Overall Loudness versus Average of Instantaneous Loudness for Excerpts of Music: Effects of Musical Style

Klaus Laumann[1/2], Hugo Fastl[1], Sonoko Kuwano[3], Seiichiro Namba[3]

[1] *AG Technische Akustik, MMK, TU München, 80333 Munich, Germany*
[2] *also: Institut für Rundfunktechnik GmbH, 80939 Munich, Germany*
[3] *Department of Environmental Psychology, Osaka University, Japan*

Email: laumann@mmk.ei.tum.de

Introduction

For the investigation of level fluctuating sounds of longer duration – in particular noise immissions – the method of "Continuous Judgment by Category" was proposed by Namba and Kuwano and applied in several studies by them and others, e.g. [1]-[4]. Arakawa et al. also demonstrated the applicability to music [5]. Recently, this method was used again as part of an investigation to study the popular question: "Does the taste in music influence the perception of loudness?"

More specifically, the following hypothesis was challenged: Is the average of instantaneous loudness of excerpts of music lower than their overall loudness? If this difference is large, this would be taken as an indication for a musical style which is disliked, since also for noise immissions large differences between the average of instantaneous loudness and overall loudness show up (cf. [4]).

Method

In psychoacoustic experiments using the method of "Continuous Judgment by Category" the participants are asked to rate their impression of the actual loudness continuously on a scale, usually in seven steps from "very soft" to "very loud". These responses are compared to the instantaneous energy equivalent level L_{eq} of the presented stimulus calculated for an interval equal to the sampling period of the category judgments, by default 100 *ms*. To compensate the reaction time of the participants, the responses and the physical values are shifted against each other until the highest correlation is reached. An example is given in *figure 1*: It displays the $L_{eq,100ms}$ of a musical piece in red and the mean of the category ratings in blue. The close agreement between the graphs indicates that the method works not only for noise immissions [1] [6], but also for excerpts of music.

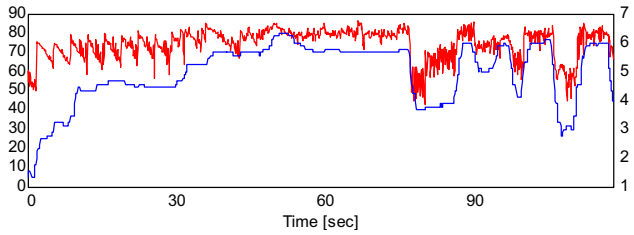

Figure 1: Example for a pop song (Bohemian Rhapsody by Queen): the graph displays the $L_{eq,100ms}$ in red with a *dB*-scale on the left and the mean of reaction time compensated responses with the category scale on the right

Experiment

As listed in *table 1*, eight musical pieces from different genres (classical, jazz, pop, hard rock) were selected for the experiment. It is meaningful to choose music with at least some dynamical range, but two points should be regarded: modern popular music shows little dynamics because of compression and limiting; in classical music the changes are sometimes so fast that participants can hardly react.

Table 1: list of musical pieces used in the experiment

name	genre	artist/composer
Oh Happy Day	jazz	St. Francis Choir & Ryan Toby
Bohemian Rhapsody	pop	Queen
Pas de Soldats	classical	Rossini
Appears	pop	Ayumi Hamasaki
Lied ohne Worte	classical	Mendelssohn-Bartholdy
My Kind of Suns	jazz	Dieter Reith
Enter Sandman	hard rock	Metallica
Straight to Hell	hard rock	Rage Against the Machine

From each piece a 2 *min* segment was taken and due to level differences of the stereo channels converted into mono format. A computer controlled the process: the eight songs were presented once in a soundproof room by a headphone system (Stax SRS-3030) via external D/A-conversion and the participants entered the category rating on a keyboard. Additionally, at the end of the experiment they were also asked to judge for each song the overall loudness and their preference. The $L_{eq,100ms}$ was measured by means of a dummy head with values varying between about 40 and 90 *dB* (cf. *figure 1*).

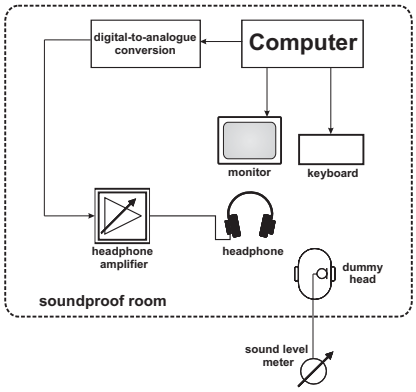

Figure 2: Setup of the psychoacoustic experiment: Stimuli were presented via a headphone system in a soundproof room, the procedure was computer-controlled

Results

In total 9 test persons (female/male: 6/3, mean age: 25.8 years) performed the procedure of about 25 *min* duration.

As described above, the intention of this psychoacoustic experiment is to quantify the difference between the average of instantaneously perceived loudness and the overall loudness with respect to the preference for several pieces of music. For that purpose the arithmetic mean of the instantaneous judgments is calculated and compared to the overall judgement per test person.

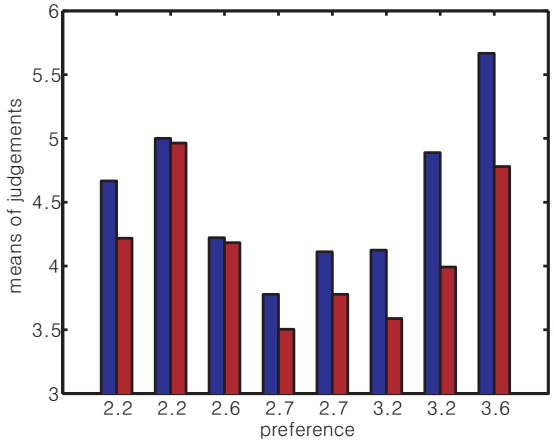

Figure 3: Means of *overall* (blue) vs. means of *averaged instantaneous* (red) category judgments, arranged in ascending order according to the mean preference

The result averaged over all nine participants is illustrated in *figure 3*: Each pair of bars represents one song with the blue bars marking the overall and the red bars the average of the instantaneous judgements. The result is arranged according to the mean preference, which is indicated on the abscissa. The order from left to right is equivalent to the listing in *table 1*. Similar to results for environmental noise (e.g. [1] [3]), the overall judgments (blue bars) exceed the averages of the instantaneous judgments (red bars). This holds for all songs presented, however with distinctly different magnitudes. One fact deserves closer attention: with decreasing preference towards the right side, generally the difference is becoming larger. This effect is illustrated in *figure 4*:

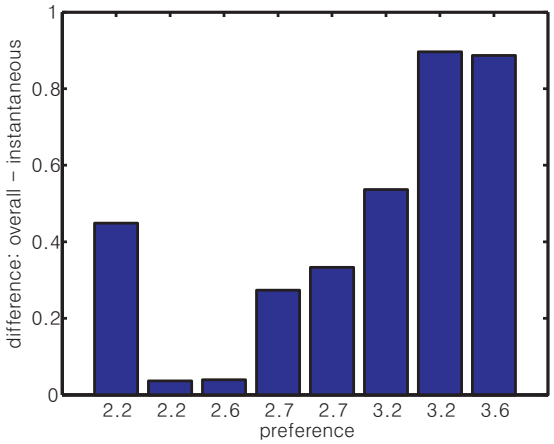

Figure 4: Difference between the means of *overall* category judgments and the means of *averaged instantaneous* category judgments, arranged in ascending order according to the mean preference

The less preferred the music, the larger is the difference between overall and averaged instantaneous evaluation. Obviously overall loudness is particularly high for music which is disliked.

To draw a final conclusion: In noise evaluations, typically "*the overall loudness of a noise immission is larger than the average of the instantaneous loudnesses of the acoustic events constituting the noise immission*"[4]. Therefore, the hypothesis put forward seems to be confirmed as follows: non-preferred music is perceived similarly to noise immissions. The perception of preferred music, however, seems to work differently, because the margin between overall and averaged instantaneous judgments is clearly smaller.

Summary

In a study on music, the method of “Continuous Judgment by Category” was applied to determine the influence of preference for a certain musical style on the loudness perception. Using this method, participants rate their instantaneous impressions of loudness on a 7-step scale. These values are averaged and compared to the judgment of overall loudness evaluated at the end of the experiment.

The results show that along with decreasing preference the difference between the means of overall judgments and averaged instantaneous judgements is becoming larger.

This leads to the assumption that the taste in music indeed influences the perception of loudness, and furthermore disliked music is sensed similarly to noise.

References

[1] Kuwano, S.; Namba, S.: Continuous Judgment of Level-fluctuating Sounds and the Relationship between Overall Loudness and Instantaneous Loudness. Psychological Research 47 (1985), pp. 27-37

[2] Namba, S.; Kuwano, S.; Koyasu, M.: The Measurement of Temporal Stream of Hearing by Continuous Judgments - In the Case of the Evaluation of Helicopter Noise. The Journal of the Acoustical Society of Japan (E) (1993), Vol.14, No. 5, pp. 341-352

[3] Kuwano, S.; Namba, S.; Kato T.; Hellbrück, J.: Memory of the Loudness of Sounds in Relation to Overall Impression. Acoustical Science and Technology (2003), Vol. 24, No.4, pp. 194-196

[4] Fastl, H.: Psychoacoustic Evaluation of Noise Immissions. The Journal of the Acoustical Society of America (1999), Vol. 105, No. 2, pp. 1082-1083

[5] Arakawa, K.; Mizunami, T.; Kuwano S.; Namba, S.; Kato, T.: The Context Effect on Loudness in Listening to Music. The Journal of the Acoustical Society of America (1996), Vol. 100, No. 4, pp. 2778-2779

[6] Kuwano, S.: Continuous Judgment of Temporally Varying Sounds. In: Fastl, H.; Kuwano, S.; Schick, A. (eds.): Recent Trends in Hearing Research – Festschrift for Seiichiro Namba. Bibliotheks- und Informations-system der Universität Oldenburg, 1996