

inter.noise 2000

*The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE*

I-INCE Classification: 6.2

COMBINING METHODS TO EVALUATE SOUND QUALITY

S. Buss*, B. Schulte-Fortkamp*, P. Muckel**

* Acoustics/Physics University of Oldenburg, Ossietzkystraße, 26111, Oldenburg, Germany

** Dept. of Psychology University of Oldenburg, Ammerländer Heerstraße, 26111, Oldenburg, Germany

Tel.: +49 441 798 3562 / Fax: +49 441 798 3698 / Email: sandra@aku.physik.uni-oldenburg.de

Keywords:

SOUND QUALITY, INTERIOR CAR SOUND, SEMANTIC DIFFERENTIAL, OBELICS

ABSTRACT

Evaluating sounds concerning sound quality is a context-sensitive process based on different subjective factors. Within the EU-project OBELICS a Semantic Differential has been developed to investigate intercultural differences in the perception of car sounds corresponding to the method AISP (Associated Imaginations on Sound Perceptions). The Semantic Differential tests carried out in Germany, Italy and France show differences and similarities between the judgements in the three countries. A factor-analysis on the adjective-pairs and on the sounds led to the three factors Comfort, Power, and Sonority. Results of the test series with the Semantic Differential compared with AISP data will be presented with a special attempt to context sensitivity.

1 - INTRODUCTION

Within the EU-project OBELICS [1] three methods were combined in order to evaluate interior car sounds: Semantic Differential method (SD), Multidimensional Preference Analyses, Associated Imaginations on Sound Perceptions method (AISP). The results of these tests will be presented and compared

2 - DEVELOPMENT OF A SEMANTIC DIFFERENTIAL

In a first step a Semantic Differential was developed especially for the evaluation of interior car sounds [2]. This Semantic Differential consisted of 15 items. It was developed for German subjects and now also is available in English, French and Italian.

3 - DATA ANALYSIS – SEMANTIC DIFFERENTIAL

French, German and Italian subjects participated in the Semantic Differential tests. They were presented interior car sounds of nine different cars, which were named car A to car I. All sounds were recorded in the driving situation 5th g and 130 km/h and were played with original loudness and also loudness equalized.

3.1 - Polarity profiles

Here two polarity profiles are presented: car F and I (Economy class) in the case of original loudness. Subjects of all three countries regard the sound of car F as unpleasant, cheap, simple and sporty. For Italian subjects it appears to be less unpleasant and powerful than for the other subjects. French and German subjects judge the car cheap and simple while Italian subjects think it is expensive. For German subjects the car seems to be less sporty than for French and Italian subjects.

Concerning car I there are only very small differences between the polarity profiles in the three countries. Nearly all adjective pairs are judged in the middle of the scale.

3.2 - Factor analysis concerning adjective pairs

In a factor analysis on adjective pairs three factors with explain variances greater than one are found in each country. The explained variances can be seen in Table 1.

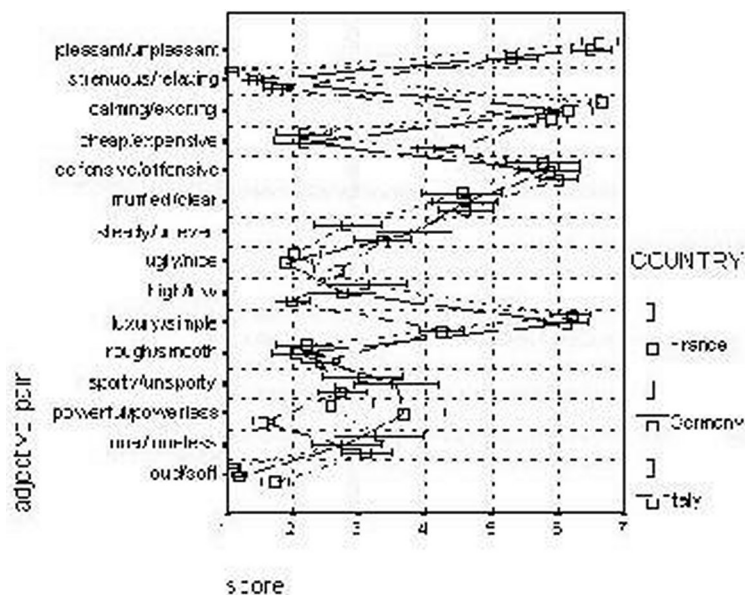


Figure 1: Polarity profile of car F.

	Factor 1	Factor 2	Factor 3	Others
France	6.1 (40.9 %)	2.5 (16.4 %)	1.4 (9.2 %)	5.0 (33.4 %)
Germany	6.3 (41.8 %)	2.1 (14.2 %)	1.6 (10.6 %)	5.0 (33.5 %)
Italy	5.1 (33.8 %)	2.2 (14.8 %)	2.1 (14.1 %)	6.0 (37.3 %)

Table 1: Factor analysis on adjective pairs – explained variance.

For the French and the German data the first factor is very similar. This factor is correlated with the adjective pairs unpleasant/ pleasant, strenuous/ relaxing, exciting/ calming, cheap/ expensive, ugly/ nice, simple/ luxury, rough/ smooth and loud/ soft. This factor is named comfort. The first factor in the Italian data loads high on the adjective pairs unpleasant/ pleasant, strenuous/ relaxing, exciting/ calming, offensive/ defensive, ugly/ nice, rough/ smooth, powerful/ powerless and loud/ soft. So this factor can also be termed comfort. But Italian subjects seem to associate comfort with the adjectives defensive and powerless instead of expensive and luxury.

The judgements of German and French subjects also lead to a similar second factor: clear/ muffled, high/ low. In the case of French subjects the adjective pair tonal/ toneless belongs to this factor as well. These adjective pairs are summarized as sonority. For Italian subjects a second factor can be found, which is correlated with the adjective pairs expensive/ cheap and luxury/ simple.

For the French and the German data a similar third factor, the factor power, can be obtained, too. This factor is explained by the adjective pair powerful/ powerless and for German subjects also the adjective pair sporty/ unsporty. The third factor in the case of Italian subjects is explained by clear/ muffled.

3.3 - Factor analysis concerning cars

A factor analysis concerning the different car sounds results in two factors for each country. In Table 2 the explained variances are summarized.

	Factor 1	Factor 2	Others
France	2.6 (29.3 %)	2.3 (25.1 %)	4.1 (45.6 %)
Germany	2.7 (30.2 %)	2.1 (23.5 %)	4.2 (46.3 %)
Italy	2.4 (26.4 %)	2.3 (25.4 %)	4.3 (48.2 %)

Table 2: Factor analysis on cars – explained variance.

The first factor found for the French data is correlated with car A (Sedan) and car B and car E (Luxury). These are the same sounds as the ones belonging to the second factor of the German and Italian data. The French data leads to a second factor, which is explained by the cars C, G, H (Compact) and car I (Economy). The judgements of the German subjects result in a first factor, which loads high on the

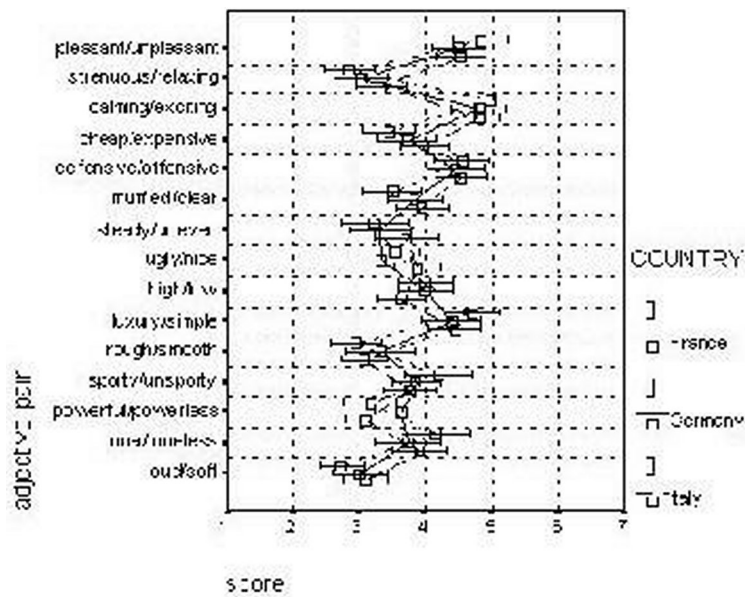


Figure 2: Polarity profile of car I.

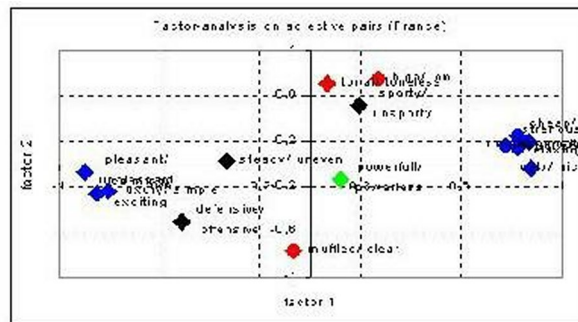


Figure 3: Factor analysis on adjective pairs.

cars C, G, H (Compact), car D (Sedan) and car F (Economy). For the Italian data a first factor can be found, which is explained by car F and I (Economy), car G and H (Compact).

4 - DATA ANALYSIS – PREFERENCE TESTS

Additionally Preference tests were carried out in France, Germany and Italy. The sound samples were the same as the sound samples used for the Semantic Differential tests.

4.1 - Consistency tests

In all three countries the subjects answered more consistent, when the sounds were played with original loudness than in the equalized condition. Also French subjects answered more consistent than German and Italian subjects.

4.2 - Factor analysis

A factor analysis concerning subjects results in one or two factors. The explained variances can be seen in Table 3.

	Original		Equalized	
	Factor 1	Factor 2 / others	Factor 1	Factor 2 / others
France	18.1 (95.0 %)	0.9 (5.0 %)	16.6 (87.5 %)	2.4 (12.5 %)
Germany	16.1 (89.6 %)	1.9 (10.4 %)	9.3 (77.7 %)	2.7 (22.3 %)
Italy	16.2 (95.1 %)	0.8 (4.9 %)	10.0 (66.7 %)	5.0 (33.3 %)

Table 3: Factor analysis on subjects – explained variance.

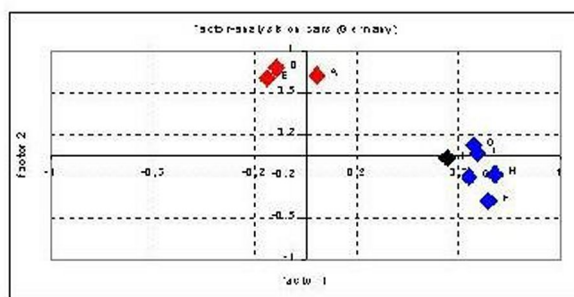


Figure 4: Factor analysis on cars.

Always only one factor is important and is correlated with most of the subjects. The ranking of the cars for the first factor can be derived from the factor values. These rankings are summarized in Table 4.

Ranking of cars		1	2	3	4	5	6	7	8	9
Original	France	B (L)	A (S)	E (L)	D (S)	G (C)	H (C)	C (C)	I (E)	F (E)
	Germany	B (L)	A (S)	E (L)	D (S)	C (C)	G (C)	H (C)	I (E)	F (E)
	Italy	B (L)	E (L)	A (S)	D (S)	G (C)	H (C)	C (C)	I (E)	F (E)
Equalized	France	F (E)	G (C)	D (S)	I (E)	C (C)	H (C)	B (L)	A (S)	E (L)
	Germany	F (E)	D (S)	G (C)	I (E)	H (C)	C (C)	A (S)	E (L)	B (L)
	Italy	F (E)	D (S)	G (C)	I (E)	H (C)	C (C)	E (L)	A (S)	B (L)

Table 4: Factor analysis – ranking of cars; L = Luxury, S = Sedan, C = Compact, E = Economy.

Nearly all subjects in all three countries arrange the original sounds in the same way according to their preference (first Luxury and Sedan Class, than Compact Class and at the end of the scale Economy Class). Also the same equalized sounds are preferred in France, Germany and Italy (Economy and Compact Class are preferred and the Luxury Class is at the end of the scale). So when the sounds are equalized the judgements of car A, B and F (and therefore Luxury Class and Economy Class) change from one end of the scale to the other.

5 - COMPARISON SEMANTIC DIFFERENTIAL TESTS AND PREFERENCE TESTS

The next step in the analysis of the intercultural data is the comparison of the results of the Semantic Differential Tests and the Preference Tests.

The Semantic Differential Tests show that French, German and Italian subjects group the different car sounds in a similar way: Luxury and Sedan Class in one group and Compact and Economy Class in the other group. The Preference Tests lead to the same result. Most subjects of all three countries sort the cars in a similar way: Luxury and Sedan Class at one end of the scale and Compact and Economy Class at the other end of the scale.

Further analysis is necessary in order to say in which way the data of the Semantic Differential tests and the Preference tests can be compared additionally.

So the results of these tests don't give evidence which method should be preferred. For international tests a Preference test might be more suitable than a Semantic Differential test because it is independent of the language. In contrast a Semantic Differential test gives more information about the perception of the sound.

Taking into account the results of the AISP analyses testpersons associated scenes within AISP experiments are explanations and illustrations of feelings as reactions to sounds. In combination with explicit feelings these associations can be used as a criterion for the data to be clustered. The *criterion of similarity* in this cluster analysis are the TP.s' basic feelings evoked by a special sound.

The basic rule of every cluster analysis – differences between objects of one group ("cluster") should be minimal and differences between different clusters should be maximum – is here realised on a semantic

level, according to semantic structure of AISP-data. The classical problem in cluster analysis, namely how to identify the best structure of the given objects, is solved within Grounded Theory Methodology by *determining a fitness criterion*: The best structure is the one which fitted best/grounded mostly in data.

With AISP-clusters it is possible to identify groups of subjects that describe and evaluate their sound perception in a similar way. At the same time the semantic quality of data includes information about the kind of similarity – the data themselves tell what subjects have in common with each other and what make them different from subjects of other clusters. Analysing the AISP-data ten (10) AISP-clusters over 24 subjects who had listened to three different sounds used in the experiment were found. These clusters based on different feelings as reactions to sounds and could be systematised around the global category of tension. Fundamental is a triad of strain/stress – tension – relaxation and its three possibilities of evaluation as positive, negative or neutral. Not all possibilities were chosen for each sound.

6 - CONCLUSION

In the Semantic Differential Tests the essential factors comfort, sonority and power were validated. Intercultural differences between the judgements of French and German subjects and Italian subjects were found, especially for the adjective pairs powerful/ powerless, cheap/ expensive and luxury/simple in the polarity profiles and in the factor analysis concerning the adjective pairs.

In all three countries the different car sounds are grouped in a similar way in the Semantic Differential Tests. The same result can be found in the Preference Tests, where most of the subjects arranged the sounds in a similar way on the scale.

AISP gives because of its introspective character insight into evaluating processes and their contextual parameters. This functions as a background for interpretation of data which usually neglect cognitive and emotional aspects of perceiving and evaluating sounds

For a deeper understanding of the subjective evaluation of interior car sound further analysis is necessary, especially concerning the comparison of the results of the different methods.

ACKNOWLEDGEMENTS

This work was supported by the Brite/EuRam Project BE-96-3727 OBELICS (Objective Evaluation of Interior Car Sound).

REFERENCES

1. **W. Krebber and al.**, Objective evaluation of interior car sound - the OBELICS project, In *DAGA 200*, 2000
2. **N. Chouard, T. Hempel**, Semantic Differential Design Especially Developed for the Evaluation of Interior Car Sound, In *ASA-EAA-DAGA Joint Meeting*, 1999
3. **P. Muckel, L. Ensel, L. Chouard, B. Schulte Fortkamp**, Sound Descriptions as a Matter of Evaluation in Sound Design, In *6th International Congress on Sound and Vibration*, 1999
4. **P. Muckel, B. Schulte-Fortkamp**, Passungsarbeit bei der Beschreibung und Bewertung von Fahrzeuggeräuschen, In *DAGA 2000*, 2000