.99	2	7.99	3.10	.048	.04
Error	371.81	144	2.58			
Total	4623.18	163				
Corrected Total	902.11	162				

a. R Squared = .59 (Adjusted R Squared = .54)

Person-related factors hardly affected the ratings of the clean sound but they did so in the cases of overdrive and distortion. Yet, the results of the overdriven and distorted sounds were similar. The univariate ANOVA (Table 5) of ratings of distorted sounds showed music preference to be most relevant, followed by the age and being an electric guitar player. Older participants showed a higher liking of distorted chords, r = .32, p < .001, as did men, r = .26, p < .001. Being a guitar player also affected the rating positively, r = .33, p < .001.

Triangulation

Spearman correlation indicated a close connection between the listeners' ratings and most of the acoustic values (Table 6).
In compliance with the psychoacoustic model (Terhardt, 1984; Aures 1985), all parameters but tonalness reduced the pleasantness of the chords. Roughness correlated with the listeners' ratings least. In contrast, spectral flux as an alternative parameter for roughness had an almost perfect correlation. Strong effects of spectral centroid and loudness were also confirmed to reduce pleasantness. Apart from the single parameters, Spearman correlation demonstrated a close connection between perceived pleasantness and structural complexity (r = −.63, p < .001) as well as between pleasantness and tonal quality (r = −.72, p < .001). Thus, more complex chords and greater distortion levels negatively affected the sensory pleasantness for many listeners.

Table 6: Correlation matrix of sociodemographic data and parameters of sensory pleasantness.

	Roughness	Spectral flux	Spectral centroid	Loudness	Tonalness
Total sample (N = 171)	$-.41^{*}$	$-.90^{***}$	$-.74^{***}$	$-.67^{***}$	$.67^{***}$
Rock / metal preference (N = 70)	$.06^{ns}$	$-.53^{***}$	$-.30^{ns}$	$-.19^{ns}$	$.30^{ns}$
No rock / metal preference (N = 84)	$-.58^{***}$	$-.94^{***}$	$-.79^{***}$	$-.77^{***}$	$.74^{***}$
Female (N = 91)	$-.46^{**}$	$-.92^{***}$	$-.78^{***}$	$-.71^{***}$	$.69^{***}$
Male (N = 80)	$-.23^{ns}$	$-.79^{***}$	$-.59^{***}$	$-.50^{**}$	$.55^{***}$
Guitarist (N = 35)	$.13^{ns}$	$-.51^{***}$	$-.25^{ns}$	$-.15^{ns}$	$.23^{ns}$
No guitarist (N = 136)	$-.45^{**}$	$-.92^{***}$	$-.76^{***}$	$-.69^{***}$	$.70^{***}$
Age up to 24 (N = 132)	$-.42^{**}$	$-.91^{***}$	$-.75^{***}$	$-.68^{***}$	$.68^{***}$
Age above 24 (N = 31)	$-.18^{ns}$	$-.76^{***}$	$-.58^{***}$	$-.48^{***}$	$.52^{***}$

*Note: * p < .05, ** p < .01, *** p < .001; rock / metal preference: persons with value below 3; no rock / metal preference: persons with value above 3.*

Person-specific variables played an important role. It was the musical preference mainly determining the perception of distortion. None of the parameters except for spectral flux significantly decreased the liking for metal fans whereas for participants not fond of rock and metal music every parameter affected their perception.

Conclusion

Both parts of the experiment indicated overdrive and distortion to alter the acoustic features and the perception of guitar chords significantly. The sound took greater influence on the acoustic properties than structure whilst the listening study emphasised the great relevance of person-related factors. Spectral fluctuation increased by distortion was the most relevant parameter to affect the liking, yet sharpness, loudness and reduced tonalness proved to be important too. This result complies with the findings by Czedik-Eysenberg, Knauf and Reuter (2016, 2017) on musical heaviness.
It can be concluded that adding overdrive and distortion to the guitar affects listeners very differently. For metal fans, more distortion hardly reduced the pleasantness even in the case of complex chord structures. Only increased spectral fluctuation associated with the guitar playing style in black metal affected their liking negatively. The results suggest that metal fans may require structural heaviness by harmonic and rhythmic complexity whilst the sound of the distorted guitar is likely to be sufficient for most of the non-metal audience to dislike the sound or to perceive it as heavy.

References

Aures, W. (1985). Der sensorische Wohlklang als Funktion psychoakustischer Empfindungsgrößen. *Acustica*, 58, 282–290 || Berger, H. M. (1999). *Metal, Rock, and Jazz. Perception and Phenomenology of Musical Experience.* Hanover || Berger, H. M. & Fales, C. (2005). "Heaviness" in the Perception of Heavy Metal Guitar Timbres. The Match of Perceptual and Acoustic Features over Time. In P. D. Greene & T. Porcello (Eds.): *Wired for sound. Engineering and technologies in sonic cultures.* Middletown, 181–197 || Czedik-Eysenberg, I., Knauf, D. & Reuter, C. (2016). Was macht Musik „hart"? Heavy Metal & Co. aus psychoakustischer Perspektive. Poster presented at the 32. annual conference "Akustik und Musikalische Hörwahrnehmung" of the German Society for Music Psychology (DGM), University of Vienna, 9.-11. September 2016 || Czedik-Eysenberg, I., Knauf, D. & Reuter, C. (2017). Was macht Musik "hart"? Klangliche Merkmale zur genreübergreifenden Identifikation musikalischer Härte. *Fortschritte der Akustik.* DAGA 2017, 43. German annual conference for acoustics. Kiel, 186-189 || Helmholtz, H. v. (1863). *Die Lehre von den Tonempfindungen als physiologische Grundlage für die Theorie der Musik.* Braunschweig || Herbst, J.-P. (2017). Akkordstrukturen im verzerrten Rockgitarrenriff. Eine experimental-analytische Studie zur Auswirkung von physikalischen und psychoakustischen Faktoren. *ASPM Samples,* 15, 1–27 || Lartillot, O. & Toiviainen, P. (2007). A Matlab Toolbox for Musical Feature Extraction From Audio. *Proceedings of the 10th International Conference on Digital Audio Effects.* Bordeaux || Online: http://dafx.labri.fr/main/papers/p237.pdf || Lilja, E. (2015). Dealing with the 3rd: Anatomy of distorted chords and subsequent compositional features of classic heavy metal. In T.-M. Karjalainen & K. Kärki (Eds.). *Modern Heavy Metal – Markets, Practices and Cultures.* Helsinki, 393–403 || Terhardt, E. (1984). The Concept of Musical Consonance: A Link Between Music and Psychoacoustics. *Music Perception,* 1(3), 276–295.

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