

# Psychoacoustic sensation magnitudes and sound quality ratings of upper middle class cars' idling noise

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The outdoor idling noise of various upper middleclass cars - one gasoline powered car, four diesel powered cars of different brands, and three different adjustments of the motor of one diesel powered car - were assessed in psychoacoustic experiments. The relations between loudness, sharpness, roughness, fluctuation strength and the newly-defined sensation "dieselness" of those sounds will be discussed. It will be challenged which psychoacoustic sensations are instrumental for the preference of the sound quality of a specific car.

## INTRODUCTION

Standing next to a car, the idling noise of it is in most cases a sufficient hint on the kind of motor. In contrast to a gasoline powered car, a diesel powered car shows a typical sound character which will be called in the following "dieselness".

To reveal the correlation between this characteristic sound described by dieselness and the basic psychoacoustic sensation magnitudes loudness, sharpness, roughness and fluctuation strength were investigated in psychoacoustic experiments for eight different outdoor idling noises. Among those eight cars were a gasoline powered car ("gp"), four diesel powered cars of different brands ("dp b1" to "dp b4") as well as three different adjustments of the motor of one particular diesel powered car ("dp a1" to "dp a3").

Furthermore, the hypothesis was posted that this special sound character of diesel powered cars (dieselness) is responsible for the judgement on the sound quality of the car. Therefore, by means of a ranking experiment the sound quality of those eight outdoor idling noises was assessed additionally.

## EXPERIMENTS

The outdoor idling noises of the above mentioned cars were recorded by a dummy head system of HEAD Acoustics positioned at a distance of 1 m lateral to the right front wheel at a height of 1.70 m. For the experiments, the sounds were presented in a sound-proof booth via a freefield equalized [1] STAX headphone calibrated to reproduce the original sound level. To evaluate the loudness, sharpness, roughness, fluctuation strength and dieselness of the sounds, the method of "magnitude estimation with anchor sound" was used, and the sound of the diesel powered car of

brand 1 ("dp b1") acted as anchor sound. The sound quality was assessed with a ranking method which is described in detail in [2]. Fourteen normalhearing subjects with a median age of 27.5 years (4 female, 10 male) participated in the experiments.

## RESULTS

Figure 1 shows the medians and the interquartile ranges of the sensation magnitudes loudness (squares), sharpness (triangles), roughness (circles), fluctuation strength (rhombs) and dieselness (stars) for the gasoline powered car, the four different brands of diesel powered cars and the three different motor adjustments of the diesel powered car.

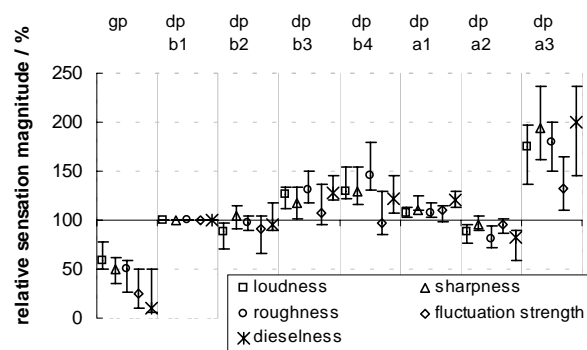


FIGURE 1. Results for the sensation magnitudes loudness, roughness, sharpness, fluctuation strength and dieselness.

If the relative sensation magnitudes of the gasoline powered car are compared with those of the diesel powered cars of different brands, it can be stated, that the gasoline powered car produces about 65 % of the loudness, 50 % of the sharpness, 60 % of the roughness, 30 % of the fluctuation strength and only

10 % of the dieselness of *that* diesel powered car with the respectively lowest estimated sensation magnitude. Comparing the results of the four different brands, roughness is the sensation magnitude which is varying most (about 50 percentage points) and fluctuation strength less (about 15 percentage points). The dieselness is differing between the four different brands for maximum 32 percentage points.

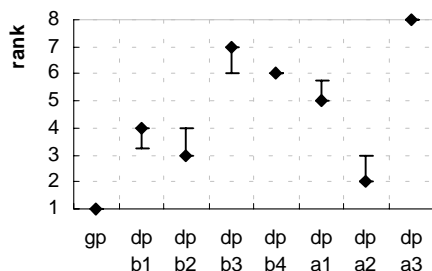
With the investigated three adjustments of the motor, fluctuation strength can be changed less (about 35 percentage points) and dieselness most (about 120 percentage points). In loudness, sharpness and roughness a difference of 85 to 100 percentage points, in fluctuation strength of about only 35 percentage points can be obtained.

Table 1 shows the rank correlation coefficients (according to Spearman) between the sensation dieselness and all other magnitudes. The correlation is for all magnitudes very high but best between dieselness and roughness ( $\rho = 0,976$ ).

**TABLE 1.** Rank correlation coefficients  $\rho$  between dieselness and the other sensation magnitudes loudness (N), sharpness (S), roughness (R) and fluctuation strength (F).

N	S	R	F
0,970	0,952	0,976	0,857

Figure 2 shows the median and the interquartile ranges of the ranks given in sound quality for the eight cars investigated. In judging the car with the best (gasoline powered car) and the worst (diesel powered car with motor adjustment 3) sound quality subjects judged consistently. Whereas the diesel powered car with motor adjustment 2 is rated better than all other diesel powered cars, that one with motor adjustment 1 is classified behind brand 1 and 2 but still before brand 3 and 4.

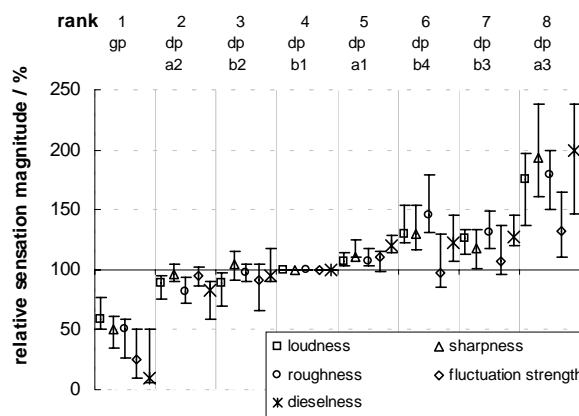


**FIGURE 2.** Results for the sound quality ratings.

## DISCUSSION

Figure 3 shows the results sorted with descending sound quality: an increase in all sensation magnitudes seems to go in line with the deterioration in sound quality. This can also be confirmed by the rank

correlation coefficients (table 2) between the rank in sound quality and the sensation magnitudes: in all cases a strong correlation is given but especially the sensation dieselness ( $\rho = 1$ ) seems to be an important clue for the subjects in classifying the sound quality.



**FIGURE 3.** Results for the sensation magnitudes ordered with respect to their sound quality.

**TABLE 2.** Rank correlation coefficients  $\rho$  between the rank in sound quality and the sensation magnitudes loudness (N), sharpness (S), roughness (R), fluctuation strength (F) and dieselness (D).

N	S	R	F	D
0,970	0,952	0,976	0,857	1,000

## CONCLUSION

The outdoor idling noise of the gasoline powered car, the diesel powered cars of different brands and especially the different adjustments of the motor of one particular diesel powered car differ substantially in terms of the psychoacoustic sensation magnitudes loudness, sharpness, roughness and fluctuation strength.

The sensation characterizing the typical sound of a diesel powered car - here called "dieselness" - is highly correlated with those basic psychoacoustic sensation magnitudes. Furthermore, the strength of the sensation dieselness seems to be the cause how subjects rank the sound quality of the sound.

## REFERENCES

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