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EFFECTS OF BINAURAL SOUND PRESENTATION ON LISTENERS' ASSESSMENTS IN A PRODUCT SOUND TASK AND PROBLEMS OF TODAY'S MEASUREMENT PROCEDURES

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ABSTRACT
Today, binaural sound measurement and reproduction methods are already widely used for the assessment of product sounds in listening tests. But the respective instrumental measurement devices mostly still treat binaural recorded signals separately as two monaural ones rather than integrating them. Due to the fact that most instrumental evaluation methods do not take into account binaural differences, the assumption arises that errors occur between instrumental and human assessments. This assumption was investigated in a listening test on interior car sounds where listeners had to assess the sounds according to given verbal attributes. Significant differences in the results of the assessment for binaural and monaural presentation could be shown for some verbal attributes.

1 - INTRODUCTION
It was investigated to what extent the presentation of binaural instead of monaural recordings of product sounds leads to a difference of what is actually heard and assessed in a product-sound task. This is of importance, because the results of assessment as obtained by means of auditory measurement procedures (here: Semantic Differential) might differ due to the way the sounds are presented, i.e., monaurally or binaurally. In fact, systematic differences of this kind should be avoided. Further, if such differences showed up, this would establish a need for suitable instrumental measuring algorithms which take interaural differences into account. As of today, the instrumental measuring algorithms as commonly used for product-sound assessment do not take into account any interaural differences.

2 - SET-UP
Monaural and binaural recordings of interior car sounds were taken from the EU-funded OBELICS sound database for presentation via headphones. The monaural recordings had been carried out via a single omni-directional microphone. Simultaneously, a dummy head had been used for the binaural recordings. The recordings had been made at a car velocity of 130 km/h. Two sets of presentation, a diotic and a dichotic one, were carried out according to the two different recording procedures. The presentation of the sets was performed successively in two sessions each, with an individual pause of 25 minutes up to 2 days per listener. This was done since in everyday life sound-quality judgements are usually made by comparison on an absolute basis and not on a relative one. The sets of sounds presented at those sessions were randomized for each group to avoid sequential dependencies. Also, the selection of listeners starting with any respective block was done randomly. 19 subjects participated in both listening tests. The headphones used for presentation were appropriately equalized with respect to the recording methods. Hempel and Chouard (1999, [1]) describe a Semantic Differential which was specifically designed for interior car sounds in this very driving situation. It was used here in an advanced version using a reduced set of 15 adjectives showing high validity and reliability. Also, the antonym pair *realistic − unrealistic* was added here. The response scale was the Rohrmann scale (Rohrmann, 1978, [2]), which had been validated before empirically for German native speakers. In the experiment reported here the listeners were to assess the sounds by means of the specific Semantic Differential applied. All sounds

were adjusted to give rise to auditory events of the same loudness. To this end the median of the N_4-loudnesses of all stimuli was applied, as proposed by Chouard and Weber (1998, [3]) and validated by Hempel (1999, [4]).

3 - RESULTS

The three attribute pairs which yielded highest statistical significance with respect to the difference of their mean scores were *tonal − not tonal*, *muffled − clear* and *realistic − unrealistic* (Fig. 1). Among these, the most striking differences appear for the latter. This is in fact worth mentioning, since no direct A−B comparison took place. The listeners' assessments were made from a rather absolute point of judgement. For what concerns the other two adjective pairs, the results are of even higher relevance in the field, as they show that the two often used verbal descriptors *tonal − not tonal* and *muffled − clear* show statistically significant variations when the mode of presentation is changed from diotic (monaural recordings) to dichotic (binaural recordings). If this is effect is not taken into account properly when applying the Semantic-Differential method to interior car sounds, misleading conclusions regarding the verbal descriptors "clearness" and "tonality" and any of its assumed physical correlates cannot be excluded.

Further, even when binaural recordings are taken, most of today's instrumental evaluation algorithms treat the respective signals of each recorded channel separately or just add them up. Hence, they do not combine the results of the two ear signals in any sophisticated way by taking into account interaural differences, e.g., such as normally-hearing human listeners would do. This reveals validity problems when listeners' assessments and signal parameters are correlated and evaluated. Consequently, there is without doubts a substantial need for considering both monaural and interaural features of the input signals to the two ears in an integrated way in instrumental algorithms for product-sound assessment − to the end of arriving at results of utmost validity.

4 - SUMMARY

The influence of interaural differences of the ear signals on verbal descriptors was investigated. Binaural recording and presentation of car sounds does not only improve the assessed realism of the performance of the presented interior car sounds, but also influences the assessment results with regard to "tonality" and "clearness". This finding is of relevance regarding the usage of these verbal descriptors in listening tests, as the method of sound presentation is likely to influence the results. Such problems can be avoided by using binaural recording and dichotic presentation throughout − such preserving the natural interaural signal differences for the assessment procedure.

Instrumental measurement devices for the assessment of product sounds, as a rule, do not yet take interaural signal differences into account properly. In the light of the results of this study, validity problems of today's instrumental measurement methods for sound-quality tasks become apparent.

ACKNOWLEDGEMENTS

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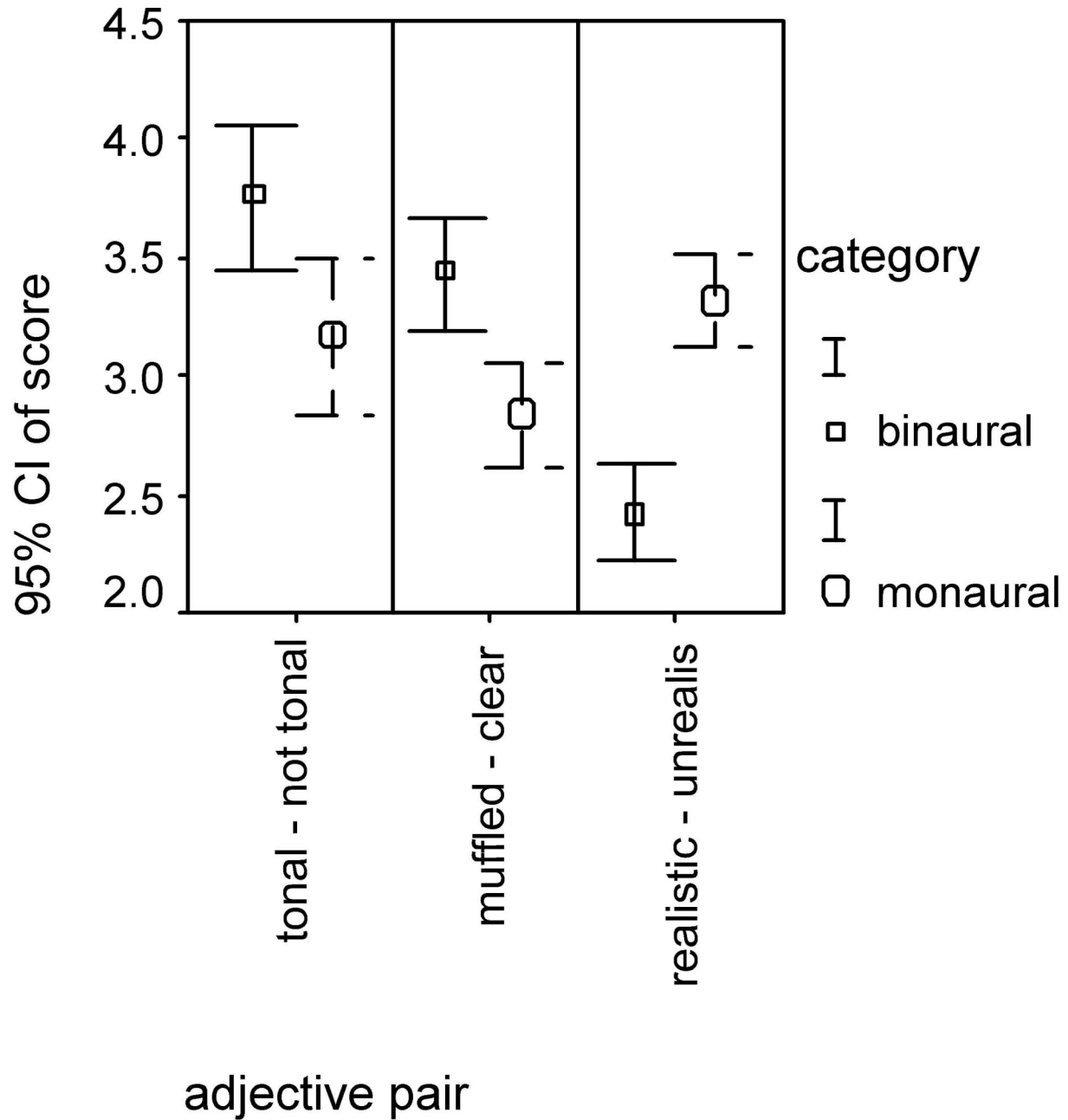
Figure 1: Mean ratings and 95%-confidence intervals regarding perceived differences between monaural and binaural interior car sound recordings, 19 listeners.