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 $v_n^b \in 1, ..., C$. The C basic-level categories are then partitioned into B second-level categories (where $K \leq N$) which are represented via the vector v_n^s of length C. Finally, the B second-level categories are then partitioned into A third-level categories which are represented via the vector v_n^t. We define p_n as the triple $< v_n^b, v_n^s, v_n^t >$, 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 α 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, α_{CRP} is the concentration parameter that encodes how frequently a new partition is produced, K is the total number of tables, τ_i is the partition that food vector n is places at, and δ_τ is the distribution that puts it's mass at a given partition, We embed a CRP *at each* category-level A, B, C.

1.2 Results

In our model we found that (.05 .5 .25) for the α parameters in the nCRP corresponding to 'category', 'sub-category' and 'instance' level concentration parameters performed well.

[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.

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.

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.

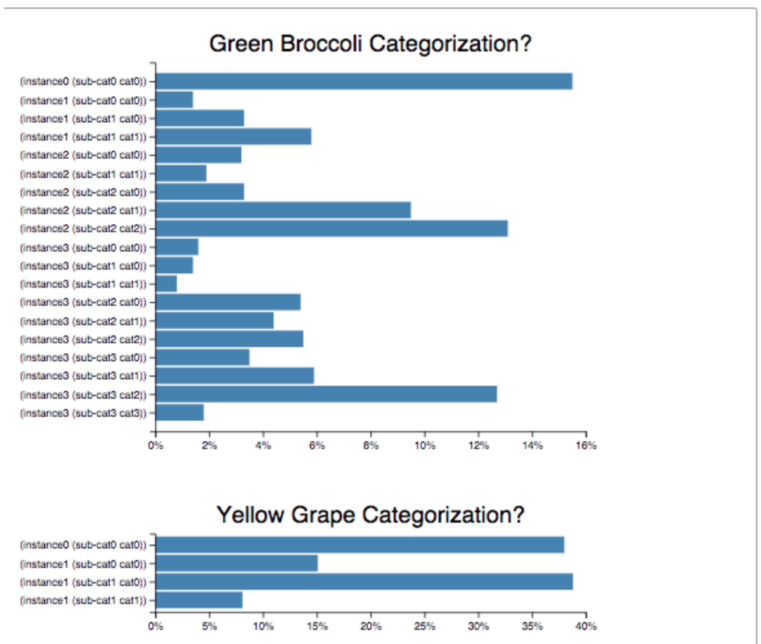

Figure 1: The probability of each clustering of the new food object as a grape, as compared to the probability of each cluster for the green broccoli. The color attribute provided little information to help cluster the object, while the shape was much more informative.

The Expected Utility of the Yellow Grape

It was important for this structured information to be used to estimate whether or not the agent would actually like the yellow grape they haven't tried. As demonstrated by the model, the agent can rationally determine the taste of the yellow grape compared to the green grape she's already had and determine that, in fact, she would like it.

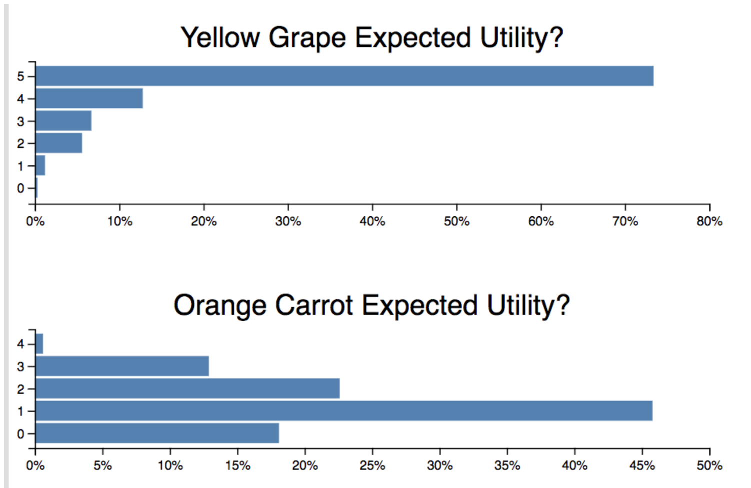

Figure 2: The expected utility of the yellow grape relative to an orange carrot.