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TESTING OF PSE EXTREME VALUES DETERMINED BY THE METHOD OF AVERAGE ERROR

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The paper points out the suitability and advantage of Dixon's nonparametric test for the exclusion of the points of subjective equality (*PSE*) from the experimental data set obtained by the method of the average error. The proposed testing is illustrated by the example of its use in psychoacoustics when determining the differential threshold for the intensity of acoustical stimuli.

I. INTRODUCTION

The method of the average error is one of the oldest and the most basic psychological methods. It is often called the method of equivalent stimuli, or the adjusment method. The latter is called so because of the subjects adjusting the variable stimulus to the standard one, according to the experimentator's instructions, up to the point where both stimuli evoke in him equal sensations. A detailed description of the measurement by the above mentioned method is, e.g., in [1].

Since today this method is suitable for solving several psychophysical problems (e.g., the determination of the differential threshold, that of the equal intervals, etc.) it is often used. The method has several advantages. One of them is that the subject does the measurements according to the exact, explicit instructions of the experimentator. He searches for the value of the variable stimulus which evokes in him a sensation equal to that evoked by the standard stimulus. This value of the variable stimulus is called the point of subjective equality, *PSE*.

Since the subject himself determines the value of the following stimulus, his interest in the experiment (and thus also his attention), should be always the same. Owing to known psychophysiological attributes of the human body it is possible to presume that the measured values of PSE_j (j-th point of the subjective equality) are basically the points of an empirically obtained distributive function of the normal distribution. However, it can happen that

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several values (usually one to two values) are "evidently" different from the rest of the measured values. These then significantly influence the following statistical data processing by means of which the measured psychophysical parameter is determined. Therefore it is advisable to carry out some statistical test of the set of the measured PSE_j values which will decide whether the "evidently" different values belong to the set or not.

II. TEST OF EXTREME PSE$_j$ VALUES

With regard to the random time variability of the subject's attention and sensitivity of the given sensor the set of the subject's answers oscillates around some middle value. It can happen that the subject is not adequately concentrated during some adjustments of the variable stimulus to the standard one, and the PSE_j values determined by him are apparently different from the other measured values of the PSE_j. One can assume that these values stand for the gross errors of measurement. Such gross errors distort significantly the psychophysical parameter determined by the following calculation. If the randomness of the occurrence of the gross errors of the measurrements and the normality of the distributive function of the rest of the PSE_j values is assumed then one can consider the gross errors of the measurement as the extreme values of the measured set. Thus it is suitable to exclude these gross errors of measurement from further calculation. In order to be able to exclude the gross errors from the set of the measured values their deviations from the rest of the values of the set have to be evaluated by a statistical test called the test of extreme deviations.

Mathematical literature describes a number of various tests of extreme deviations. The testing critetia of the parametric test of extreme deviations contain the standard deviation of the fundamental population σ or its assessment by another measurement series and also the sample standard deviation σ_s. Since we do not know these values before performing the psychophysical experiments it is good to carry out the nonparametric Dixon test in the set of measured values. However, this test can be performed only upon the assumption that the set of the measured values PSE_j is normally distributed. This condition is fulfilled by the psychophysical test sufficiently.

If no systematic error of measurement occurs due to the arrangement of the experiment, it is possible in psychoacoustics to assume the normality of the PSE_j distribution. After the fulfilment of this assumption the course of the Dixon test of extreme deviations is as follows [2]:

a. Experimentally obtained values of the PSE_j will be arranged in such a manner as to have $PSE_1 \leqslant PSE_2 \leqslant \ldots \leqslant PSE_{j-1} \leqslant PSE_j \leqslant PSE_{j-1} \leqslant$

$\leqslant \ldots \leqslant PSE_n$, where $j = 1, 2, \ldots, n$ and n stands for the number of points of subjective equality measured, the range of the set of the PSE_j values, respectively.

b. We coose the significance level p[1].

c. We calculate the value of the testing criterion given by the relationships:

$$Q_1 = \frac{PSE_2 - PSE_1}{PSE_n - PSE_1} \tag{1}$$

for the minimal value of the set and by

$$Q_n = \frac{PSE_n - PSE_{n-1}}{PSE_n - PSE_1} \tag{2}$$

for the maximal value of the set.

d. The tested value PSE_1 or else PSE_n is to be excluded from the set of the PSE_j values if it is valid that $Q_{1;p} < Q_1$ or $Q_{n;p} < Q_n$, respectively, since it is justified to consider it as a gross error. The values $Q_{1;p} = Q_{n;p}$ are the tabulated critical values of the Dixon test of extreme deviations for a chosen significance level p and the range of the set n. Their values for two significance levels are plotted in Table 1.

Table 1

Critical values $Q_{1;p} = Q_{n;p}$ of the Dixon test of extreme deviations
(p is the significance level and n is the range of the set)

n \ p	0.05	0.01	n \ p	0.05	0.01
3	0.941	0.988	17	0.320	0.416
5	0.642	0.780	19	0.306	0.398
6	0.560	0.698	20	0.300	0.391
7	0.507	0.637	21	0.295	0.384
8	0.468	0.590	22	0.290	0.378
9	0.437	0.555	23	0.285	0.372
10	0.412	0.527	24	0.281	0.367
11	0.392	0.502	25	0.277	0.362
12	0.376	0.482	26	0.273	0.357
13	0.361	0.465	27	0.269	0.353
14	0.349	0.450	28	0.266	0.349
15	0.338	0.438	29	0.263	0.345
16	0.329	0.426	30	0.260	0.341

[1] The significance level p is a probability which warrants that the tested parameter will not exceed a certain given value.