

Background: “If we make this change only 10% of our consumers will be able to detect it”, may be a very appealing statement to managers in consumer products companies. These managers are often faced with the need to make product changes and substitutions to change ingredients, lower costs, switch to more stable sources of raw materials, comply with government regulations, or develop more healthful products. Usually there is an attempt to ensure that consumers notice as little difference as possible in the sensory performance of the product. In the food and personal care industries, methodologies used to investigate consumer perception include several discrimination techniques such as the duo-trio method, the triangular method and directional difference tests (such as the 2-Alternative Forced Choice or 2-AFC method.)

Fundamentally, any alteration to a formulation or manufacturing process will create products that are different from those already present on the market. This concept can easily be demonstrated by the fact that differences already exist from one manufacturing site to the next or from one daily manufacturing cycle to the next, even if the same formulation and processes are used. Therefore the question becomes how much difference can be tolerated before alienating consumers. A popular concept that has been used to address this issue for over 40 years in sensory evaluation and market research is that of ‘proportion of discriminators.’ This concept makes the assumption that the consumer population is comprised of individuals who can discriminate between the products and individuals who cannot. Following an appropriate data collection exercise, the proportion of consumers who can discriminate the products (10%, 20%, 50%, etc.) can be estimated. A decision can then be made whether this proportion is low enough so that the alternate product can be distributed in place of its current counterpart. This concept is very popular and is still an area of active research interest¹. Another attractive aspect of the concept of proportion of discriminators is that it is used to calculate the minimum sample size for an experiment to ensure that a difference of a given size is not missed.

In this report we will discuss the value of using the proportion of discriminators as a fundamental measure of sensory difference and explore its method-specificity.

Scenario: Your company produces dairy-based frozen desserts and your management initiates a research program to reduce dairy ingredients in one of your products. The objective is to modify the dessert’s formulation while minimizing the detectability of the change to your consumers. After some research, a substitute ingredient is considered which changes the smoothness of the product. You conduct an experiment with 3 substitution levels to investigate whether consumers can discriminate the 3 new products versus the current product and to estimate the proportion of consumers who are discriminators. The action standard uses a maximum of 10% discriminators.

Your company has two manufacturing plants, one on the West Coast, the other in the Midwest. Testing will be done in each region to take into account possible inter-plant variability. Testing in the plant on the West Coast usually involves the triangular method while that in the midwestern region usually involves the

2-AFC. For the triangular method, consumers are presented with three alternatives (two of the same type and one of a different type) and instructed to indicate the sample that is most different from the other two. For the 2-AFC method, consumers indicate which of the two different types is ‘smoother.’ The results obtained from two regional samples of 100 consumers are shown in Table 1.

	West, Triangle	Midwest, 2-AFC
	# Correct / 100	# Correct / 100
Level 1	37	67
Level 2	45	81
Level 3	57	89

Table 1. Results of two consumer studies.

The Proportion of Discriminators (P_d): The calculation of P_d , illustrated in Figure 1, is straightforward. Assume that each of 4 subjects performed a 2-AFC test between two products A and B which differ in intensity on some attribute and the instruction is to choose the sample with the greatest intensity. Three of them correctly identified the sample with the greater intensity while one did not (Figure 1a.) The subject who did not identify the sample correctly is a non-discriminator (Figure 1b): He/she had to guess and guessed incorrectly. Since the guessing probability for the 2-AFC method is $1/2$, if one subject guessed incorrectly, we can assume that another subject must have guessed correctly (Figure 1c.) Therefore, out of the 4 subjects, 2 were discriminators and made correct choices, one was a non-discriminator who guessed incorrectly, while the fourth one was a non-discriminator who guessed correctly. In this example, $P_d = 50\%$ (Figure 1d.) This idea can be used for other sample sizes and protocols, such as the triangular or duo-trio methods.

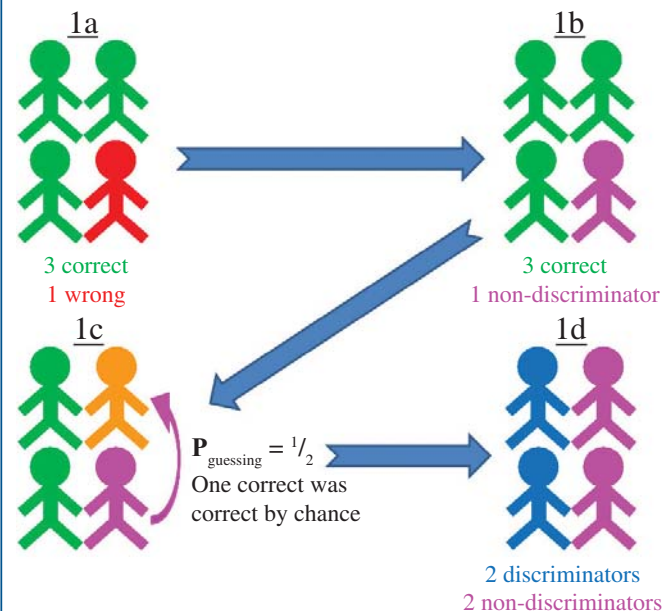


Figure 1. Estimation of the proportion of discriminators in the population.

P_d for each of the tests conducted previously are shown in Figure 2. The results indicate strong discrepancies between the two plants. While a Level 1 change seems acceptable in the West (triangle, $P_d = 5\%$), it is not in the Midwest (2-AFC, $P_d = 34\%$). The differences in predicted proportion of discriminators are quite striking. You speculate that these differences might be due to a plant effect with greater differences created in the Midwest or to the consumers in the Midwest who might somehow be more sensitive to the difference.

In order to investigate this discrepancy, you re-run the study in the Midwest this time using the triangular method. The results, also shown in Figure 2, corroborate the earlier results obtained in the West. This appears to rule out a plant or differential consumer sensitivity effect. The discrepancy may be linked to the actual methodologies used in each plant (triangular method versus the 2-AFC method.)

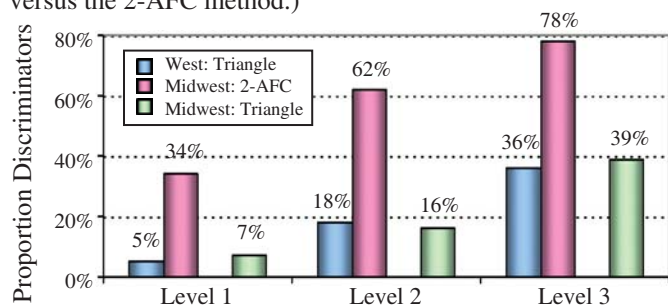


Figure 2. Predicted proportion of discriminators for each substitution level.

Why the Proportion of Discriminators is Method-Specific:

While the P_d concept would seem very useful when estimating product similarities and differences, results are highly dependent on the methodology used² so that for the same degree of dissimilarity, different techniques will yield different proportion of discriminators. These types of effects have been described in previous technical reports^{3,4}.

Ennis² demonstrated that proportions of discriminators are linearly correlated with proportions of correct responses as shown in Figure 3. As the proportions of correct responses are method-specific and do not accurately represent the underlying degree of difference between the samples compared (for instance, a subject will get a higher proportion of correct responses when using the 3-AFC method than when using the triangular method), the proportions of discriminators are also method-specific and do not accurately measure consumer aptitude to discriminate between the samples. The use of d' values^{2,3} are a better alternative to the concept of proportion of discriminators.

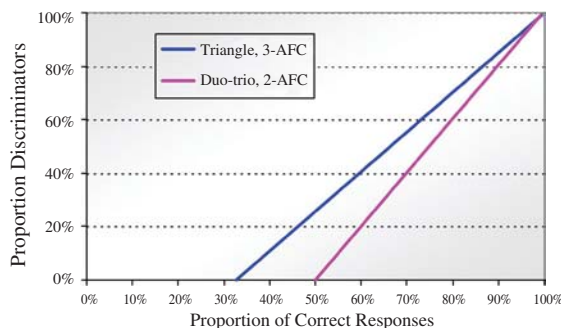


Figure 3. Relationships between proportion of discriminators and proportion of correct responses.

Developing a New Action Standard: Figure 4 shows the d' values corresponding to the data in Table 1. The d' values can easily be estimated using published tables² or suitable software, such as *IFPrograms*. The same degree of difference was measured in each of the studies, but the method-dependent P_d approach prevented you from seeing this. The next step is to develop a new action standard in terms of d' values that will allow decisions to be made on which level of substitution, if any, is appropriate. This will allow for more stable results than those based on P_d , especially if different methodologies are being used. As a first step, you can translate the 10% discriminators level in the triangular method that you have been using as an action standard into d' . This value translates to a d' of 0.88. However, this criterion might be too conservative or too lenient. Further research such as that relating d' values to consumer preference can provide useful insights on the size of a difference above which consumers start expressing a preference between two samples.

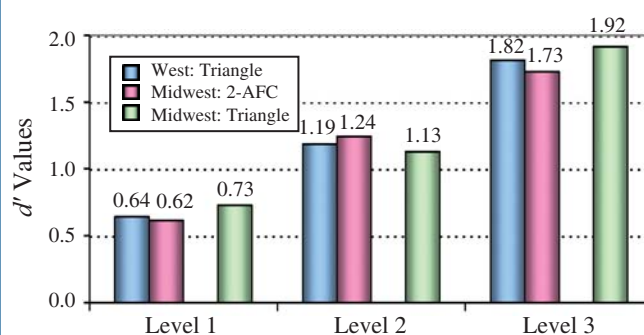


Figure 4. d' values for each substitution level.

Conclusion: The concept of the proportion of discriminators is intuitive and appealing. Unfortunately, it is also method-specific and one can achieve very different values using different methods, which reduces its appeal as a management criterion. The use of a method-independent index, such as the Thurstonian d' , can provide more stable and accurate information that may be valuable in any decision that involves the consideration of consumers' ability to discriminate between alternate product formulations.

References

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