

# Which driving situations best represent "the characteristic sound" of diesel engines? Comparison between Germany and France

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## Introduction

In 2007, the proportion of diesel cars reached 74% in the French market. This growth is similar in other Western Europe countries like Germany for instance. However, customers usually associate the sound of this motorisation with negative features ("it sounds like a tractor"). In the last ten years, these drawbacks of diesel engine noise were significantly reduced [1]. A part of current research works deals with the improvement of perceived characteristics towards a higher customer appreciation [2]. As part of a study on the sound perception of diesel engines, we are focusing on positive attributes of different driving situations. This paper presents an intercultural study between French and German diesel cars owners.

## Laboratory test

The experiment proposed to the participants, consists in assessing the dieselness of twelve driving situations (for three diesel cars) on a continuous scale [3].

## Participants

In each country, 30 participants who do not work in automobile or acoustics domains performed this test. Three criterions have been chosen for the recruitment of the participants. They had to be devoid of hearing problems, own a diesel car and drive often their diesel vehicle (daily or several times per week).

Table 1 summarizes the informations about the 60 participants.

Table 1: German and French participants

	Men	Female	Mean age
German	19	11	30
French	13	17	41

## Stimuli

The stimuli presented to the participants correspond to twelve various driving situations of three different diesel cars (C1, C2 and C3). They were recorded with an artificial head at the co-driver position. All of these situations can be encountered during a daily trip:

- six unstationary situations: start up the motor, stop the motor, traffic light start, acceleration, deceleration and traffic jam;
- six stationary situations: hot idle, constant speed 50-kph, 70-kph, 90-kph, 110-kph and 130-kph.

## Assessment of the dieselness

In each country, the experiment took place in an isolation booth with the same playback system (HPS IV amplifier of Head Acoustics and a Sennheiser half-opened electrostatic headphone).

During the test, the subjects evaluated the dieselness [4][5][6][7] for each driving situation sound (listened in a random order). This assessment was made with a cursor, on a continuous scale from 0 (no diesel) to 1 (diesel), answering to this question: "Up to what point does this sound correspond to a typical driving situation of a diesel car?".

## Results and discussion

Figure 1 presents the mean score and standard deviation for the dieselness of six unstationary driving situations. The results are presented for German and French participants.

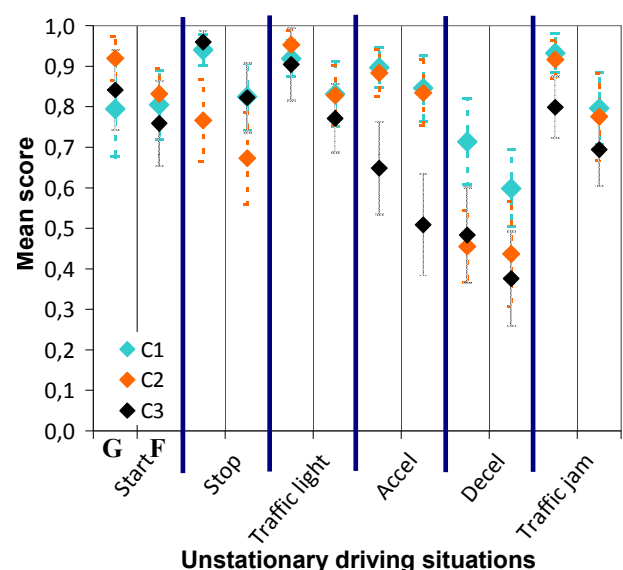
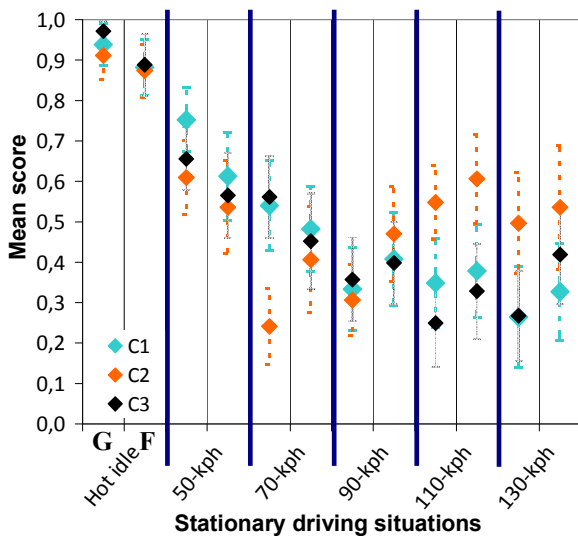


Figure 1: Dieselness scores of six unstationary driving situations given by 30 German (G) and by 30 French (F) for C1 (3-cylinders car), C2 (4-cylinders car) and C3 (6-cylinders car)

The first column corresponds to the German participants and the second one to the French participants for each driving situation.

The higher the score for one driving situation is, the more the dieselness is perceived by the participants. An ANOVA analysis shows that the dieselness of the deceleration is (for each country and for each car) significantly different from the five other rating of dieselness. Concerning those five other ones, the difference is not significant except for the dieselness of acceleration of C3 which seems to be linked to the dieselness of deceleration.

In the same way as Figure 1, Figure 2 presents the mean score and standard deviation for the dieselness of six stationary driving situations. The results are still presented for German and French participants.



**Figure 2:** Dieselness scores of six stationary driving situations given by 30 German (G) and by 30 French (F) for C1 (3-cylinders car), C2 (4-cylinders car) and C3 (6-cylinders car)

Like for the six unstationary situations, an ANOVA analysis is realized. It shows that the dieselness of hot idle appears (for each country and for each car) like being significantly different from the dieselness of the other stabilized speeds. Furthermore, it is appraised like the most characteristic of diesel sound (of these six stationary driving situations but also, of the twelve driving situations proposed to the participants). Indeed, even if in two cases, German people assess the dieselness of stop the motor (for C1) and the one of traffic light start (for C2) more diesel than hot idle, a T-test gives a difference which is not significant between these two situations compared to the hot idle ( $p > 0,05$ ).

Another ANOVA analysis allows to conclude that the difference between each car, for the dieselness of the hot idle, is not significant ( $p = 0,948$  for French participants and  $p = 0,136$  for German participants).

Furthermore, for the whole of twelve driving situations, German participants rated the dieselness higher than French except for situations like 90-kph, 110-kph and 130-kph.

## Conclusion

The dieselness of twelve different driving situations was rated by German and French participants during a listening test. We were focus on this in order to find in which driving situation the diesel character is prominent.

For each of those countries, the results show the hot idle like the driving situation that best represents “the characteristic sound” of diesel engines. In addition, for most of driving situations, German people evaluate them more diesel than French people assess.

## References

- [1] Bodden, M. and Heinrichs, R.: Diesel sound quality analysis and evaluation, in Proceedings of Forum Acusticum 2005, Budapest, 2005.
- [2] Miśkiewicz, A. and Letowski, T.: Psychoacoustics in the automotive industry, Acta Acustica 85 (1999), 646-649.
- [3] Frère, A. and al.: Which driving situations best represent “the characteristic sound” of diesel engines? in Proceedings of Euronoise, Edimburgh, 2009.
- [4] Heinrichs, R. and Groemping, U.: Customer driven diesel vehicle sound quality, in Proceedings of Internoise 2004, Prague, 2004.
- [5] Fastl, H. and al.: Rating the “dieselness” of engine sounds, in Proceedings of Acoustics’08, Paris, 2008.
- [6] Patsouras, C. and al.: How far the sound quality of a diesel powered car away from that of a gasoline powered one?, in Proceedings of Forum Acusticum 2002, Seville, 2002.
- [7] Patsouras, C. and al.: Psychoacoustic sensation magnitudes and sound quality ratings upper middle class cars’ idling noise, in Proceedings of 17<sup>th</sup> International Congress on Acoustics, Rome, 2001.