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THE POTENTIAL OF MASTER SCALING OF PERCEPTUAL ATTRIBUTES IN SOCIAL SURVEYS

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ABSTRACT
Dose-response relationships for differently exposed populations cannot be inferred to be valid for individual residents. By using the principle of master scaling in quantifying annoyance in social surveys, it is possible to "calibrate" for interindividual differences. Comparability between populations can, thus, be obtained although different residents have reported annoyances uniquely linked to their own local noise exposure. So far, master scaling has been successfully applied in field studies and tested in psychoacoustical model experiments. The "calibration" of scales for perceptual attributes has also been validated experimentally. By master scaling annoyance and other perceptual attributes, it would be possible to predict changes in these variables and to evaluate the efficiency of various noise abatement procedures.

1 - INTRODUCTION

Noise-annoyance surveys examine in detail and ascertain the annoyance experienced by noise-exposed persons. Therefore, great efforts must be invested in the measurement of annoyance in social surveys. Typically, one goal of noise annoyance surveys is to determine a general quantitative relationship between annoyance and noise exposure. In practice, it is anticipated that this relationship may be used for predicting the noise annoyance in an exposed population from assessments of noise exposures only. For example, in Environmental Impact Assessments (EIA) of land-use projects (new or enlarged roads, railways, runways), it is hoped that invariant dose-response relationships exist and that these may be used for assessing the present and prognosticating the future noise annoyance in the affected geographical areas (e.g., number of persons exposed within different $L_{Aeq,16h}$ iso-contours around an airport).
The differently exposed subpopulations in noise-affected areas must be representative of the population for which the dose-response relationship for annoyance was assessed. In EIAs this is seldom the case. Therefore, a noise-annoyance "field study" should be distinguished from a noise-annoyance "population study". The latter requires representative (random) samples of the general population, the former requires that the participants live in the noise-exposed area of concern. Valid knowledge on noise annoyance is obtained from both, but the field study is superior for determining noise annoyance in a particular noise-exposed area. Such areas are also typically the target in EIAs. The areas will undergo a change in noise exposure for which the EIA wants to prognosticate the corresponding change in annoyance. High quality annoyance measurement is thus needed in EIAs.

2 - NEEDS TO CALIBRATE ANNOYANCE SCALES

The *extensity* of annoyance in a population, spread geographically, is typically utilized as an outcome measure in questionnaire surveys even though individual residents report their *degree* of annoyance on a category scale. The most commonly used "cut-off" on these category scales (rank order or interval scale) is the category "highly annoyed" (HA). However, this "cut off" requires that all respondents have used the category scale in a similar way independent of their noise exposure. Research findings indicate otherwise [3, 4]. In order to enhance comparability among questionnaire field studies, the wording of annoyance questions is currently developed for international standardization [10]. This initiative is commendable

but it does not address the measurement problem as such, namely, how to obtain calibrated annoyance scales. Only scales with interval or ratio properties are possible to calibrate.
Berglund and associates [3, 4] used a Thurstonian scaling model to ensure interval scales of annoyance from category judgements in a questionnaire. They demonstrated that it is in practice possible to calibrate annoyance scales from differently noise exposed areas (=different respondents). By introducing annoyance questions for two references (memory of a noise environment & a taped sound), calibration by an annoyance difference was made possible. The findings were that both the annoyance to the own noise exposure and the response criteria of the subpopulations were dependent on noise exposure area. Respondents in less exposed areas need less exposure to become highly annoyed than those in areas of excessive exposure. It follows that predictions of (uncalibrated) annoyance due to changes in exposure are particular precarious when they are based on dose-response functions obtained in cross-sectional studies.
The ecological fallacy has also to be avoided in interpreting data of annoyance surveys. That is, dose-response relationships for differently exposed populations cannot be inferred to be valid for individual residents. This is a problem, indeed, because we wish to change individual resident's annoyance by noise abatement, and prediction of the change cannot be inferred from (invariant) population-based or group-based relationships. By using master scaling for quantifying annoyance in social surveys, it is possible to "calibrate" for interindividual differences in scaling behavior among respondents. This approach is particularly helpful in field studies where small samples of respondents are available in the noise-exposed areas.

3 - THE MASTER SCALING PROCEDURE

The embryo to the master scaling idea was created from the necessity to use different observers for judging different exposures and still wanting to construct a scale of a defined unit of measurement (odors at fields around a hog farm [2]). In master scaling, the main idea is to move the observer into a well-defined measurement context by the aid of a larger set of references (sounds or questionnaire items) used in the scaling situation. The references constitute an invariant scaling context common for all observers (respondents), whereas the target noise exposure is unique to each observer (respondent) but scaled within the same frame of reference (exposure & judgmental context). References should be neutral relative to targets because it is assumed that all observers have similar perceptions of the references. The references should cover the potential range of individual annoyance scales for the targets and provide a good resolution of measurement. In master scaling, each respondent's annoyance scale for the references is transformed to be identical to the previously determined master scale for the same references. Then the master scale transformation is used for calibrating the individual annoyance scales for the target noise to the master scale. The master scale of annoyance may be postulated or empirically determined for a group of individuals or for a representative sample of the population. So far, research has shown that nonlinear master scale transformations apply [1], [5], [8], [9], [12]. Master scaling reduces the interindividual variation in scaled attributes to approximate that of the intraindividual variation [7], [12].
In summary, the Master Scaling Principle consists of five steps [1]: (a) Create a study setting for psychologically controlled scaling of targets and references with a quantitative scaling method (e.g., free number magnitude estimation). (b) Determine a master scale of annoyance for a set of references (sounds or items) to be used in the master scaling. (c) Calibrate empirical individual scales to the master scale of annoyance for the set of references (sounds or items). (d) Use the same mathematical scale transform for "calibrating" the individual annoyance scale values of the targets. (e) Compare in an absolute sense the individual master scale values of the target exposures that are read off on the calibrated annoyance scale.

4 - UTILIZING MASTER SCALING IN SOCIAL SURVEYS

Master scaling with reference stimuli (sounds or odors) has successfully been utilized in field studies of odor or noise annoyance [5], [9], [12]. The procedure has stood up in a legal case concerning bad odors in a residential area from an energy producing plant based on composting of household garbage [5]. So far, master scaling has not been utilized in social surveys, although the master scaling procedure may readily be incorporated. For example, reference stimuli may be brought by interviewers and be presented together with questions on annoyance, interspersed among other questions. In postal questionnaires, reference stimuli may be replaced by specifically developed items serving as references. Such items for measuring and calibrating annoyance were developed and utilized by Galanter [11] in a study of residents living in the vicinity of an airport. The reference items consisted of annoying life-familiar events, for example,

"You get gum on your shoe". A utility comparison scale was used to calibrate annoyance to a numerical disutility that can be equated to a monetary loss. A linear transformation was used for taking care of the interindividual differences.
A great advantage of the master scaling procedure is that it requires no knowledge whatsoever of the targets except their empirical scale values. It is, thus, particularly suited in cases where noise exposure consists of combined sources and no evident exposure measure is adequate as a substitute measure. The scale values may be expressed in units of the master scale (defined by reference questions) or in terms of equivalents of the units of the physical scale of the references (defined by reference sounds). Comparability between noise-exposed groups of persons can, thus, be obtained although different residents have reported annoyances uniquely linked to their own local noise exposure.

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REFERENCES

1. **B. Berglund**, Quality assurance in environmental psychophysics, In *Ratio Scaling of Psychological Magnitudes - In Honor of the Memory of S.S. Stevens*, pp. 140-162, 1991

2. **B. Berglund, U. Berglund, & T. Lindvall** , A psychological detection method in environmental research, *Environmental Research*, Vol. 7, pp. 342-352, 1974

3. **B. Berglund, U. Berglund, & T. Lindvall** , A study of response criteria in populations exposed to aircraft noise, *Journal of Sound & Vibration*, Vol. 41, pp. 33-39, 1975

4. **B. Berglund, U. Berglund, & T. Lindvall** , Scaling of annoyance in epidemiological studies, In *Proceedings from the CEC-WHO-EPA International Symposium "Recent Advances in the Assessment of the Health Effect of Environmental Pollution"*, pp. 119-137, 1975

5. **B. Berglund, U. Berglund, & L. Lundin** , Odor reduction by biological soil filters, In *Indoor and Ambient Air Quality*, pp. 410-419, 1988

6. **B. Berglund, & R.F.S. Job**, Theory and method in perceptual evaluation of complex sound, In *Recent Trends in Hearing Research*, pp. 215-238, 1996

7. **B. Berglund & S. Nordin**, Utilizing individual differences in loudness measurement, In *Fechner Day '90*, pp. 117-122, 1990

8. **B. Berglund, & A. Preis**, Is perceived annoyance more subject dependent than perceived loudness?, *Acustica/Acta Acustica*, Vol. 83, pp. 313-319, 1997

9. **G.W. Evans, S. Hygge, & M. Bullinger**, Chronic noise and psychological stress, *Psychological Science*, Vol. 6, pp. 333-338, 1995

10. **J.M. Fields, R.G. de Jong, A.L. Brown, I.H. Flindell, T. Gjestland, R.F.S. Job, S. Kurra, P. Lercher, A. Schuemer-Kohrs, M. Vallet, & T. Yano**, Guidelines for reporting core information from community noise reaction surveys, *Journal of Sound and Vibration* , Vol. 206, pp. 685-695, 1997

11. **E. Galanter**, Utility functions for nonmonetary events, *American Journal of Psychology*, Vol. 103, pp. 449-470, 1991

12. **E. Linden, A. Ulander, F. Deniz, A. Gidlöf Gunnarsson, S. Nordin, & L. Högman**, Odor-annoyance estimates from road-traffic combustion exhausts: calibration with master scaling using pyridine as a reference, *Environment International*, Vol. 23, pp. 829-837, 1997