Predicting Food Healthiness **Judgments** using **associations** (word embeddings) and **nutrient content** information.

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Background

To date, perceptions of food healthiness have been predominantly investigated in relation to how well they match up with government recommended nutrient guidelines. Yet, people are exposed to a wide array of information about foods that shape their beliefs; information that might even be at odds with a food's objective nutrient content. Recent advancements in computational linguistics mean we can capture this information (aka food associations) using natural language data. Here we present a series of studies in which we assess the importance of nutrient and non-nutrient attributes of foods individually and together, with the goal of uncovering what associations underpin all food healthiness judgments. Using the same approach, we can also consider the effects of different nutrient labelling formats on healthiness judgments.

Methods

To assess how well associations predict people's judgments, we ran a series of studies to obtain food healthiness ratings from participants. All participants provided healthiness ratings for the same food items (n = 172) using a scale ranging from -100 (most unhealthy) to +100 (most healthy). Using regularized linear functions, we attempted to predict the actual (aggregate) healthiness ratings of out-of-sample foods using three computational models (detailed below):

1. **Nutrient Model:** uses key nutrient content (per 100g) and coded traffic light colour criteria to form an 10-dimensional vector. This is our baseline model.
2. **Vector Representation Model:** uses 300-dimensional semantic vector representations that quantify associations for the food stimuli within natural language data.
3. **Combined Model:** concatenates the vectors of the Nutrient Model with the vectors from the Vector Representation Model (310-dimensional vector).

In total, our models were fitted to data from five studies (n = ~200 participants in each). This allowed us to assess differences between lay (Studies 1A, 2, 3 & 4) and expert judges (1B) as well as differences in judgments between individuals exposed to different nutritional labelling strategies (Studies 2, 3 & 4). The presentation of food stimuli in all conditions is visually shown in *Figure 1*.

Results

As *Figure 1* shows:

- The vector representation model performed very well across all studies and conditions: predictive accuracy (r^2) ranges from 0.65 to 0.77.
- In comparison, the nutrient model was lower and much more variable, with r^2 ranging from 0.33 to 0.77.
- Only in the case of the most complex label, the Traffic Light label (Study 4), did the nutrient model perform better than the vector representation model.
- We can also see that the combined model performs better than the individual models in 7 out of 8 cases.
- The highest accuracy was achieved in the case of TL labels, with r^2 of 0.91, suggesting associations capture something unique from nutrient-related content about the way people make healthiness judgments.

Together, these results show that associations with food names play an important role in people's judgments of food healthiness, often more so than the nutritional composition of the food.

Whilst the dimensions of our word vector model are not directly interpretable, we were able to identify words that relate to the concept of food healthiness in semantic space. This was achieved by passing the vector representations of common words through our model trained on participants' food healthiness judgments. The 50 words with the highest healthiness predictions are illustrated in *Figure 2.*

Conclusions

Our data driven and bottom up approach provides deeper insights into healthiness judgment formation than has been possible in a traditional study. This study demonstrates the foundations of an easily accessible tool that can be built upon and extended to help registered dietitians and policy makers alike evaluate current and future health interventions.

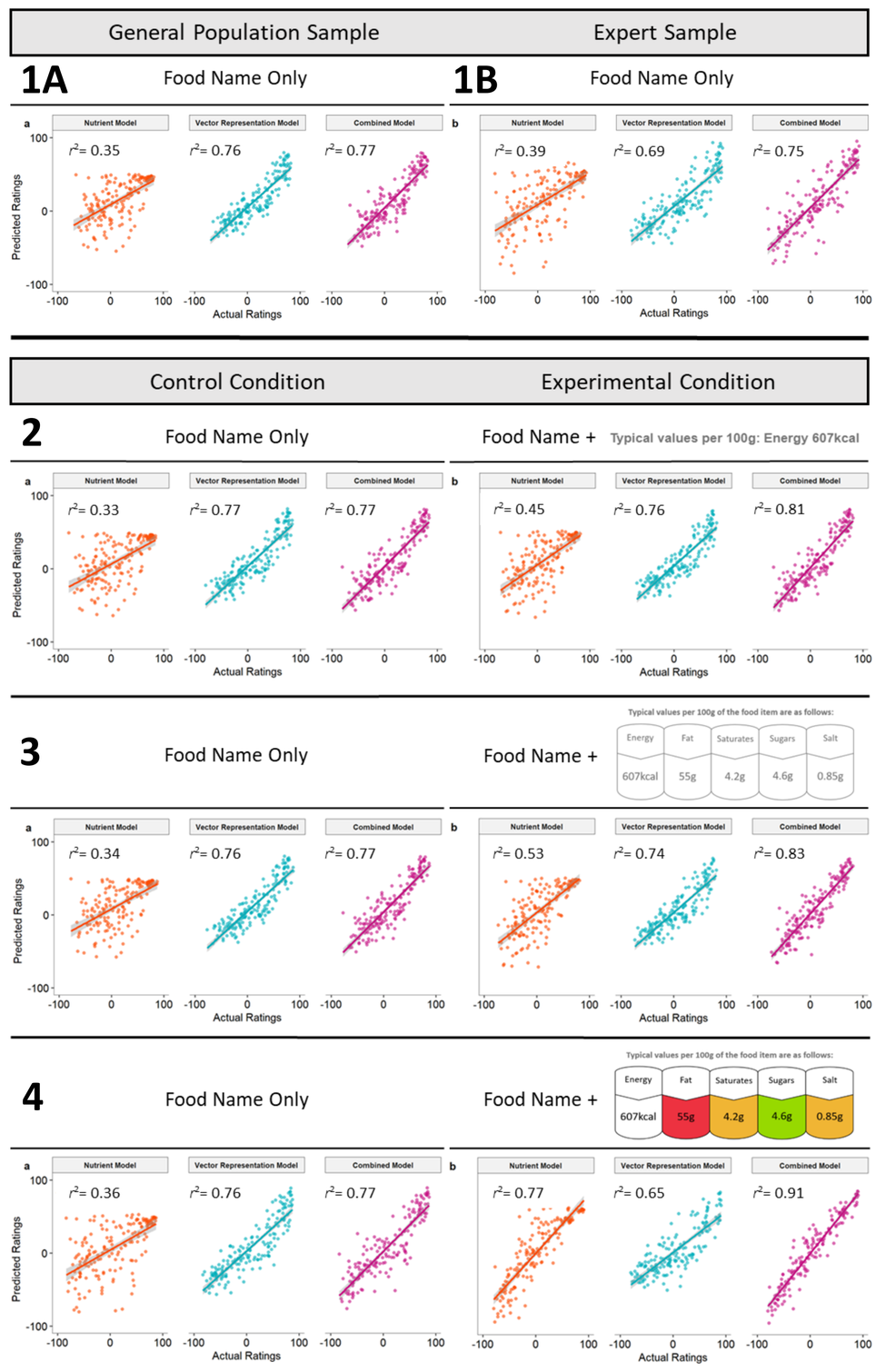

Figure 1. *Leave-one-out cross validation results for the control and experimental conditions of each study, comparing models predicting health ratings of foods using only nutrient content, only semantic vector representations, or a combination of nutrient content and semantic vector representations.*

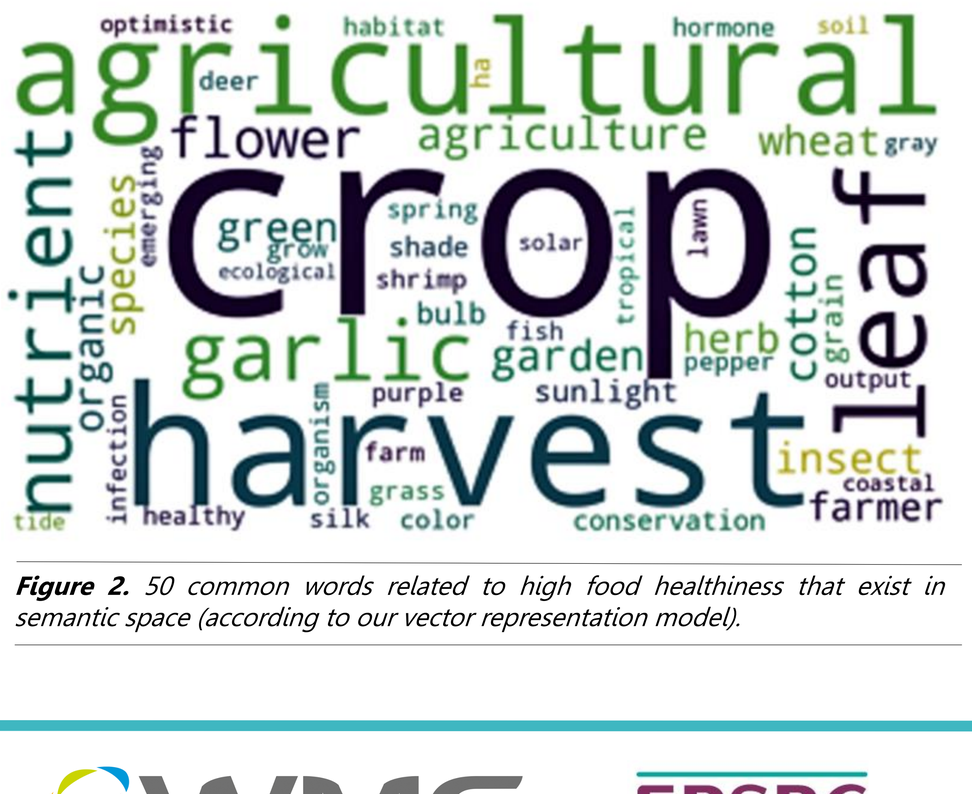

Figure 2. *50 common words related to high food healthiness that exist in semantic space (according to our vector representation model).*

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