

## Unfolding Conjoint Utilities

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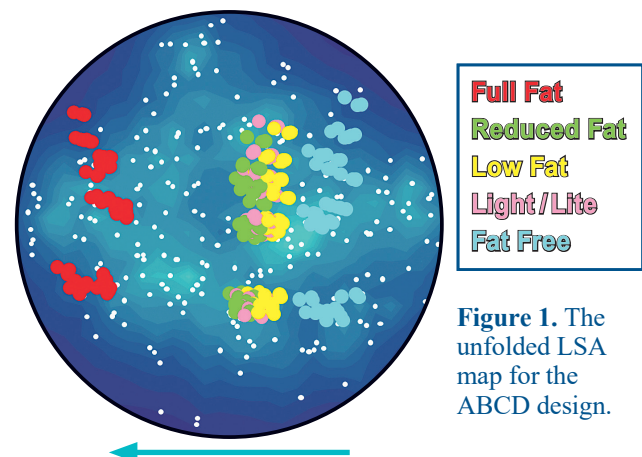
**Background:** Conjoint analysis is a popular method used in the study of items involving combinations of attributes at one or more levels which comprise *decomposable* stimuli. In contrast, *unitary* stimuli are items that cannot be readily decomposed into attributes experimentally (e.g., the components of a fine fragrance). The idea behind conjoint analysis is that there is a latent hedonic continuum and that there are part-worth utilities that correspond to parts of this continuum that can be estimated for each attribute level for groups of respondents or for individuals. Notwithstanding consistent violations of the assumptions underlying conjoint analysis, the method has proven to be of use in making marketing decisions<sup>1</sup>. Conjoint analysis is limited to applications involving stimuli in which the variables and their levels are identified in advance. In this respect conjoint analysis has features in common with external preference mapping which also requires prior knowledge of the attributes of interest that may influence hedonics. The stimuli in a conjoint study are typically drawn from an orthogonal array and in this respect the method shares features in common with designed experiments involving factorial, central composite and fractional factorial designs.

The hedonic continuum assumption in conjoint analysis is a construction that parallels other continua, such as those for sensory variables. In the case of sensory variables involved in, for example, taste and olfaction, there is good justification for the idea of a unidimensional perceptual scale. For example, there are receptors on the tongue for sweet taste and the effect of the tastant is transduced to a signal following the participation of a transducer<sup>2</sup>. However, a hedonic continuum does not have such a compelling justification or process model. Instead of thinking that there is a mental interval hedonic scale, as there might be for sweetness, a hedonic response is better thought of as arising from a combination of the present sensory experience and a mental reference constructed from past experience. With this process model in mind, both decomposable and unitary stimuli can be evaluated and the hedonic response by individuals can be accounted for in terms of item and ideal locations in a drivers of liking (hedonic) space. This method is referred to as unfolding and one example of it is Landscape Segmentation Analysis<sup>®</sup> (LSA)<sup>3</sup>. In this technical report we will consider how individual utilities from a conjoint analysis project can be interpreted using LSA and thus provide a method to enrich the results obtained in a typical conjoint study. In a collaboration between The Institute for Perception and a group at North Carolina State University<sup>4</sup>, this idea was proposed and implemented<sup>5</sup>. The scenario in this technical report is built on the experiment and part of the analysis published jointly<sup>6</sup>.

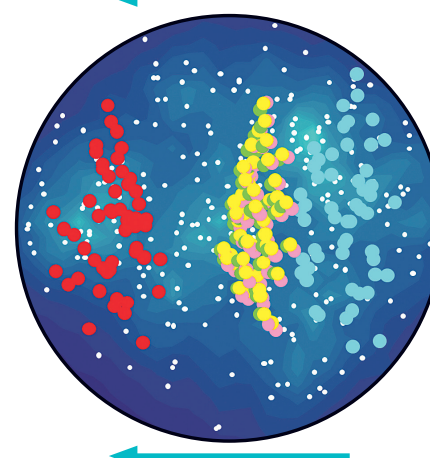
It is worth noting that many conjoint projects could be designed so that they use graph theory<sup>7</sup>. The variable level components of the stimuli tested are judged for compatibility, as opposed to preference or liking. Compatibility itself may drive a hedonic response. An advantage of this approach is that it provides for a much more extensive set of stimuli than that accommodated in a typical conjoint analysis project

and does not require an orthogonal array. In addition, since the outcome measure is compatibility, it would not require the exclusion of certain combinations due to component incompatibility which is often required in a conjoint study.

**Scenario:** You work for a dairy manufacturer and are interested in how consumers trade brand component variables in assessing the hedonic value that they place on sour cream products. The variables of interest include brand, price, fat level, container size, and a label claim. Part of your interest is to assess two ways of conducting a conjoint study involving either a full profile choice method (choice-based conjoint or CBC) or an adaptive method (ACBC). In the CBC method, participants may be presented with any of the possible variable level combinations (excluding some prohibited profiles.) In the ACBC method, variable level combinations are presented which depend on prior choices made during the choice task. The prohibitions include some incompatible combinations involving price and container size and also include an organic brand and regular label claims. A random sample of 250 participants are chosen from a larger sample of the CBC method data to compare with the ACBC method data which is also comprised of 250 consumer responses. Your interest is in understanding how these two different methodologies compare, in the absence of price, when the individual utilities predicted from a hierarchical Bayesian analysis of the data are unfolded using Landscape Segmentation Analysis (LSA.)



**Figure 1.** The unfolded LSA map for the ABCD design.

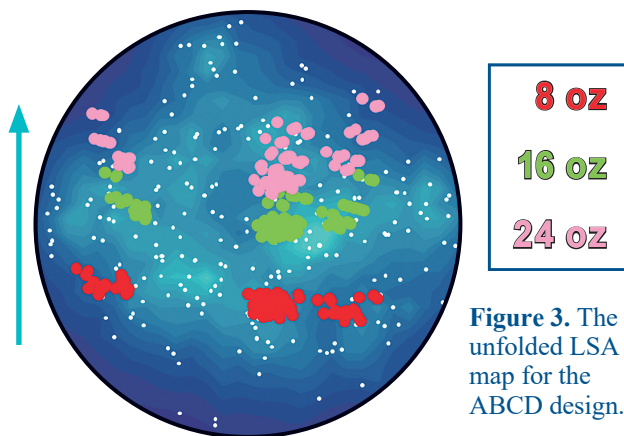


**Figure 2.** The corresponding figure for the CBC design.

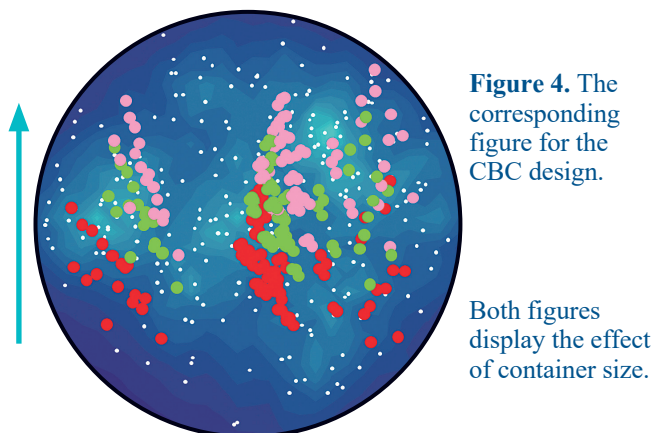
Both figures display the effect of fat level.

**Unfolding using LSA:** Unfolding is a process model developed to understand individual hedonic responses to items. The central idea was proposed by Clyde Coombs<sup>8</sup> in 1950 and involves the insight that a person's hedonic reaction to an item may be thought of as a response to a comparison of the item to an ideal based on past experience with the category to which the item belongs. Coombs only considered deterministic items and ideals as opposed to a probabilistic (Thurstonian) account. This limitation seriously handicapped Coomb's excellent insight because many solutions based on it were degenerate and therefore not useful. A solution to the degeneracy problem and an implementation of unfolding was accomplished in 2001 using a probabilistic similarity model<sup>9</sup> and it was used to implement Coomb's unfolding proposal at an individual level.

**Application to Conjoint Analysis Results:** There is significant value in combining analytic methods when they act synergistically. Conjoint analysis is a very popular method that provides individual utilities that can be used as a starting point for unfolding. An advantage of conducting this analysis is that it may provide insight into the results of a conjoint study that may not have been apparent, as will be shown in this report. It may also provide an opportunity to check the validity of the individual utility predictions because unfolding can be conducted both on the original hedonic data, if it takes the form of ratings, and after the individual predicted utilities are derived.



**Figure 3.** The unfolded LSA map for the ABCD design.



**Figure 4.** The corresponding figure for the CBC design.

Both figures display the effect of container size.

Figures 1 and 2 show the unfolded LSA maps for the CBC and ACBC methods for fat level. Figures 3 and 4 show a similar comparison for container size. These figures show the location of individual ideals (white dots) along with the location of the items used in the conjoint studies in a drivers of liking (hedonic) space. These figures revealed that the CBC method provides more item separation than the ACBC method which tends to compress item distances. Both conjoint methods yielded similar average utility and importance scores. The application of LSA allowed clarification of differences between the two approaches not readily apparent from traditional conjoint modeling. Adaptive conjoint (ACBC) appears to compress item positions in the utility space by focusing on positives. Across the sour cream attributes that have been highlighted on the LSA plots, CBC uniformly provides better differentiation of the specific preferred item components across all consumers. This greater differentiation allows the identification of potential product profiles that are uniquely appealing to different groups of consumers.

**Conclusion:** Conjoint analysis is a popular method for understanding the contributions of item components to overall utility or liking, notwithstanding challenges to its underlying assumptions. These assumptions concern the existence of a hedonic continuum and whether it can be partitioned. The process model underlying unfolding is compelling and may provide insights into the results of a conjoint study. LSA, a successful implementation of unfolding, can be applied to the individual utilities derived from conjoint analysis and provide insights into what conjoint analysis predicts. It can also be applied at the response level, when ratings data are available, and provide an opportunity to check the validity of the conjoint analysis predictions.

## References and Notes

1. Huber, J. (2005). Conjoint analysis: How we got here and where we are (an update.) *Sawtooth Software Research Paper Series*.
2. Ennis, D. M. (1991). Molecular mixture models based on competitive and non-competitive agonism. *Chemical Senses*, **16**(1), 1-17.
3. Ennis, D. M. and Rousseau, B. (Eds.). (2020). *Tools and Applications of Sensory and Consumer Science*, (pp. 78-113). Richmond, VA: The Institute for Perception.
4. The research group at North Carolina State University is led by Dr. MaryAnne Drake.
5. The idea for unfolding conjoint utilities was proposed and implemented by Dr. John M. Ennis.
6. Jervis, S. M., Ennis, J. M., and Drake, M. A. (2012). A comparison of adaptive choice-based conjoint and choice-based conjoint to determine key choice attributes of sour cream with limited sample size. *Journal of Sensory Studies*, **27**, 451-462.
7. Ennis, D. M. and Rousseau, B. (Eds.). (2020). *Tools and Applications of Sensory and Consumer Science*, (pp. 136-137 and 140-141). Richmond, VA: The Institute for Perception.
8. Coombs, C. H. (1950). Psychological scaling without a unit of measurement. *Psychological Review*, **57**(3), 145-158.
9. Ennis, D. M. and Johnson, N. L. (1993). Thurstone-Shepard similarity models as special cases of moment generating functions. *Journal of Mathematical Psychology*, **37**(1), 104-110.