



Standard Test Method for Paired Preference Test¹

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1. Scope

1.1 This document covers a procedure for determining preference between two products using either a two-alternative forced-choice task, or with the option of choosing no preference. Preference testing is a type of hedonic testing.

1.2 A paired preference test determines whether there is a statistically significant preference between two products for a given population of respondents. The target population must be carefully considered.

1.3 This method establishes preference in a single evaluation context. Replicated tests will not be covered within the scope of this document.

1.4 Paired preference testing can address overall preference or preference for a specified sensory attribute.

1.5 The method does not directly determine the magnitude of preference.

1.6 This method does not address whether or not two samples are perceived as different. Refer to Test Method E2164 for directional difference test.

1.7 A paired preference test is a simple task for respondents, and can be used with populations that have minimal reading or comprehension skills, or both.

1.8 Preference is not an intrinsic attribute of the product, such as hue is, but is a subjective measure relating to respondents' affective or hedonic response. It differs from paired comparison testing which measures objective characteristics of the product. Preference results are always dependent on the population sampled.

1.9 *This standard does not purport to address all of the safety problems associated with its use, when testing includes hazardous materials, operations, or equipment. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

E253 Terminology Relating to Sensory Evaluation of Materials and Products

E456 Terminology Relating to Quality and Statistics

E1871 Guide for Serving Protocol for Sensory Evaluation of Foods and Beverages

E1958 Guide for Sensory Claim Substantiation

E2164 Test Method for Directional Difference Test

2.2 ISO Standard:

ISO 5495 Sensory Analysis—Methodology—Paired Comparison³

3. Terminology

3.1 For definition of terms relating to sensory analysis, see Terminology E253, and for terms relating to statistics, see Terminology E456.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 α (alpha) risk—the probability of concluding that a preference exists when, in reality, one does not. (Also known as Type I Error or significance level.)

3.2.2 β (beta) risk—the probability of concluding that no preference exists when, in reality, one does. (Also known as Type II Error.)

3.2.3 *common responses*—for a one-sided test, the number of respondents selecting the product that is expected to be preferred. For a two-sided test, the largest number of respondents selecting either product.

3.2.4 *one-sided test*—a test in which the researcher has an *a priori* assumption concerning the direction of the preference. In this case, the alternative hypothesis will express that a specific product is preferred over another product (that is only, $A > B$ or $A < B$), depending on the *a priori* belief.

3.2.5 *two-sided test*—a test in which the researcher does not have any *a priori* assumption concerning direction of the

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

preference. In this case, the alternative hypothesis is that the two products are not equally preferred (that is, $A \neq B$).

3.2.6 P_{max} —a test sensitivity parameter established prior to testing and used along with the selected values of α and β to determine the number of respondents needed in a study. P_{max} is the proportion of common responses that the researcher wants the test to be able to detect with a probability of $1-\beta$. For example, if a researcher wants to have a 90 % confidence level of detecting a 60:40 split in preference, then $P_{max} = 60\%$ and $\beta = 0.10$.

3.2.7 *sensitivity*—a general term used to summarize the performance characteristics of the paired preference test. The sensitivity of the test is defined, in statistical terms, by the values selected for α , β , and P_{max} . Smaller values of α , β , and P_{max} indicate a more sensitive test.

3.2.8 p_c —the proportion of common responses which is calculated from the test data.

3.2.9 *product*—the material from which samples are selected.

3.2.10 *sample*—the unit of product prepared, presented, and evaluated in the test.

3.2.11 *respondent*—also known as assessor; a general term for any individual responding to stimuli in a sensory test. Trained panelists or experienced discrimination panelists do not serve as respondents in a paired preference test.

4. Summary of Test Method

4.1 Clearly define the test objective in writing, specifying the type of audience or population you wish to recruit as respondents. (If objective involves substantiating an advertising claim, refer to Guide E1958.)

4.2 Choose the number of respondents (N) to be recruited based on the sensitivity level desired for the test (P_{max} , α , and β). The sensitivity of the test is, in part, a function of two competing risks—the risk of declaring a preference when there is none (that is, α -risk) and the risk of not declaring that a preference exists when there is a preference (that is, β -risk). Acceptable values of α and β vary depending on the test objective. The values should be agreed upon by all parties affected by the results of the test before the test is conducted.

4.3 In paired preference testing, an assessor receives a pair of coded samples that are identified with appropriate non-biasing codes. The assessor is asked to choose the sample that is preferred.

4.3.1 When using a forced choice procedure, a sample must be chosen even if the selection is based only on a random selection by the assessor.

4.3.2 If a choice is not forced, a “no preference” option should be included, and the data must be handled in a different way.

4.4 Results are tallied and significance determined by reference to a statistical table (or calculation).

4.5 Testing is generally conducted for one pair of samples to avoid bias from one set of samples to another.

5. Significance and Use

5.1 The paired preference test determines whether or not there is a preference for one product over another product among a specific target population. Knowledge of consumer segments, brand loyalties, the range of product offerings in the marketplace, and the decision risk must be understood when planning a paired preference test.

5.2 The paired preference method is commonly used in tests with one or more of the following objectives: (1) to establish superiority in preference versus the competition for advertising claims support; (2) to establish the preference of a new product for launch versus a competitor’s product; (3) to establish the preference of a reformulated product in a product improvement or product modification project (for example, process change or ingredient change); and (4) to establish the preference of a cost improved product versus the current formulation in a cost savings project. Selected values of P_{max} , α , and β will change with all four types of test objectives. These should be selected prior to determination of N .

5.2.1 *Preference versus Competition or Launching a New Product versus Competition*—Select a P_{max} to represent what you expect a reasonable preference split to be. The main risk to avoid is to wrongly claim your product is preferred over the competitors. Thus, low values of α are selected, for example, 0.05, 0.01, or 0.001. The desired outcome of this test is to reject the null hypothesis. The alternative hypothesis is one sided: A new or improved product (A) is preferred over the competitor’s product (B). The test is one-sided. The value of β will be determined by the sample size chosen and the size of the preference in the consumer segment selected for the test. Selection of the appropriate number of respondents is determined by P_{max} , α , and β , as well as the market segment that must be included in the test (for issues specific to conducting a paired preference test for an advertising claim, refer to Guide E1958).

5.2.2 *Cost Reduction or Reformulation of an Existing Product*—When parity preference is the desired test outcome, values of α are increased and values of β are decreased. For example, if a product is developed which represents a significant cost savings over the current formulation and there is concern over alienation of current users, α might be selected at 0.20 and β might be selected at 0.01. Parity testing can be either one-or two-sided depending on the action standards of the test. The test is one-sided if the action standard is that the product must be parity or better. The test is two-sided if the action standard is parity only. The number of respondents chosen must reflect the risk of replacing the current product with the cost-reduced product.

5.3 A test result of superiority or parity does not ensure that the test conclusion is correct. An incorrect test result can be obtained when the sample of respondents is selected in a way that does not reflect the true preference in the population of interest, or when the number of respondents is too small to correctly reflect the preference status of the two products among the target consumer group. Careful selection of P_{max} , α , and β and an appropriate selection of respondents is needed to minimize the risk of drawing an incorrect conclusion in forced-choice paired preference testing.

6. Apparatus

6.1 Carry out the test under conditions that prevent contact between respondents until the evaluations have been completed.

6.2 Sample preparation and serving sizes should comply with Practice E1871, or see Herz and Cupchik⁴ or Todrank et al.⁵

7. Respondents

7.1 Choose the appropriate set of respondents on the basis of the test objective. Selecting the appropriate set of assessors for a preference test is critical since preference responses vary depending on the consumer group targeted. The most appropriate respondents to determine product preference are the current or potential consumers of the product category.

7.2 Respondents must be selected based upon the objective of the study and are dependent on the business implication. For a new product, the respondents should represent target consumers. For an existing product, respondents may include users of the product. If your business objective is to ensure that market share is not lost when making formula changes, respondents should include heavy category or product users.

8. Number of Respondents

8.1 Once the target population has been clearly defined, choose the number of respondents required for the test as follows: (1) first determine if the test is one-sided or two-sided, and (2) establish the sensitivity required by the test objectives by selecting values for the three test-sensitivity parameters: the α -risk, the β -risk, and the maximum allowable proportion of common responses, P_{max} , that would represent a meaningful departure from parity (50:50) preference as decided by the research team.

8.1.1 The test is one-sided if the researcher has an *a priori* interest in only one of the samples being preferred. For example, the test is one-sided if the researcher wants to determine if the product is preferred to the major competitor's product. The test is two-sided if the researcher has no *a priori* assumption in a particular sample being preferred. For example, the test is two-sided if two prototype samples are being compared and the researcher wants to establish if one sample is preferred over the other sample. More respondents are needed for a two-sided test than for a one-sided test (see 5.2.1 and 5.2.2).

8.1.2 When the researcher wants to take only a small chance of concluding that a preference exists when it does not (for example, when testing to support a claim of superiority), the most commonly used values for α -risk and β -risk are $\alpha = 0.05$ and $\beta = 0.20$. These values can be adjusted on a case-by-case basis to reflect the sensitivity desired versus the number of respondents available. When testing for a preference with a

limited number of respondents, hold the α -risk at a relatively small value and allow the β -risk to increase in order to control the risk of falsely concluding that a preference is present.

8.1.3 When the researcher wants to take only a small chance of missing a preference that exists (for example, when testing to support a claim of parity preference), the most commonly used values for α -risk and β -risk are $\alpha = 0.20$ and $\beta = 0.05$. These values can be adjusted on a case-by-case basis to reflect the sensitivity desired versus the number of respondents available. When testing for parity with a limited number of respondents, hold the β -risk at a relatively small value and allow the α -risk to increase in order to control the risk of missing a preference that truly exists.

8.1.4 For P_{max} , the proportion of common responses falls into three ranges: (1) $P_{max} < 55\%$ represents "small" values; (2) $55\% \leq P_{max} \leq 65\%$ represents "medium sized" values; and (3) $P_{max} > 65\%$ represents "large" values.

8.2 Having defined the required sensitivity for the test using 8.1, use Table X1.1 to determine the number of respondents necessary for a one-sided test, or Table X2.1 to determine the number of respondents necessary for two-sided test. Select the section of the table corresponding to the selected P_{max} value and the column corresponding to the selected β value. The minimum required number of respondents is found in the row corresponding to the selected value of α . Alternatively, Table X1.1 can be used to develop a set of values for P_{max} , α , and β that provide acceptable sensitivity while maintaining the number of respondents within practical limits.

8.2.1 Using the parameters: $\alpha = 0.05$, $\beta = 0.20$, and $P_{max} = 60\%$, the researcher would use the section of Table X1.1 corresponding to $P_{max} = 60\%$ and the column corresponding to $\beta = 0.20$. In the row corresponding to $\alpha = 0.05$, it is found that 158 respondents will be needed for the test.

8.3 Often in practice, the number of respondents is determined by project constraints (for example, duration of the experiment, number of respondents available, quantity of sample, budgetary constraints). The power of the test should then be computed. For this purpose, the following parameters need to be defined: α , observed P_{max} , and the number of respondents, n . The observed P_{max} corresponds to the observed proportion of common responses, n is determined by the test realization, and α should be fixed by the experimenter prior to the test being conducted. With this information, an exact power computation can be achieved using appropriate software. However, an approximate value can already be inferred by reverse lookup using Table X1.1 or Table X2.1, depending on whether the alternative is one- or two-sided. First, use the value of P_{max} closest to the observed one to select a group of rows, then select among these rows the one corresponding to the selected value of α . Finally, select the cell having the number of assessors closest to the actual number of assessors. The corresponding column heading will give a close estimate of the actual power of the test ($1 - \beta$). Lower sample sizes will reduce the power of the test.

9. Procedure

9.1 Paired preference can be used in either CLT (Central Location Test) or IHUT (in-home use test) designs. The

⁴ Herz, R. S. and Cupchik, G. C., "An Experimental Characterization of Odor-evoked Memories in Humans," *Chemical Senses*, Vol 17, No. 5, 1992, pp. 519-528.

⁵ Todrank, J., Wysocki, C. J., and Beauchamp, G. K., "The Effects of Adaptation on the Perception of Similar and Dissimilar Odors," *Chemical Senses*, Vol 16, No. 5, 1991, pp. 476-482.

following discussion focuses on CLT testing procedures, however, randomizations and data analyses would be similar for IHUT's.

9.2 Prepare serving order worksheet and ballot in advance of the test to ensure a balanced order of presentation of the two samples. Balance the serving sequences of the samples (AB and BA) across all respondents. Serving order worksheets should also include complete sample identification information either by product name or coded reference for double blind studies. See [Appendix X1](#).

9.3 It is critical to the validity of the test that respondents cannot differentiate the samples based on the way they are presented. For example, in a test evaluating flavor differences, one should avoid any subtle differences in temperature or appearance caused by factors such as the time sequence of preparation. Code the vessels containing the samples in a uniform manner, using three digit numbers chosen at random for each test. Prepare samples out of sight and in an identical manner: same apparatus, same vessels, same quantities of sample (see Practice [E1871](#), ASTM Serving Protocols).

9.4 Present the pair of samples simultaneously if possible, following the same spatial arrangement for each assessor (on a line to be sampled always from left to right, or from front to back, etc.). Respondents are typically allowed to evaluate each sample more than once. If the conditions of the samples restrict reevaluating the samples (for example, if samples are bulky, leave an aftertaste, or show slight differences in appearance that cannot be masked), present the samples sequentially and do not allow repeated evaluations.

9.5 It is not recommended that more than the preference question be asked about the samples, because the selection the respondent has made on the initial question may bias the response to subsequent questions. Responses to additional questions may be obtained through separate tests for acceptance, degree of difference, etc. See Manual 26⁶. A section soliciting open-ended comments may be included following the initial preference question.

9.6 The paired preference test can either be forced-choice or have the option of no preference.

9.6.1 When using the paired preference test as a forced-choice procedure, respondents are not allowed the option of reporting “no preference.” A respondent who has no preference for either of the samples should be instructed to randomly select one of the samples, and can indicate in the comments section that they had no preference.

10. Analysis and Interpretation of Results

10.1 The procedure used to analyze the results of a paired preference test depends on whether or not a “no preference” option is allowed.

10.1.1 If a forced choice procedure is used, analyze as detailed in [10.2](#).

10.1.2 If a “no preference” option is allowed, then there are various ways to handle the data depending on the test objec-

tives. Typically the no preference data is split in some manner between “A” and “B.” Regardless of how the no preference data are handled, it is always important to report the percentage of no preference responses and take those into account for your final action steps. (Refer to Guide [E1958](#) for decision rules regarding handling of no preference votes and specific claims.)

10.2 *Analysis for Preference*—Different analyses are used depending on whether the number of respondents is equal to or greater than planned or fewer than planned.

10.2.1 If the actual number of respondents is equal to or greater than planned, refer to [Table X1.2](#) (one-sided) or [Table X2.2](#) (two-sided) to analyze the data. If the number of common responses is equal to or greater than the number given in the table, conclude that there is a preference between the products. If the number of common responses is fewer than the number given in the table, conclude that there is no preference. The conclusions, “preference” or “no preference,” are based on the predetermined α , β , and P_{max} levels.

10.2.2 When the number of respondents is fewer than planned, then the data analysis is the same as [10.2.1](#) above. Understand that the β -risk is now larger than the value chosen because a smaller number of respondents participated in the test. A result of “no preference” becomes more likely as N decreases.

10.3 *Analysis for Parity*—Different analyses are used depending on whether the number of respondents is equal to or greater than planned or fewer than planned. There is a direct relationship between sample size (N) and test sensitivity in parity testing.

10.3.1 When the actual number of respondents is equal to or greater than planned, then the analysis is conducted as outlined in [10.2.1](#).

10.3.2 When the number of respondents is fewer than planned, then data analysis consists of calculating a confidence interval. A confidence interval is calculated because the α , β , and P_{max} levels are different in parity preference testing. The calculations are as follows, where c = the number of common responses, and n = the total number of respondents:

$$\begin{aligned} \text{Proportion of common responses} \\ P_c &= c/n \\ S_c \text{ (standard deviation of } P_c) &= \sqrt{P_c(1 - P_c)/n} \\ \text{Confidence Limit} &= P_c \pm z_\beta S_c \end{aligned}$$

10.3.3 z_β is the critical value of the standard normal distribution. Values of z_β for some commonly used values of β -risk are:

β -risk	z_β
0.50	0.000
0.40	0.253
0.20	0.842
0.10	1.282
0.05	1.645
0.01	2.326
0.001	3.090

Given the values chosen for β and P_{max} , if the confidence limit is less than P_{max} , then conclude that there is parity (that is, no more than P_{max} of the population would have a preference at the β -level of significance). If the confidence limit is greater than P_{max} , then conclude that the products are not at parity.

⁶ MNL26-2ND *Sensory Testing Methods: Second Edition*, Chambers, E. and Wolf, M.B., Eds., ASTM International, 1996.

Understand that the α -risk is larger than the value chosen when a smaller number of respondents participate in the test.

10.4 If desired, calculate a two-sided confidence interval on the proportion of common responses.

11. Report

11.1 Report the test objective, the results, and the conclusions. The following additional information is recommended:

11.1.1 The purpose of the test and the nature of the treatment studied;

11.1.2 Full identification of the samples: origin, method of preparation, quantity, shape, storage prior to testing, serving size, and temperature. (Sample information should communicate that all storage, handling, and preparation was done in such a way as to yield samples that differed only in the variable of interest, if at all.);

11.1.3 The number of respondents, recruitment criteria, the number of selections of each sample, and the result of the statistical analysis;

11.1.4 Test sensitivity parameters: α , β , and P_{max} levels, one-tailed or two-tailed test, critical value, decision risk;

11.1.5 Respondents: age, gender, frequency of product usage: typical/usual product consumption in the category (for example, brand loyal or rotators);

11.1.6 The test environment: use of booths, simultaneous or sequential presentation and lighting conditions;

11.1.7 The location and date of the test and name of the test administrator;

11.1.8 Next steps.

12. Precision and Bias

12.1 Because results of paired preference tests are a function of individual preferences, a general statement regarding the precision of results applicable to all populations of respondents cannot be made. Unless the demographics of the test population are matched to U.S. census, results cannot be projected to the total U.S. population. However, adherence to the recommendations stated in this standard should increase the reproducibility of results and minimize bias if the same target population is sampled from over repeated preference tests and the underlying population is homogeneous in its preferences.

13. Keywords

13.1 paired preference; preference; sensory; test method

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLE X1: PAIRED PREFERENCE TEST: BEVERAGE FLAVORING FORCED CHOICE PROCEDURE

X1.1 Background

X1.1.1 A beverage manufacturer wants to determine if a new chocolate flavoring that is sweeter and more “chocolatey” is preferred when used in a milk alternative beverage prior to fielding more expensive in-home consumer testing. Chocolate flavor “A” is a new, less expensive flavor that was determined by descriptive analysis to be higher in Sweetness and Chocolate Flavor impact. It is hypothesized by the development team that this sweeter flavor system will also be preferred and is intended to replace chocolate flavor “B,” which is the current product. It was decided to force a choice between the two flavors.

X1.2 Test Objective

X1.2.1 To determine if chocolate flavoring “A” is preferred over “B” in a milk alternative beverage. This is a one-sided test.

X1.3 Number of Respondents

X1.3.1 To protect the product developer from falsely concluding that a preference exists, the sensory analyst proposes $\alpha = 0.05$, and a P_{max} of 70 % with $\beta = 0.01$. The analyst enters **Table X1.1** in the section corresponding to $P_{max} = 70\%$ and the column corresponding to $\beta = 0.01$. Then, reading from the row corresponding to $\alpha = 0.05$, it is determined that a minimum of 94 respondents will be needed for the test. The sensory analyst recruits more than 94 respondents that have been identified as

users of the product category to ensure that the minimum number of respondents are tested.

X1.4 Conducting the Test

X1.4.1 One hundred cups of “A” and 100 cups of “B” are coded with unique random three digit numbers. Each sequence, AB and BA, is presented 47 times so as to cover at least 94 respondents in a balanced random order, with extra servings available in case of accidental spills, etc. An example of the worksheet and scoresheet is shown in **Figs. X1.1 and X1.2**. Ninety-six respondents participated in the test.

X1.5 Analysis and Interpretation of Results

X1.5.1 Thirty-eight respondents selected the sample with chocolate flavor “A” as preferred, and 67 selected sample with flavor “B.” In **Table X1.2**, the row corresponding to 96 respondents and the column corresponding to $\alpha = 0.05$, the sensory analyst finds that 57 common responses were needed in order to conclude that there is a preference.

X1.6 Report and Conclusions

X1.6.1 The sensory analyst reports that there was a significant preference for the current product with chocolate flavor “B,” given the sensitivity chosen for the test ($P_{max} = 70\%$, $\alpha = 0.05$, $\beta = 0.01$). The analyst concludes that product with chocolate flavor “A” would be a poor candidate for in-home testing, and recommends further development and screening of

TABLE X1.1 Number of Respondents Needed for a Paired Preference Test One-Sided Alternative^A

α		β							
		0.50	0.40	0.30	0.20	0.10	0.05	0.01	0.001
0.50	$p_{max} = 75 \%$	2	4	4	4	8	12	20	34
0.40		2	4	4	6	10	14	28	42
0.30		2	6	8	10	14	20	30	48
0.20		6	6	10	12	20	26	40	58
0.10		10	10	14	20	26	34	48	70
0.05		14	16	18	24	34	42	58	82
0.01		22	28	34	40	50	60	80	108
0.001		38	44	52	62	72	84	108	140
0.50	$p_{max} = 70 \%$	4	4	4	8	12	18	32	60
0.40		4	4	6	8	14	26	42	70
0.30		6	8	10	14	22	28	50	78
0.20		6	10	12	20	30	40	60	94
0.10		14	20	22	28	40	54	80	114
0.05		18	24	30	38	54	68	94	132
0.01		36	42	52	64	80	96	130	174
0.001		62	72	82	96	118	136	176	228
0.50	$p_{max} = 65 \%$	4	4	4	8	18	32	62	102
0.40		4	6	8	14	30	42	76	120
0.30		8	10	14	24	40	54	88	144
0.20		10	18	22	32	50	68	110	166
0.10		22	28	38	54	72	96	146	208
0.05		30	42	54	70	94	120	174	244
0.01		64	78	90	112	144	174	236	320
0.001		108	126	144	172	210	246	318	412
0.50	$p_{max} = 60 \%$	4	4	8	18	42	68	134	238
0.40		6	10	24	36	60	94	172	282
0.30		12	22	30	50	84	120	206	328
0.20		22	32	50	78	112	158	254	384
0.10		46	66	86	116	168	214	322	472
0.05		72	94	120	158	214	268	392	554
0.01		142	168	208	252	326	392	536	726
0.001		242	282	328	386	480	556	732	944
0.50	$p_{max} = 55 \%$	4	8	28	74	164	272	542	952
0.40		10	36	62	124	238	362	672	1124
0.30		30	72	118	200	334	480	810	1302
0.20		82	130	194	294	452	618	1006	1556
0.10		170	240	338	462	658	862	1310	1906
0.05		282	370	476	620	866	1092	1584	2238
0.01		550	666	820	1008	1302	1582	2170	2928
0.001		962	1126	1310	1552	1908	2248	2938	3812

^A The values recorded in this table have been rounded to the nearest whole number evenly divisible by two to allow for equal presentation of both pair combinations (AB and BA).

alternative cost-reduced chocolate flavors.

Paired Preference Test Worksheet					
Project Name: <u>Chocolate Milk Alternative Beverages</u>			Date of Test: <u>02/09/2000</u>		
Sample "A": <u>Proposed alternative chocolate flavor</u>					
Sample "B": <u>Current chocolate flavor</u>					
Serving Order:			(page 1)		
Set #	1st	2nd	Set #	1st	2nd
01	A – 417	B – 293	37	A – 427	B – 693
02	B – 582	A – 605	38	B – 780	A – 403
03	A – 167	B – 324	39	A – 867	B – 329
04	B – 129	A – 772	40	B – 629	A – 744
05	A – 238	B – 679	41	A – 328	B – 769
06	B – 386	A – 405	42	B – 836	A – 195
07	A – 181	B – 976	43	A – 811	B – 796
08	B – 392	A – 447	44	B – 932	A – 247
09	A – 462	B – 800	45	A – 642	B – 075
10	B – 189	A – 391	46	B – 819	A – 319
11	A – 492	B – 264	47	A – 942	B – 246
12	B – 572	A – 469	48	B – 752	A – 496
13	A – 168	B – 342	49	A – 618	B – 324
14	B – 607	A – 358	50	B – 327	A – 385
15	A – 455	B – 594	51	A – 545	B – 549
16	B – 255	A – 486	52	B – 525	A – 468
17	A – 645	B – 532	53	A – 465	B – 523
18	B – 175	A – 922	54	B – 715	A – 986
19	A – 613	B – 783	55	A – 163	B – 738
20	B – 217	A – 441	56	B – 127	A – 414
21	A – 689	B – 513	57	A – 869	B – 531
22	B – 763	A – 889	58	B – 673	A – 898
23	A – 290	B – 187	59	A – 920	B – 178
24	B – 476	A – 733	60	B – 076	A – 723
25	A – 133	B – 610	61	A – 313	B – 605
26	B – 992	A – 530	62	B – 092	A – 503
27	A – 624	B – 491	63	A – 264	B – 419
28	B – 935	A – 171	64	B – 395	A – 117
29	A – 864	B – 680	65	A – 684	B – 608
30	B – 156	A – 577	66	B – 516	A – 507
31	A – 367	B – 549	67	A – 637	B – 594
32	B – 611	A – 327	68	B – 161	A – 372
33	A – 715	B – 907	69	A – 175	B – 961
34	B – 682	A – 834	70	B – 862	A – 843
35	A – 539	B – 817	71	A – 239	B – 124
36	B – 946	A – 147	72	B – 472	A – 369

FIG. X1.1 Example Paired Preference Test Worksheet



Name: _____ Date: MM/dd/yyyy

Set: 01

INSTRUCTIONS:

- You have received 2 coded samples.
- Please evaluate these samples from left to right. Answer the following question by circling the code number which corresponds to the sample you select.

Which sample do you *PREFER*? (Circle ONE)

417

293

Thank you.

Please raise the window and leave your scorecard in the booth.

FIG. X1.2 Example Paired Preference Test Scoresheet

TABLE X1.2 Number of Common Responses Needed for Significance in a Paired Preference Test, One-Sided Alternative^A

NOTE 1—Entries are the minimum number of common responses required for significance at the stated significance level (that is, column) for the corresponding number of respondents “*n*” (that is, row). Reject the assumption of “no preference” if the number of correct responses is greater than or equal to the tabled value.

Significance Level, %							Significance Level, %						
<i>n</i>	0.50	0.20	0.10	0.05	0.01	0.001	<i>n</i>	0.50	0.20	0.10	0.05	0.01	0.001
4	3	4	4	-	-	-	31	16	19	20	21	23	25
5	4	4	5	5	-	-	32	17	19	21	22	24	26
							33	17	20	21	22	24	26
6	4	5	6	6	-	-	34	18	20	22	23	25	27
7	4	6	6	7	7	-	35	19	21	22	23	25	27
8	5	6	7	7	8	-							
9	6	7	7	8	9	-	36	19	22	23	24	26	28
10	6	7	8	9	10	10	40	21	24	25	26	28	31
							44	23	26	27	28	31	33
11	6	8	9	9	10	11	48	25	28	29	31	33	36
12	7	8	9	10	11	12	52	27	30	32	33	35	38
13	7	9	10	10	12	13							
14	8	10	10	11	12	13	56	29	32	34	35	38	40
15	9	10	11	12	13	14	60	31	34	36	37	40	43
							64	33	36	38	40	42	45
16	9	11	12	12	14	15	68	35	38	40	42	45	48
17	9	11	12	13	14	16	72	37	41	42	44	47	50
18	10	12	13	13	15	16							
19	10	12	13	14	15	17	76	39	43	45	46	49	52
20	11	13	14	15	16	18	80	41	45	47	48	51	55
21	12	13	14	15	17	18	84	43	47	49	51	54	57
22	12	14	15	16	17	19	88	45	49	51	53	56	59
23	12	15	16	16	18	20	92	47	51	53	55	58	62
24	13	15	16	17	19	20							
25	13	16	17	18	19	21	96	49	53	55	57	60	64
							100	51	55	57	59	63	66
26	14	16	17	18	20	22							
27	14	17	18	19	20	22							
28	15	17	18	19	21	23							
29	16	18	19	20	22	24							
30	16	18	20	20	22	24							

^A Adapted from Meilgaard, M., Civille, G. V., and Carr, B. T., *Sensory Evaluation Techniques*, 2nd Edition, CRC Press, Inc., Boca Raton, FL, 1991, p. 339.

NOTE 1—For values of *n* not in the table, compute the missing entry as follows: Minimum number of responses (*x*) = nearest whole number greater than $x = (n/2) + z\sqrt{n/4}$, where *z* varies with the significance level as follows: 0.84 for $\alpha = 0.20$; 1.28 for $\alpha = 0.10$; 1.64 for $\alpha = 0.05$; 2.33 for $\alpha = 0.01$; 3.10 for $\alpha = 0.001$. This calculation is an approximation. The value obtained may differ from the exact value as presented in the table, but the difference never exceeds one response. Exact values can be obtained from binomial distribution functions widely available in statistical computer packages.

X2. EXAMPLE X2: PAIRED PREFERENCE TEST: FORMULATION CHANGE NO PREFERENCE ALLOWED

X2.1 Background

X2.1.1 A syrup manufacturer has changed their formulation to increase maple flavor. When testing to determine if this change would increase preference for their product, it was decided to allow a no preference option.

X2.2 Test Objective

X2.2.1 To determine if the new syrup formulation is preferred over the current formulation by target consumers.

X2.3 Number of Respondents

X2.3.1 The sensory analyst proposes $\alpha = 0.05$, and a P_{max} of 65 % with $\beta = 0.20$. Looking at [Table X2.1](#) for a two-sided test, it is determined that a minimum of 90 respondents is needed.

X2.4 Conducting the Test

X2.4.1 The syrups were given to the respondents in portion cups coded with random three digit numbers. The respondents

were also given frozen pancakes that were heated on cookie sheets in a conventional oven. Respondents were asked to pour the syrup on the pancakes then try each product and indicate their preference. The syrups were served in a balanced order with the control seen first 50 % of the time, and the test product seen first 50 % of the time. An example of the scoresheet is shown in [Fig. X2.1](#).

X2.5 Analysis and Interpretation of Results

X2.5.1 A total of 92 respondents participated in this study. No preference responses were given by 28 of the respondents. Preference for the test sample was obtained from 51 if the respondents, while preference for the current formulation was obtained from 13 of the respondents.

X2.5.2 The data were analyzed as follows. Since the objective was to reformulate an existing product, the no preference responses were split between the two products with the rationale that if the respondents had been forced to make a

TABLE X2.1 Number of Respondents Needed for a Paired Preference Test Two-Sided Alternative^A

α		β							
		0.50	0.40	0.30	0.20	0.10	0.05	0.01	0.001
0.50	$p_{max} = 75 \%$	2	6	8	12	16	24	34	52
0.40		6	6	10	12	20	26	40	58
0.30		6	8	12	16	22	30	42	64
0.20		10	10	14	20	26	34	48	70
0.10		14	16	18	24	34	42	58	82
0.05		18	20	26	30	42	50	68	92
0.01		26	34	40	44	58	66	88	118
0.001		42	50	58	66	78	90	118	150
0.50	$p_{max} = 70 \%$	6	8	12	16	26	34	54	86
0.40		6	10	12	20	30	40	60	94
0.30		8	14	18	22	34	44	68	102
0.20		14	20	22	28	40	54	80	114
0.10		18	24	30	38	54	68	94	132
0.05		26	36	40	50	66	80	110	150
0.01		44	50	60	74	92	108	144	192
0.001		68	78	90	102	126	148	188	240
0.50	$p_{max} = 65 \%$	8	14	18	30	44	64	98	156
0.40		10	18	22	32	50	68	110	166
0.30		14	20	30	42	60	82	126	188
0.20		22	28	38	54	72	96	146	208
0.10		30	42	54	70	94	120	174	244
0.05		44	56	68	90	114	146	200	276
0.01		74	92	108	132	164	196	262	346
0.001		122	140	162	188	230	268	342	440
0.50	$p_{max} = 60 \%$	16	28	36	64	98	136	230	352
0.40		22	32	50	78	112	158	254	384
0.30		32	44	66	90	134	180	284	426
0.20		46	66	86	116	168	214	322	472
0.10		72	94	120	158	214	268	392	554
0.05		102	126	158	200	264	328	456	636
0.01		172	204	242	292	374	446	596	796
0.001		276	318	364	426	520	604	782	1010
0.50	$p_{max} = 55 \%$	50	96	156	240	394	544	910	1424
0.40		82	130	194	294	452	618	1006	1556
0.30		110	174	254	360	550	722	1130	1702
0.20		170	240	338	462	658	862	1310	1906
0.10		282	370	476	620	866	1092	1584	2238
0.05		390	498	620	786	1056	1302	1834	2544
0.01		670	802	964	1168	1494	1782	2408	3204
0.001		1090	1260	1462	1708	2094	2440	3152	4064

^A The values recorded in this table have been rounded to the nearest whole number evenly divisible by two to allow for equal presentation of both pair combinations (AB and BA).

choice, there was a 50 % chance for preference going to each of the samples. Therefore preference for the test product was recalculated to be 65 respondents (51 votes plus 14 or 50 % of the no preference votes). Looking at [Table X2.2](#), it was noted that for $N = 92$ respondents, 56 common responses are needed for significance at the 95 % confidence level. Therefore, it can be concluded that the new syrup formulation was preferred over the current product.

X2.6 Report and Conclusions

X2.6.1 The sensory analyst reports that the test product was significantly preferred over the current product at a confidence level of 95 %. Therefore, it is recommended to use the new syrup formulation.



Name: _____ Date: MM/DD/YYYY Set: 01

INSTRUCTIONS:

- You have received 2 samples of syrups and 2 plates of pancakes. Please pour the syrup unto the pancakes, and then evaluate the sample on the left followed by the sample on the right.

Which sample do you prefer? (Check one box only)

Sample on the Left (#387) ☐

Sample on the Right (#629) ☐

Did not prefer either sample: ☐

Thank you for your participation!

FIG. X2.1 Example Scoresheet for Paired Preference With No Preference Option

TABLE X2.2 Number of Common Responses Needed for Significance in a Paired Preference Test, Two-Sided Alternative^A

NOTE 1—Entries are the minimum number of common responses required for significance at the stated significance level (that is, column) for the corresponding number of respondents “*n*” (that is, row). Reject the assumption of “no preference” if the number of correct responses is greater than or equal to the tabled value.

Significance Level, %							Significance Level, %						
<i>n</i>	0.50	0.20	0.10	0.05	0.01	0.001	<i>n</i>	0.50	0.20	0.10	0.05	0.01	0.001
5	4	5	5	-	-	-	31	18	20	21	22	24	25
6	5	6	6	6	-	-	32	19	21	22	23	24	26
7	5	6	7	7	-	-	33	19	21	22	23	25	27
8	6	7	7	8	8	-	34	20	22	23	24	25	27
9	7	7	8	8	9	-	35	20	22	23	24	26	28
10	7	8	9	9	10	-	36	21	23	24	25	27	29
11	8	9	9	10	11	11	40	23	25	26	27	29	31
12	8	9	10	10	11	12	44	25	27	28	29	31	34
13	9	10	10	11	12	13	48	27	29	31	32	34	36
14	9	10	11	12	13	14	52	29	32	33	34	36	39
15	10	11	12	12	13	14							
16	10	12	12	13	14	15	56	32	34	35	36	39	41
17	11	12	13	13	15	16	60	34	36	37	39	41	44
18	11	13	13	14	15	17	64	36	38	40	41	43	46
19	12	13	14	15	16	17	68	38	40	42	43	46	48
20	13	14	15	15	17	18	72	40	42	44	45	48	51
21	13	14	15	16	17	19	76	42	45	46	48	50	53
22	14	15	16	17	18	19	80	44	47	48	50	52	56
23	14	16	16	17	19	20	84	46	49	51	52	55	58
24	15	16	17	18	19	21	88	48	51	53	54	57	60
25	15	17	18	18	20	21	92	50	53	55	56	59	63
26	16	17	18	19	20	22	96	52	55	57	59	62	65
27	16	18	19	20	21	23	100	54	57	59	61	64	67
28	17	18	19	20	22	23							
29	17	19	20	21	22	24							
30	18	20	20	21	23	25							

^A Adapted from Meilgaard, M., Civille, G. V., and Carr, B. T., *Sensory Evaluation Techniques*, 2nd Edition, CRC Press, Inc., Boca Raton, FL, 1991, p. 340.

NOTE 1—For values of *n* not in the table, compute the missing entry as follows: Minimum number of responses (*x*) = nearest whole number greater than $x = (n/2) + z\sqrt{n/4}$, where *z* varies with the significance level as follows: 1.28 for $\alpha = 0.20$; 1.64 for $\alpha = 0.10$; 1.96 for $\alpha = 0.05$; 2.58 for $\alpha = 0.01$; 3.29 for $\alpha = 0.001$. This calculation is an approximation. The value obtained may differ from the exact value as presented in the table, but the difference never exceeds one response. Exact values can be obtained from binomial distribution functions widely available in statistical computer packages.

X3. EXAMPLE X3—PRODUCT COST SAVINGS: FORCED CHOICE PROCEDURE

X3.1 Background

X3.1.1 A household cleaner manufacturer has identified an alternative fragrance manufacturer that provides significant cost savings over the current formulation. However, the manufacturer wants to make sure that this alternative fragrance for its spray cleaner can be substituted without alienating current users. It was decided to force a choice between the current product and the alternative formula.

X3.2 Test Objective

X3.2.1 To determine if alternate fragrance source is parity or better in preference compared to the current product. This is a one-sided test.

X3.3 Number of Respondents

X3.3.1 To protect the manufacturer from falsely concluding that no preference exists, the sensory analyst proposes $\alpha = 0.1$, and a P_{max} of 60 % with $\beta = 0.01$. The analyst enters **Table X1.1** in the section corresponding to $P_{max} = 60\%$ and the

column corresponding to $\beta = 0.01$. Then, reading from the row corresponding to $\alpha = 0.1$, it is determined that a minimum of 322 respondents will be needed for the test. The sensory analyst recruits more than 322 respondents that have been identified as users of the product category to ensure that the minimum number of respondents are tested.

X3.4 Conducting the Test

X3.4.1 Identical spray bottles are coded with unique random three digit numbers. Each sequence, AB and BA, is presented 161 times so as to cover at least 161 respondents in a balanced random order. Respondents are instructed to spray each product a set number of times unto hard surface, and wipe with cloth. Two hundred and seventy-five respondents participated in the test.

X3.5 Analysis and Interpretation of Results

X3.5.1 One hundred and thirty respondents selected the sample with alternate fragrance as preferred, and 145 selected

the control sample as preferred. Since the number of respondents that participated was less than desired, instead of utilizing tables to determine if parity was achieved, confidence interval must be calculated as described in 10.2. Proportion of common responses $p_c = c/n$, S_c (standard deviation of P_c) = $\sqrt{P_c(1 - P_c)/n}$ and the confidence limit = $P_c \pm z_\beta S_c$. For P_c of 0.527, β of 0.1, $z_\beta = 2.326$. Confidence limit = $0.527 + (2.326 \times 0.03) = 0.597$. Where the value 0.03 is the standard deviation of P_c . The upper confidence limit of 59.7 % is less

P_{max} of 60 %, so there is no preference.

X3.6 Report and Conclusions

X3.6.1 The sensory analyst reports that there was parity between the current and alternative fragrance samples given the sensitivity chosen for the test ($P_{max} = 60\%$, $\alpha = 0.1$, $\beta = 0.01$). The analyst concludes that the alternative fragrance can be substituted for the current fragrance.

X4. EXAMPLE X4—COST SAVINGS: NO PREFERENCE ALLOWED

X4.1 Background

X4.1.1 A pharmaceutical firm needs to establish a new supplier relationship for the orange flavoring in its antacid tablets. It wants to determine if the new flavoring can be substituted for its existing flavoring without alienating existing customers. It was decided to allow for a “no preference” option between the two flavors.

X4.2 Test Objective

X4.2.1 To determine if there is parity between the test flavor and current orange flavor. This is a two-sided test.

X4.3 Number of Respondents

X4.3.1 To protect the product developer from falsely concluding that no preference exists, the sensory analyst proposes $\alpha = 0.2$, and a P_{max} of 65 % with $\beta = 0.01$. The analyst enters Table X1.1 in the section corresponding to $P_{max} = 65\%$ and the column corresponding to $\beta = 0.01$. Then, reading from the row corresponding to $\alpha = 0.2$, it is determined that a minimum of 146 respondents will be needed for the test. The sensory analyst recruits more than 146 respondents that have been identified as users of the product category to ensure that the minimum number of respondents are tested. Prior to recruitment, the analyst ensures that consent forms are reviewed with legal and safety departments per policy. During recruitment, respondents are informed of the nature of the test and any appropriate safety precautions.

X4.4 Conducting the Test

X4.4.1 One hundred and fifty cups of “A” and 150 cups of “B” are coded with unique random three digit numbers. Each sequence, AB and BA, is presented 75 times so as to cover at least 146 respondents in a balanced random order, with extra servings available. One hundred and fifty respondents participated in the test.

X4.5 Analysis and Interpretation of Results

X4.5.1 Fifty-six respondents selected the control as preferred, 48 selected the test sample as preferred and 46 had no preference. The no preference responses are split between the control and test resulting in 79 (56+23) common responses for the control and 71 (48+23) for the test. In Table X1.2, the calculations are completed for up to 100 respondents; therefore formulas in the Table X1.2 appendix need to be used. For α of 0.2, $z = 1.28$. Therefore the sensory analyst calculates that 80 common responses were needed in order to conclude that there is a preference.

X4.6 Report and Conclusions

X4.6.1 The sensory analyst reports that there is no preference between the two samples, given the sensitivity chosen for the test ($P_{max} = 65\%$, $\alpha = 0.2$, $\beta = 0.01$). The analyst concludes that test flavor can be substituted for the current orange flavor in the antacid.

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