# 1 Technical Appendix

## 1.1 The Nested Chinese Restaurant Process

The generative model we have described so far for creating new food instances is the *nested Chinese Restaurant Process* (nCRP). The nCRP is an unsupervised, non-parametric, generative model for assigning probability distributions to branching tree structures.[1]

First we need to define a food object's partition, or it's possible paths throughout the structured generative model defined above. Consider a set of an $N$ *i.i.d.* input food vectors, indicating an agent's previously eaten foods. Our model uses a three-level category hierarchy. The food vectors are partitioned into $C$ level-one categories. We represent the partition via a vector $v^b$ of length $N$, where each $v^b_n \in 1, ...., C$. The $C$ basic-level categories are then partitioned into $B$ second-level categories (where $K \leq N$) which are represented via the vector $v^s_n$ of length $C$. Finally, the $B$ second-level categories are then partitioned into $A$ third-level categories which are represented via the vector $v^t_n$. We define $p_n$ as the triple $< v^b_n, v^s_n, v^t_n >$, which defines for each $n \in N$ a path through the three-level tree.

As the name suggests, the nCRP is composted of nested Chinese Restaurant Processes. The CRP provides a way to partition food instances at each level of the hierarchy as they enter which is represented via a single $\alpha$ parameter. Imagine a Chinese Restaurant with an infinite number of tables that can each seat an infinite number of persons. At a given time $t$, after a number of other people have been seated, the CRP provides the probability a person has of sitting at all the occupied tables, *and a new table.* The CRP is defined as:

$$p^{N+1}|p^1.....p^N, \alpha_{CRP} \sim \sum_{i=1}^{K} \frac{n_i}{N+\alpha}\delta_{\tau_i} + \frac{\alpha_{CRP}}{N+\alpha_{CRP}}\delta_{\tau_{K+1}} \tag{1}$$

Where $p^i$ is the partition define above, $\alpha_{CRP}$ is the concentration parameter that encodes how frequently a new partition is produced, $K$ is the total number of tables, $\tau_i$ is the partition that food vector $n$ is places at, and $\delta_\tau$ is the distribution that puts it's mass at a given partition, We embed a CRP *at each* category-level $A, B, C$.

In our model we found that (X X X) for the $\alpha$ parameters in the nCRP corresponding to 'category', 'sub-category' and 'instance' level concentration parameters performed well.

This enables our agent to infer the placement of a novel experience with respect to an agent's previous structured knowledge and experiences, further informing their expected utility at a given time.

[1] See Blei, Griffiths, and Jordan 2010 for a more in-depth discussion of the nested Chinese Restaurant Process. While our model leverages the hierarchical categorization that the nCRP offers, our models offers a finite, deterministic tree depth. The original paper places an IID over the tree depth as well, enabling for an infinite depth to the trees.

**Placement of new item in hierarchy** We mention in the paper the importance of inferring the placement of the yellow grape but did not demonstrate it. As shown in Figure XXX, the agent places a greater degree of belief on the new food being a type of grape.

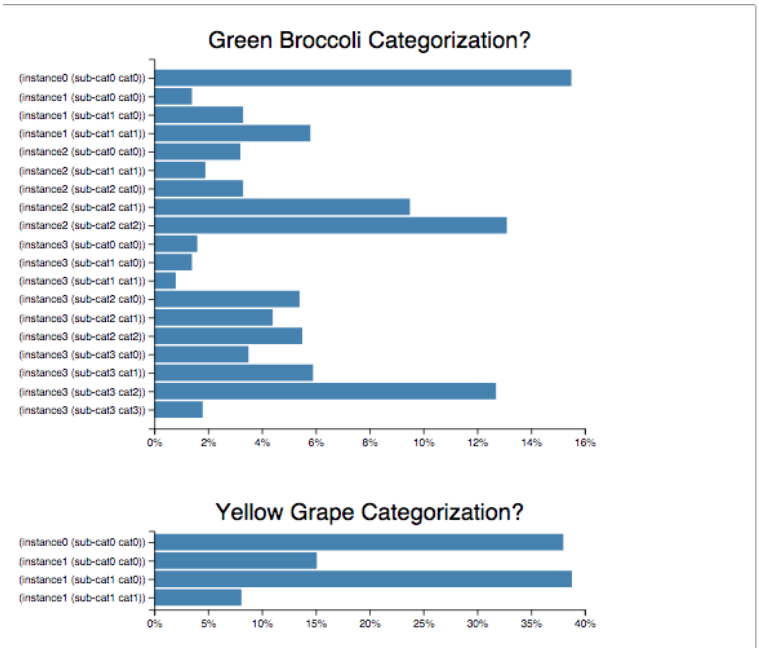


Figure 1: The probability of each clustering of the new food object as a grape, as compared to the probability of each cluster for the green broccoli. The color attribute provided little information to help cluster the object, while the shape was much more informative.