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Sensory analysis — Methodology — Sequential analysis

Analyse sensorielle — Méthodologie — Analyse séquentielle

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Foreword

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Sensory analysis — Methodology — Sequential analysis

1 Scope

This International Standard describes a procedure for statistically analysing data from forced-choice sensory discrimination tests, such as the Triangle, Duo-Trio, 3-AFC, 2-AFC, in which after every trial of the discrimination test the decision can be made to stop testing and declare a difference, to stop testing and declare no difference, or to continue testing.

The sequential method often allows for a decision to be made after fewer trials of the discrimination test than would be required by conventional approaches that use predetermined numbers of assessments.

The method is effective for

a) determining that

— either a perceptible difference results, or

— a perceptible difference does not result when, for example, a change is made in ingredients, processing, packaging, handling or storage;

b) or for selecting, training and monitoring assessors.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5492:1992, *Sensory analysis — Vocabulary*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5492 and the following apply.

3.1.1
alpha-risk
α-risk
probability of concluding that a perceptible difference exists when one does not

NOTE This is also known as Type I error, significance level or false positive rate.

3.1.2
beta-risk
β-risk
probability of concluding that no perceptible difference exists when one does

NOTE This is also known as Type II error or false negative rate.

3.1.3
sensitivity
general term used to summarize the performance characteristics of the test

NOTE In statistical terms, the sensitivity of the test is defined by the values of α, β and p_d.

3.2 Symbols

p_0 probability of a correct response when no perceptible difference exists

p_d proportion of assessments in which a perceptible difference is detected between the two products

p_1 probability of a correct response when a perceptible difference does exist

4 Principle

The type of discrimination test (triangle, duo-trio, etc.) is chosen. The sensitivity of the test is defined by selecting values for α, β and p_d.

The boundaries of the decision regions are computed based on α, β, p_0 and p_1. After every trial of the discrimination test, the total number of correct responses [for the panel, see Clause 1a), or per assessor, see Clause 1b)] is compared to the decision boundaries to determine

— if testing can be stopped and a difference can be declared,

— if testing can be stopped and no difference can be declared, or

— if testing should continue.

5 Procedure

5.1 Construct a graph, as in Figure A.1, which illustrates the boundaries of the decision regions based on α, β, p_0 and p_1 as follows.

a) α and β are chosen based on the risks the researcher is willing to take of obtaining a false positive or a false negative result, respectively. α is the probability of declaring that a difference exists when the true probability of a correct response is p_0. β is the probability of failing to declare that a difference exists when the true probability of a correct response is p_1 ($p_1 > p_0$).

b) p_0 is the probability of a correct response when no perceptible difference exists (i.e. the probability of a correct guess). The value of p_0 depends on the discrimination test being used:

— for the triangle and the 3-AFC tests, $p_0 = 1/3$

— for the duo-trio and the 2-AFC tests, $p_0 = 1/2$

c) p_1 is the probability of a correct response when a perceptible difference does exist. The value of p_1 depends on p_d:

— for the triangle and 3-AFC tests, $p_1 = p_d + \left(\frac{1 - p_d}{3}\right)$

— for the duo-trio and 2-AFC tests, $p_1 = p_d + \left(\frac{1 - p_d}{2}\right)$

d) the lines that form the boundaries of the decision regions are calculated as:

lower line: $$d_0 = \frac{\lg(\beta) - \lg(1-\alpha) - n \times \lg(1-p_1) + n \times \lg(1-p_0)}{\lg(p_1) - \lg(p_0) - \lg(1-p_1) + \lg(1-p_0)}$$

upper line: $$d_1 = \frac{\lg(1-\beta) - \lg(\alpha) - n \times \lg(1-p_1) + n \times \lg(1-p_0)}{\lg(p_1) - \lg(p_0) - \lg(1-p_1) + \lg(1-p_0)}$$

where α, β, p_0 and p_1 are as defined above, and n is the number of trials of the test.

NOTE The distance between the two lines depends on $p_1 - p_0$.

5.2 After each trial of the discrimination test, plot the total number of correct responses (on the vertical axis) versus the number of trials (on the horizontal axis):

— if the total number of correct responses falls between the lower and upper lines on the chart, then continue testing by conducting another trial;

— if the total number of correct responses falls above the upper line on the chart, then stop testing and conclude that a perceptible difference exists (at the α-level of significance);

— if the total number of correct responses falls below the lower line on the chart, then stop testing and conclude that no meaningful difference exists [i.e. there is less than a (1 – β) probability that the true probability of a correct response is as high as p_1].

Annex A
(informative)

Examples

A.1 Example 1 — Sequential analysis of a series of triangle tests: acceptance vs. rejection of two trainees on a panel

A.1.1 Background

A sensory analyst wishes to base the decision to accept or reject two trainees on the panel on their performance in triangle tests using a typical pair of products. Each trainee receives a series of triangle tests. Intervals between tests are kept long enough to avoid sensory fatigue.

A.1.2 Test design

The number of trials required to accept or reject a trainee is determined by sequential analysis using a graph as shown in Figure A.1. To position the boundaries of the decision regions (i.e., the two lines in Figure A.1), assign a value to each of the four parameters, α, β, p_0 and p_1. In the triangle test $p_0 = 1/3$ (i.e. the probability of a correct guess, $p_d = 0$). Usually the minimum acceptable rate of detection is set at $p_d = 50$ %, which makes

$$p_1 = 0,50 + (1 - 0,50)\,(\frac{1}{3}) = \frac{2}{3}$$

If it is desired to reduce the number of trials to reach a decision, lower the minimum acceptable rate of detection e.g. to $p_d = 40$ %, which makes

$$p_1 = 0,40 + (1 - 0,40)\,(\frac{1}{3}) = 0,60 \text{ , etc.}$$

NOTE In this example the definition of p_d is not the proportion of the population of assessors who can distinguish the samples but rather the proportion of trials in which a single assessor actually distinguishes the samples.

The analyst chooses the following values for the parameters:

— $\alpha = 0,05$ is the probability of selecting an unacceptable trainee;

— $\beta = 0,10$ is the probability of rejecting an acceptable trainee;

— $p_0 = 1/3$ is the maximum unacceptable ability (i.e. the null hypothesis p-value of the triangle test);

— $p_1 = 2/3$ is the minimum acceptable ability (i.e. the probability that the odd sample will be detected when $p_d = 0,50$).

A.1.3 Analysis and interpretation of results

As each triangle is completed, the results are entered in the diagram in Figure A.1 as follows. Enter the result of the first trial, if correct, as $(x, y) = (1,1)$ and, if incorrect, as $(x, y) = (1,0)$. For each succeeding trial, increase the value of x by 1 and increase y by 1 for a correct response, or increase x by 1 and y by 0 for an incorrect response. Continue testing until a plotted point touches or crosses either of the decision boundaries. Draw the indicated conclusion (i.e. accept or reject the trainee).

Trainee A is correct in all tests and is accepted after five trials. Trainee B fails in the first triangle, succeeds in triangles 2 and 3, but then fails on every subsequent triangle and is rejected after the 8th trial.

Parameters of the test:	$\alpha = 0{,}05$ $\beta = 0{,}10$ $p_0 = \frac{1}{3}$ $p_1 = \frac{2}{3}$
Boundary lines:	Lower: $d_0 = \frac{\lg(\beta) - \lg(1-\alpha) - n \times \lg(1-p_1) + n \times \lg(1-p_0)}{\lg(p_1) - \lg(p_0) - \lg(1-p_1) + \lg(1-p_0)}$ Lower: $d_0 = \frac{\lg(0{,}10) - \lg(1-0{,}05) - n \times \lg[1-(2/3)] + n \times \lg[1-(1/3)]}{\lg(2/3) - \lg(1/3) - \lg[1-(2/3)] + \lg[1-(1/3)]}$ Lower: $d_0 = -1{,}624 + 0{,}5\,n$
	Upper: $d_1 = \frac{\lg(1-\beta) - \lg(\alpha) - n \times \lg(1-p_1) + n \times \lg(1-p_0)}{\lg(p_1) - \lg(p_0) - \lg(1-p_1) + \lg(1-p_0)}$ Upper: $d_1 = \frac{\lg(1-0{,}10) - \lg(0{,}05) - n \times \lg[1-(2/3)] + n \times \lg[1-(1/3)]}{\lg(2/3) - \lg(1/3) - \lg[1-(2/3)] + \lg[1-(1/3)]}$ Upper: $d_1 = 2{,}085 + 0{,}5\,n$