To be precise, the details don't matter: predictive processing, precision, & level of detail

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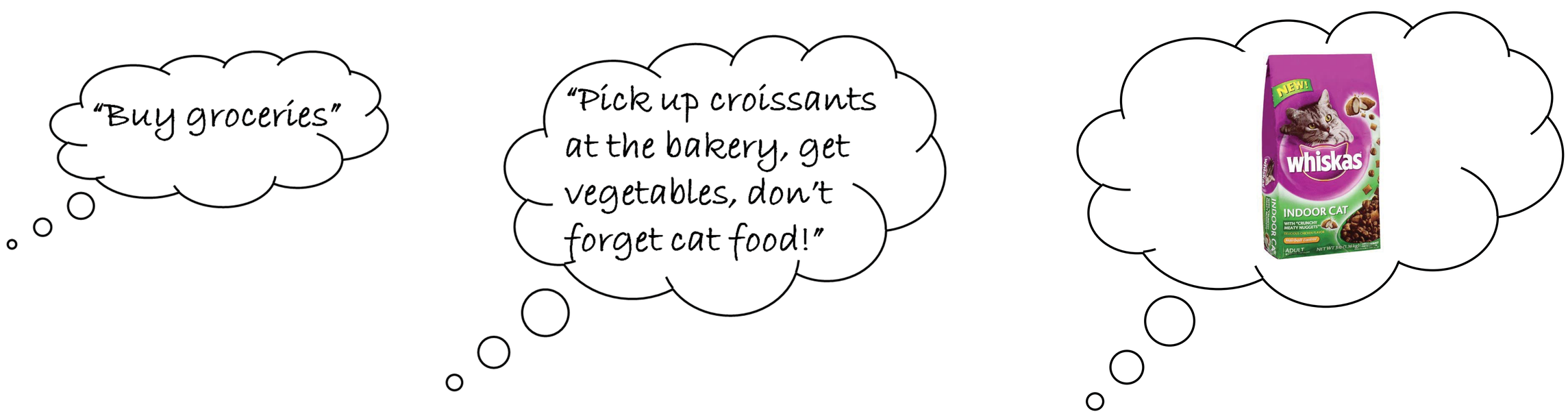
Introduction

Many theoretical and empirical contributions to the **Predictive Processing** framework emphasize the important role of **precision modulation** within the framework. Importantly, the precision of a prediction is not to be mistaken for the level of detail with which a prediction is made. Precision and **level of detail** interact in Predictive Processing; in particular, lowering the level of detail of a prediction can be a suitable mechanism for lowering prediction error by actually increasing the precision of the prediction. This comes at the price, however, of **lowering the amount of information** that can be gained by correct predictions. We identify the question how the brain optimizes the trade-off between predictions with high precision and predictions with high information gain as one of the **crucial theoretical open issues** for Predictive Processing.



Low, medium, and high detailed predictions about one's plans after work. In the left panel, the predictions (or expectations) are fairly abstract and coarse. In order to successfully plan our actions, the predictions need to be more detailed. The more detailed, however, the more likely a prediction error will be when the prediction happens to be incorrect, for example, if we bought a different brand of cat food than we expected.

Level of detail

In probability distributions that describe the stochastic relation between a particular hypothesis and a prediction, we can make the prediction more or less fine-grained by aggregation of the conditional probabilities. The right panel gives an example of the aggregation of P(*marker)* by grouping some of the *categorical* values that a prediction on the marker that will be grasped can take. Note that lowering the detail of the prediction (and interpreting the observation similarly) will by definition lower the entropy of the prediction, and therefore increase its precision; it will also lower the relative entropy (or Kullback-Leibler divergence) between prediction and observation. That is, lowering detail of prediction (and observation) by definition lowers prediction error.

Example

We can make predictions on which marker will be grasped next by various levels of detail. A rather coarse prediction may be P(black) = 0.4, P(colored) = 0.6. The latter category might be refined as P(red) = 0.5, P(blue) = 0.1. At a high level of detail, we may make a prediction where each marker is seen as different: P(red1) = 0.2, P(red2) = 0.3, P(black1) = 0.3, P(black2) = 0.1, P(blue) =0.1.

The entropy of these three distributions is 0.85, 1.32, and 2.17, respectively; when we observe the lower red marker to be grasped, and interprete this in terms of the prediction categorization, the KL divergence is 1.74, 1, and 0.74, respectively. The more detail, the lower the precision and the higher the prediction error will be.

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