Animacy Dimensions Ratings and Approach for Decorrelating Stimuli Dimensions

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Abstract:

The distinction between animate and inanimate objects plays an important role in object recognition. The following 5 dimensions were shown in previous studies to be important for animacy perception independently: "being alive", "looking like an animal", "having mobility", "having agency" and "being unpredictable". However, it is not known how these dimensions in combination determine how we perceive animacy. To investigate, we created a stimulus set (M = 300) with almost all dimension combinations for which we acquired behavioural ratings on the 5 dimensions. We show that subjects (N = 26) are consistent in animacy ratings (r = 0.6) and that "being alive" and "having agency" dimensions are highly correlated (r = 0.62). To design a stimulus sub-set that is decorrelated on animacy dimensions for future fMRI and EGG experiments we used a genetic algorithm. Our approach proved to be successful in stimuli selection (max r = 0.35, compared to max r = 0.59 when using a random search). In summary, our study systematically investigates animacy dimensions, provides new insights in animacy perception, and presents an approach for decorrelating stimuli dimensions that can be useful for other studies.

Keywords: visual neuroscience; object recognition; animacy dimensions; animacy ratings; decorrelation of stimuli dimensions; genetic algorithm

Introduction

One of the basic distinctions that enables humans to interact with their environment is between animate and inanimate objects. The following 5 dimensions were shown in previous studies to be important for animacy perception independently: "being alive" (Looser, Guntupalli, & Wheatley, 2013), "looking like an animal" (Sha et al., 2015), "having mobility" (Shultz & McCarthy, 2014), "having agency" (Gobbini et al., 2010) and "being unpredictable" (Lowder et al., 2015). However, it is not known how humans perceive objects with respect to animacy taking into account all these dimensions, and how these dimensions relate to each other. Here, we present behavioural ratings of object images (M = 300) for 5 animacy dimensions using a stimulus set that spans across almost all animacy dimensions combinations. We also developed an approach for selecting a subset of the stimulus set that maximises decorrelation on animacy dimensions using a genetic algorithm.

Methods

Stimulus Set Generation

We created a grid with all possible animacy dimensions combinations (2^5 = 32). We asked subjects (S = 12, mean age = 33, 6 females) to write down object category names (e.g. "humanoid robot") for each dimension combination in the grid, to obtain a list of object categories for every combination. Subjects listed 100 categories and we selected 3 images per category (total = 300 images), which formed the basis for the animacy dimensions ratings experiment.

Animacy Dimensions Ratings

Twenty-six subjects (mean age = 33, 21 females) performed animacy ratings of 300 object images. Subjects judged each object image using a continuous scale from -10 to 10 for each dimension, e.g. -10 meant "dead" and 10 meant "alive" for "being alive" dimension. Thirty images were repeated for a within-subject consistency measure.

Stimuli Subset Selection Using a Genetic Algorithm

To select a subset of 128 images for which ratings on the animacy dimensions were maximally decorrelated we used a Genetic algorithm (GA). GA is an optimisation method that mimics biological evolution through natural selection. Fitness was defined as minimising the maximum correlation between animacy dimensions. To ensure that stimuli were selected from a wide range of categories, we also introduced a penalty if more than two stimuli from the same category were selected.

Results

Animacy Dimensions Ratings

We asked subjects to perform animacy ratings of 300 object images in 100 categories, and spanning almost all combinations of the 5 animacy dimensions. Subjects were consistent in animacy ratings (r = 0.60). Object images with the highest correlation of animacy ratings across-subjects were e.g. “ball” and “trophy”. Object images with the lowest correlation were e.g. “human robot” and “sea sponge”. The ratings of some object images e.g. “baby” and “household robot”, had low across-subjects, but high within-subject consistency. This suggests that there are individual differences in animacy perception. Subjects were most consistent in their ratings for “being alive” dimension, followed by “looking like an animal”, “having mobility”, “having agency” and finally “being unpredictable” dimension. Dimensions that were most correlated were “being alive” and “having agency” (r = 0.64), whereas dimensions that were correlated the least were “looking like an animal” (r = 0.28) and “having mobility”; and “looking like an animal” and “being unpredictable” (r = 0.25). All 32 possible dimension combinations were present in the animacy ratings.

Genetic Algorithm-Driven Stimuli Selection

To select a subset of stimuli with low correlations between dimension ratings we used a genetic algorithm (GA). The maximum correlation between dimensions in the stimulus set selected by the genetic algorithm was 0.35 (10,000 generations). This was better than when randomly selecting the stimuli 10,000 times (0.59) without optimization.

Discussion

We created a stimulus set that spanned almost all combinations of five major animacy dimensions, and investigated how humans judge object images based on these dimensions. We observed that subjects were consistent in animacy ratings. Interestingly, the ratings of some object images had low across-subjects but high within-subject consistency, suggesting that there are individual differences in animacy perception. The approach of using a genetic algorithm to decorrelate stimuli on animacy dimensions proved successful and the selected stimulus set will be used in subsequent fMRI and EGG experiments. Our study systematically investigated animacy dimensions, provides new insights in animacy perception; and presents an approach for decorrelating stimuli dimensions, that can be useful in a wide range of studies.

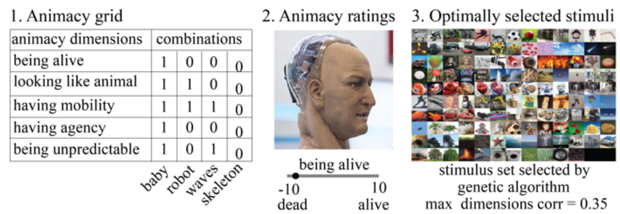

Figure 1. A schematic overview of the study. Firstly, to generate an initial stimulus set for behaviour rating subjects (N=26) listed categories of objects for all animacy dimensions combinations. Secondly, an independent set of subjects performed animacy ratings of these object images. Finally, we selected an optimal set of stimuli that has a low correlation between dimensions (as behaviourally rated) using a genetic algorithm. These stimuli will be used in subsequent neuroimaging experiments.

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