

# Physiological and Acoustical Correlates of Unpleasant Sounds

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## Background

It had been shown in an explorative study\*, that chalkboard squeaking noises are perceived as extremely unpleasant especially because of two timbral attributes: a very intense pitch salience as well as strong amplitudes in a frequency band between 2 and 4 kHz. In a replication study the general validity of these results have been examined under several test conditions on a higher number of test subjects as well as on further unpleasant noises.

(\*Reuter, Oehler 2011; based on Boyd 1959; Ely 1975; Halpern et al. 1986; Neumann, Waters 2006; Cox 2008; Grewe et al. 2010).

## Aims and leading questions

- To what extent is it possible to generalize the distinct pitch salience and the strong spectral amplitudes between 2000 and 4000 Hz as typical attributes of unpleasant noises?
- Why does a vomiting noise lead the ranking list of unpleasant noises (cf. Cox 2008) although it has neither a perceptible pitch salience nor a strong frequency band between 2000 and 4000 Hz?
- Are there any differences in the physiological reaction and/or subjective estimation, when the test subject is informed (vs. is not informed) about the real origin of the noise?
- Are there any differences in the listeners' subjective judgements while listening to the noises via headphones or via loudspeakers?

## Methods and Stimuli

Test subjects (TS): N = 96 listeners, arranged into four groups:

- **Group A:** Listening via headphones, TS know about the real origin of the stimuli.
- **Group B:** Listening via headphones, TS were told, the stimuli are „contemporary music“
- **Group C:** Listening via loudspeaker, TS know about the real origin of the stimuli.
- **Group D:** Listening via loudspeaker, TS were told, the stimuli are „contemporary music“

Headphones: Elektrostatic headphones (Koss E/90; ESP 950)

Loudspeakers: Elektrostatic speakers (Audiostatic ES 200 rs)

(Test subjects: age: M = 30,26; SD = 13,14; gender: male: 34,4 %, female: 65,6 %)

Stimuli: Nails on chalkboard – Squeaking of styrofoam – Vomiting – Tschiritsch (or „throaty lung“ = bicycle pump played with double-reeds, contemporary experimental musical instrument) in seven variations:

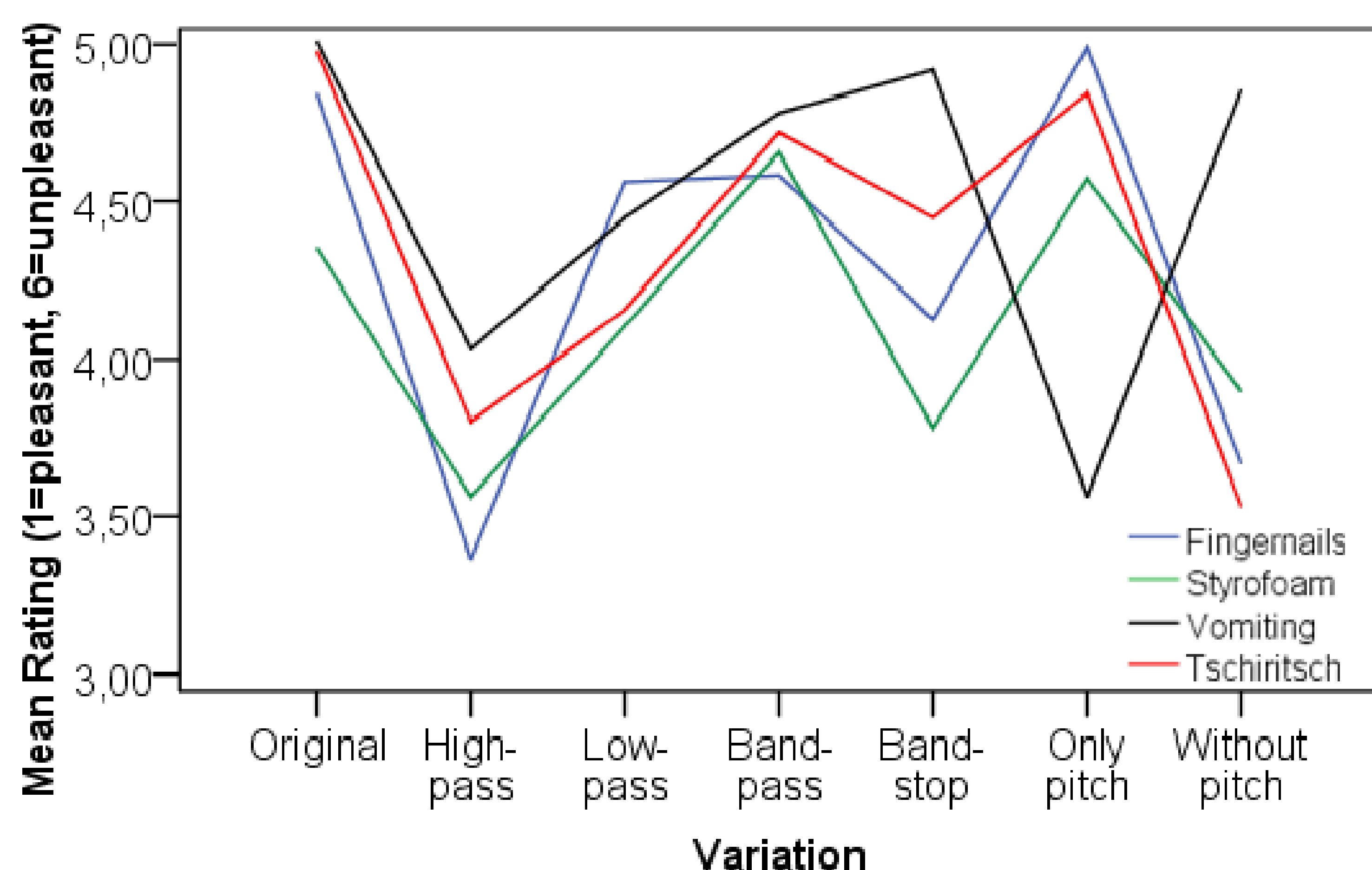
- original
- pitch only = only the pitch information (only harmonic spectral parts)
- noise only (without pitch) = only noisy parts (only inharmonic spectral parts)
- low-pass = low-pass filtered stimuli (only spectral parts below 2 kHz)
- band-pass = band-pass filtered stimuli (only spectral parts between 2 and 4 kHz)
- notch = notch filtered stimuli (without spectral parts between 2 and 4 kHz)
- high-pass = high-pass filtered stimuli (only spectral parts above 4 kHz)

Test subjects evaluate the stimuli and their variations on a Likert scale between 1 (very pleasant) and 6 (very unpleasant), while their skin conductance level and muscle tone is logged.

## Results

### A) Subjective Estimations:

Mean subjective ratings of (un)pleasantness for the different variations of the stimuli fingernails, styrofoam, vomiting and Tschiritsch (please note the contrary trajectory (black curve) for the sound versions of the vomiting noise)



## Results

Styrofoam Rating Tukey-HSD

(I) Variation	(J) Variation	Cohens d	Significance	95% confidence interval	
				Lower limit	upper limit
Original	High-pass	0,79	,000	,3622	1,2211
	Low-pass	0,25	,602	-,1794	,6794
	Band-pass	0,29	,366	-,7315	,1274
	Band-stop	0,61	,002	,1435	1,0024
	Pitch only	0,23	,741	-,6482	,2107
	Without pitch	0,47	,028	,0289	,8878
Band-Pass	Band-stop	0,85	,000	,4456	1,3044
Without pitch	Pitch only	0,69	,000	-,11065	-,2476

Tschiritsch Rating Tukey-HSD

(I) Variation	(J) Variation	Cohens d	Significance	95% confidence interval	
				Lower limit	upper limit
Original	High-pass	1,20	,000	,7191	1,6351
	Low-pass	0,80	,000	,3649	1,2809
	Band-pass	0,26	,629	-,1976	,7184
	Band-stop	0,51	,011	,0732	,9893
	Pitch only	0,13	,976	-,3226	,5934
	Without pitch	1,51	,000	,9899	1,9059
Band-Pass	Band-stop	0,24	,583	-,7288	,1872
Without pitch	Pitch only	1,22	,000	-,17705	-,8545

Fingernails Rating Tukey-HSD

(I) Variation	(J) Variation	Cohens d	Significance	95% confidence interval	
				Lower limit	upper limit
Original	High-pass	1,52	,000	1,0661	1,8922
	Low-pass	0,27	,407	-,1318	,6943
	Band-pass	0,26	,505	-,1526	,6735
	Band-stop	0,72	,000	,3057	1,1318
	Pitch only	0,15	,944	-,5589	,2672
	Without pitch	1,20	,000	,7640	1,5901
Band-Pass	Band-stop	0,14	,979	-,6027	,3319
Without pitch	Pitch only	1,16	,000	,8244	1,7590

Vomiting Rating Tukey-HSD

(I) Variation	(J) Variation	Cohens d	Significance	95% confidence interval	
				Lower limit	upper limit
Original	High-pass	0,80	,000	,5119	1,4465
	Low-pass	0,51	,007	,0952	1,0298
	Band-pass	0,21	,774	-,2381	,6965
	Band-stop	0,09	,997	-,3735	,5610
	Pitch only	1,26	,000	,9806	1,9152
	Without pitch	0,14	,956	-,3110	,6235
Band-Pass	Band-stop	0,14	,979	-,6027	,3319
Without pitch	Pitch only	1,16	,000	,8244	1,7590

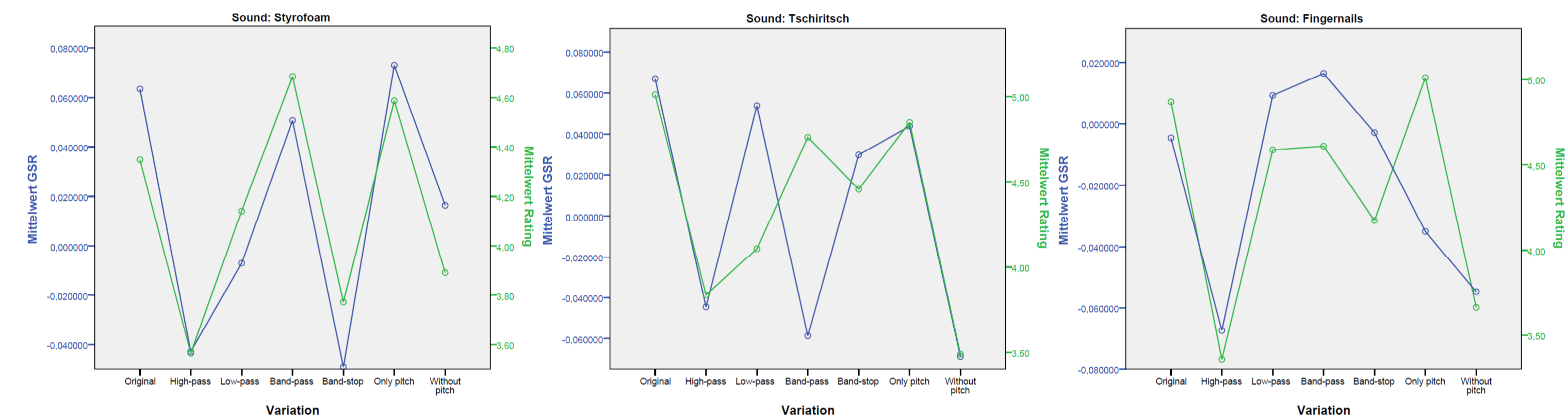
- There had been no significant differences between the listeners' judgements while listening via headphones (group A&B) and listening via loudspeaker (group C & D).

- There had been as good as no significant differences between the judgements of test subjects with previous knowledge about the real origin of the sounds (group A & C) and the test subjects, who took the sounds for excerpts from contemporary compositions (group B & D). The latter estimated tendentially the sounds as a little bit more pleasant (but without statistical significance).

- Exception: Vomiting (surely because even in the context of contemporary music the sound of vomiting is rather unusual).

### B) Physiological reactions: skin conductance and muscle tone

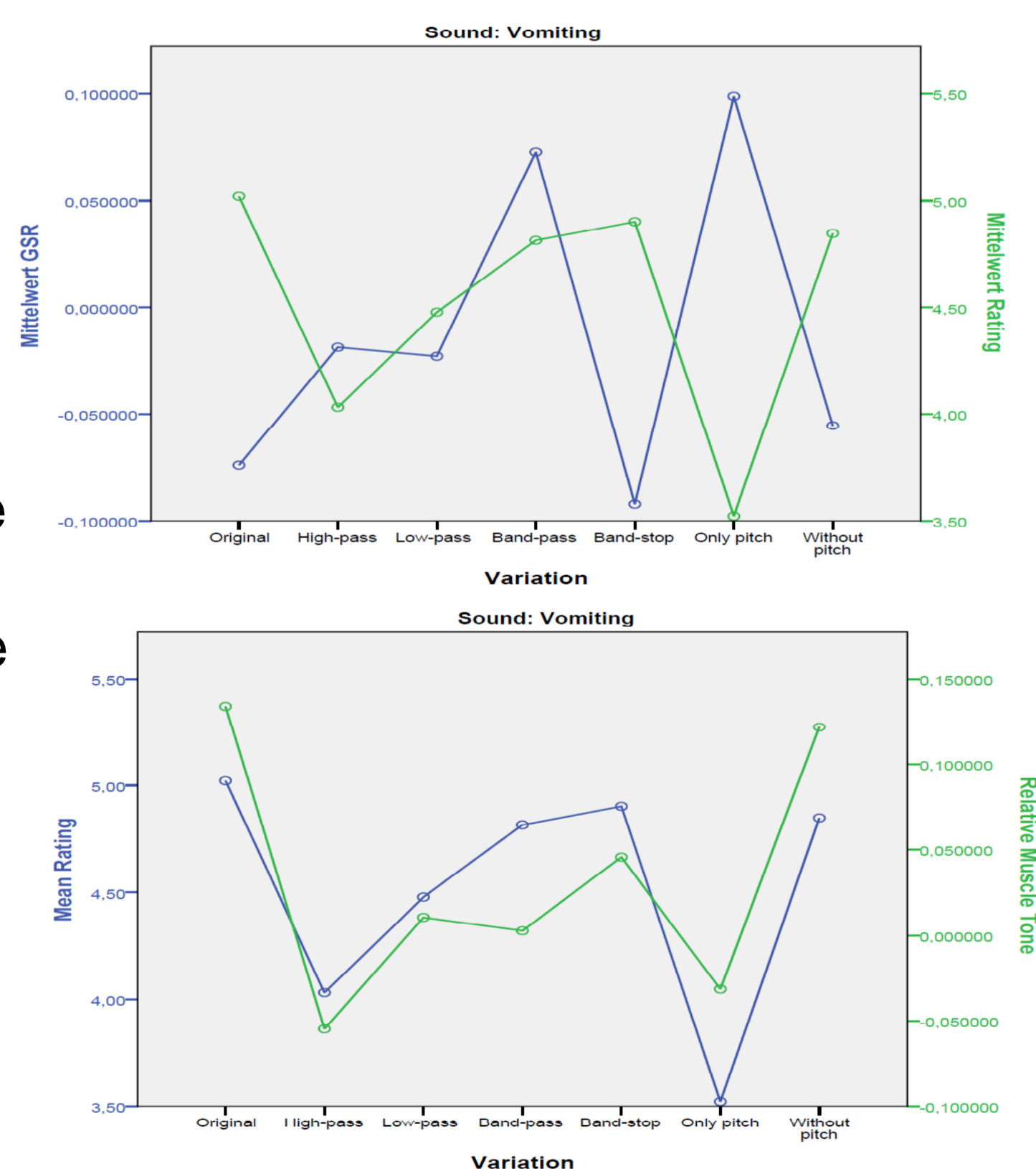
The correlations between the skin conductance values and the listeners' judgements are not significant, but in the case of sounds with a strong pitch salience (styrofoam, fingernails and Tschiritsch) the trajectories of the skin conductance are in a certain conformity with the curve shapes of the subjective listeners' judgements.



In case of the vomiting noise (a noise without perceptible pitch salience) a strong contradictory course of the skin conductance curve is visible.

No significant correlation between the muscle tone and the listeners' judgements could be found in the case of noises with a perceptible pitch salience, while in the case of the vomiting noise the correlation of the listeners' judgements and their muscle tone is clearly significant.

Furthermore in the case of the vomiting noise the muscle tone values of listeners, who took the sounds for contemporary music excerpts (group B & D), had been slightly higher than that of the non-misled test subjects (group A & C).



## Conclusion

➤ Unpleasant squeaking sounds like nails on chalkboard, styrofoam etc. are characterized by a **intense pitch salience** as well as by **strong spectral amplitudes between 2 and 4 kHz**. Without these attributes squeaking sounds are perceived as far more pleasant.

Psycho-acoustic explanation: Sensory pleasantness and tonality (Fastl & Zwicker 2006, p. 245ff.)

Physiological explanation: Self-resonance of the outer ear channel.

- The vomiting noise (cf. Cox 2008) is not so much perceived as unpleasant because of physiological/psycho-acoustical reasons but more **because of a certain deep emotion (disgust)** connected with this sound. This is not only because of the opposing trajectories of the skin conductance curve and the curve of the listeners' judgements, but also because of the significant correlation of the listeners' judgements with the muscle tone values. **The reason for the unpleasant perception is not in the vomiting sound by itself**, one has to consider this in listings like "The worst sound of the world".
- Independent of the listeners' prior knowledge the **skin conductance correlates tendentially** with the listeners' subjective judgements. In the case of the **vomiting** the **muscle tone correlates significantly** with the subjective listeners' sensation.
- The listeners' judgements **have not been influenced** by the way of presentation (headphone vs. loudspeakers)

## Literature

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