Shapes, Colors and Emotional Responses to Car Driving Sounds in Terms of Personality

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Background

Driving cars has developed over the years and so has perception of driving sounds: studies about car quality show that combustion engines are negatively rated regarding **tonal sharpness**, **roughness** and with an increasing A-weighted **sound pressure level** [1]. With growing use of electric engines, tonal components, noises of the chassis and sounds of driving now get more present due to the more silent powertrain in electric cars [2]. Most studies on electric cars focus on the perceived quality of the interior or the car in general and mainly collect verbal statements [e.g. 3] - how are driving sounds theirselves rated? Is electric engine perception contingent on differences in underlying audio characteristics?

Research about musical preferences indicate differences regarding personality traits and prefered tempo, genre and rhythm [4]. Furthermore, the perception of a restaurants atmosphere in terms of sound and music reveals personality differences and shows effects even in the context of noise perception [5]. Therefore, it is incorporated in this study if personality influences the associations and ratings of driving sounds to gain deeper insight in humans perception. Visual dimensions should enable to adress sensations of car driving sounds in multiple ways.

Hypotheses

The overall aim is to investigate for the first time, if and how visual and emotional associations are related to car driving sounds.

What is the relationship between car driving sounds‘ audio features and their associations in shapes and colors?

What impact does personality have on visual associations?

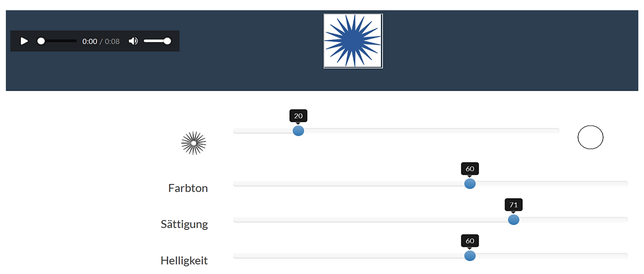
H1: There are correlations between subjective ratings and the most common audio properties spectral centroid (SC), attack time (AT) and spectral flux (SF) of engine sounds.
H2: Loudness (Zwickers) of sounds influences the appreciation (valence) negatively.
H3: There are group differences in terms of personality traits and associated colors and shapes to sounds.

Method

To explore which audio features are primarly responsible for appreciation of electric engine sounds, a pilot study (n=11) was carried out. A total of 38 accelerations (AC) and recuperation sounds (RE) were mainly desribed by acousticians on a 10-point scale in terms of their quality. The spectral analysis showed a strong connection between negative ratings and the proportional roughness, fluctuations and spectral energy in sounds (*r*=,761, p<0,01). After classifying over 500 more sounds in terms of their features, the results of the pilot study were taken into account to choose in total 32 prototypical original and manipulated stimuli (2x2x8 AC/RE) for the online study.

All dependent variables are visually implemented and based on studies of crossmodal correspondences [6; 7].

3 measurements are used, whereby the MAT was specially created for this purpose and pretested in a group of students:



- continuous ratings in 4 visual dimensions **hue** (0-360 degree), **shape** (0/sharp - 100/round); **saturation** and **brightness** (0-100%)
- each variable is rated on a slider bar

Multidimensional Assessment Test (MAT)

Self Assessment Manikin (SAM)

- taken from [8], measures emotional ratings in 3 dimensions **valence, arousal** and **dominance**
- each variable is rated on a 5-point icon scale

- measures the **estimated** underlying **car size** of the 8 original stimuli
- rated on a 5-point icon scale

Subjective Car Characteristics (SCC)

Procedure

77 participants regulated the volume of their device by setting a -42 LUFS sinus tone so that it was just audible. 5 sound examples of different electronic devices were used to gain practice in answering the MAT. The raters were randomly assigned to one of 4 groups, resulting in 2 acceleration and recuperation groups each, with different answer sequences.

Soziodemographic data, professional occupation in music/sound industry and the use of public transport was requested. Before the listening test, participants answered the SEPPO-questionnaire [9], a short version of the Eysenck Personality Profiler with NEO-PI-R Openness, successfully applied in 2022 [10].

acceleration sounds (AC)
- **group 1: MAT + SAM**
- **group 2: SAM + MAT**

recuperation sounds (RE)
- **group 3: MAT + SAM**
- **group 4: SAM + MAT**

Results

40 male, 35 female and 2 divers participants answered the online questionnaire and listening task in 4 weeks. The mean age was 31,6 years (18-74), most of them declared themselves as car drivers (n=30) or users of public transport (n=19). The majority classified as non-musicians (67,6 %), a small amount of 13 % stated working professionally with music or audio (e.g. acousticians).

Ratings (Valence, Arousal, Dominance)

Possible differences in ratings concerning the answer sequence (groups) were tested and could not be determined (*t*(32)= 3,30, p=0,174) the same applies for mostly used means of transport. Overall, the stimuli sound similar which was confirmed by similar ratings, residing mostly in the middle range of scale.

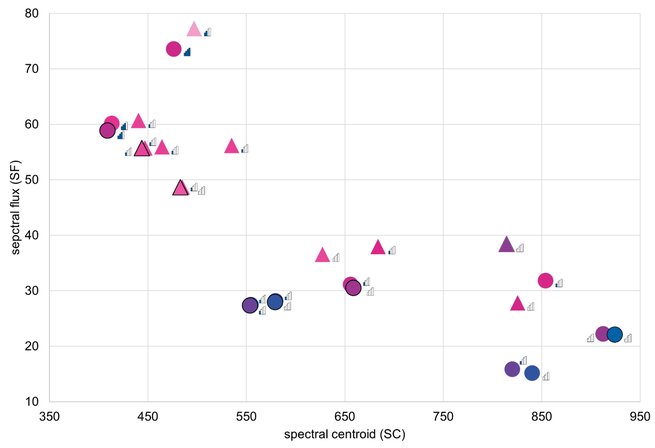


Fig.1. valence and arousal (Ø) of acceleration and recuperation sounds

All sounds and ratings are interactively available via **QR-code.**

legend: recuperation and acceleration sounds, valence rating: blue=higher arousal rating:

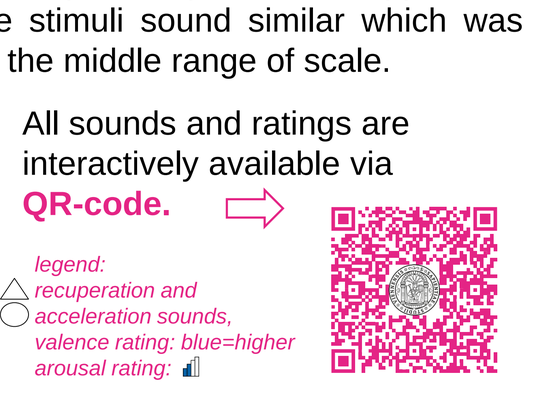
	$r_{(valence)}$		$r_{(arousal)}$		$r_{(dominance)}$	
audio features	**AC**	**RE**	**AC**	**RE**	**AC**	**RE**
spectral flux (SF)	-0,808	-0,532	0,671	0,663	0,708	-0,711
spectral centroid (SC)		0,557		-0,697	-0,734	-0,607
spectral spread		0,642		-0,746		-0,706
inharmonicity	0,651	0,675		-0,724		-0,549
rms	-0,805	-0,530	0,628	0,703	0,667	0,646
roughness (Sethares)	-0,712	-0,751	0,641	0,613	0,699	0,673
tonal energy	-0,651	-0,675		0,724		
loudness (Zwicker)		-0,619		0,780		0,809

Correlation analysis (p<0,05) show that less **fluctuations** ($r_{(valence/RE)}$= -,532; $_{/AC}$= -,808), less **roughness** ($r_{(valence/RE)}$= -,751; $_{/AC}$= -,712) and less **tonal energy** ($r_{(valence/RE)}$= -,675; $_{/AC}$= -,651) are rated significantly better in both recuperation and acceleration sounds. Only at recuperation the **brightness** (SC) of sounds influences the choices positively, just as **loudness** negatively, as predicted in **H1** and **H2**.

Shapes, Colors and Personality

Raters personality was assayed according to expressions of openness, extroversion, neuroticism and psychoticism (Cronbach‘s $\alpha > 0,70$). There is a small effect (Cohen) that raters with openness scores above average ($M_{/AC}$=74,78; *SD*=33,6) choose significantly more rounded shapes (*t*(26)=3,64; p=0,002) than less open-stated participants ($M_{/AC}$=64,95; *SD*=46,57).

Fig.2. associated shapes of acceleration sounds in terms of openness



There is no overall accordance in hue, but tendencies regarding personality traits and shapes, brightness and saturation in terms of audio features (**H3**):

- **angularity** with increasing loudness ($r_{(AC)}$= -,504) in openness to new experiences
- **angularity** with longer fade outs ($r_{(RE)}$= -,771)
- **color brightness** with higher spectral centroid (SC) in case of extroversion ($r_{(RE)}$= ,729) and neuroticism ($r_{(RE)}$= ,776)
- **color saturation** with increasing fluctuations in raters with higher expressions of neuroticism ($r_{(AC)}$= ,646)

Conclusion and Outlook

Electric car driving sounds are evaluated by perceived loudness and furthermore means of fluctuations, roughness and tonal components, which is congruent with former results. Recuperation sounds show an even clearer differentiation:

- **Valence** rises with brightness, inharmonicity and a broadband spectrum
- **Arousal** increases with fluctuations, loudness, roughness and tonal energy
- **Dominance** increases with loudness, roughness and decreasing fluctuations

Estimated Car Sizes relies on dominance ratings of sounds, especially in recuperation (*r*= ,766) and influences its overall assessment ($r_{(valence/RE)}$= -,755) – Interactive graph via **QR-Code.**

Color brightness assessments show significant similarities in recuperation, whereby brightness is mainly related to spectral centroid.

Shapes (RE) are jugded by expressions of fade outs and get rounder with openness of participants.

One goal for the future is the further development of the MAT, which shall enable an easier handling and more interactive presentation of visual dimensions.

References