Advanced Hands-on fMRI Analysis - Final Assignment

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Module 1 (Moritz): Classification

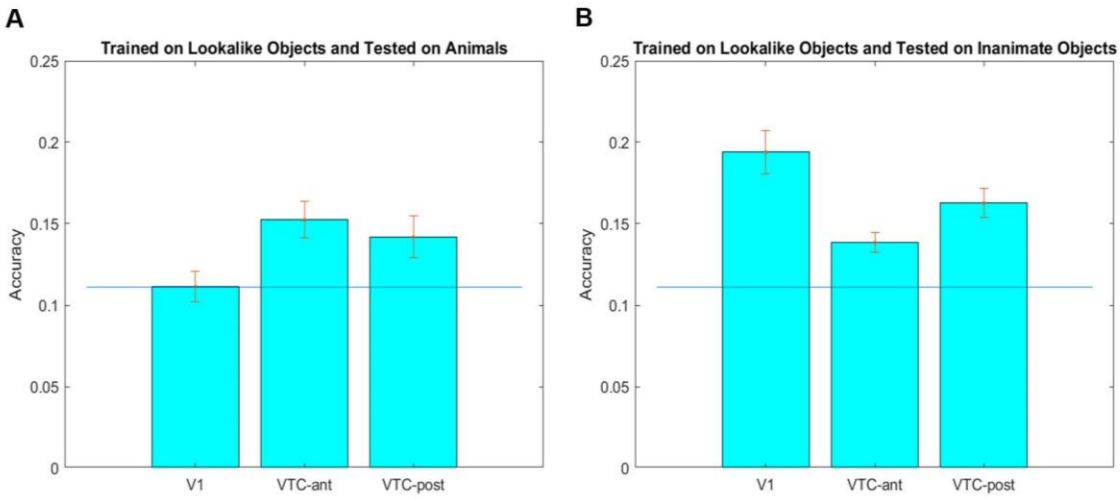
Question: *Does the pattern of activity for lookalike objects (in the three ROIs) generalizes to its corresponding animal (cow-shaped mug to a real cow) and/or to its corresponding object identity (cow-shaped mug to the mug)?*

To answer this question, I applied the One-vs-One multiclass decoding method we had discussed in the class. That is to say, I trained the classifier with the functional magnetic resonance imaging (fMRI) data resulting from the presentation of lookalike objects. Later, I tested it on the fMRI data resulting from the presentation of animate and inanimate objects separately for all regions of interest (ROI) and subjects. Finally, I applied a one-tailed one-sample t-test and tested the accuracies against the 1/9 chance level. The analysis pipeline is in "..._*FinalAssignment_OrhanSoyuhos\Moritz\scripts*\".

The results (Figure 1 and 2) show that the pattern of BOLD activity for lookalike objects generalizes to their matching animate objects in the anterior ventral temporal cortex (VTC-ant) ($p=0.002$) and the posterior ventral temporal cortex (VTC-post) ($p=0.017$). However, it does not generalize in the primary visual cortex (V1) ($p=0.48$). Also, the pattern of activity for lookalike objects is highly significant to classify inanimate objects based on their BOLD activity in all three ROIs ($p<0.001$). These results imply that V1 encodes information related to object identity, while VTC responds to object appearance when subjects are presented with lookalike objects. Furthermore, while VTC-ant prefers object appearance, VTC-post seems to be more sensitive to object identity. We can infer an increasing/decreasing selectivity for appearance/identity from V1 to VTC-post.

Figure 1

One-vs-One Multiclass Decoding



Note. The accuracies for One-vs-One multiclass decoding. (A) The classifier was trained on the fMRI data evoked by lookalike objects and tested on the fMRI data caused by animate objects. (B) The classifier was trained on the fMRI data evoked by lookalike objects and tested on the fMRI data caused by inanimate objects.

Figure 2

Significance Test for Figure 1A

ROI	**H**	**P**	**α**
V1	0	0.483861	0.05
VTC_ant	1	0.001783	0.05
VTC_post	1	0.016746	0.05

Significance Test for Figure 1B

ROI	**H**	**P**	**α**
V1	1	0.00003	0.001
VTC_ant	1	0.00036	0.001
VTC_post	1	0.000066	0.001

Note. The results for a one-tailed one-sample t-test against the chance level of 1/9. ROI - region of interest; H - significant or not; P - p-value; α - alpha level tested.

Module 2 (Stefania): RSA

Question: *What is the underlying object dimension driving the object space organization in the three ROIs? Object appearance or object animacy?*

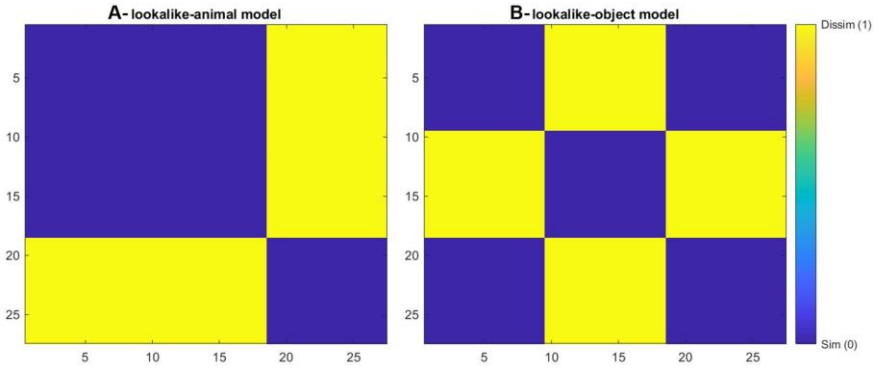
To test these two alternative hypotheses, I first created representational dissimilarity matrices (RDM) to model the clustering between lookalike, animate and inanimate objects. The lookalike and animate objects are grouped in the first model, reflecting object appearance. The lookalike and inanimate objects are gathered in the second, indicating object animacy (Figure 3). Additionally, I computed RDMs for each of the three ROIs (V1, VTC-ant, and VTC-post) per subject to cluster the stimuli based on their evoked blood-

oxygen-level-dependent (BOLD) signal and averaged them across subjects (Figure 4). Finally, I applied representational similarity analysis (RSA) to test the partial correlation between each model and ROI in a higher-order space. The results were Fisher transformed, and their significance is reported in Figure 6. Additionally, the noise ceiling was calculated. The analysis pipeline is in "..._*FinalAssignment_OrhanSoyuhos**Bracci**scripts*\".

The results (Figure 4 and 5) indicate that the lookalike-animal (Figure 3A) and lookalike-object models (Figure 3B) fails to predict the information encoded in V1. However, these two models are representative of the BOLD activity in VTC-ant. They can fully explain the variance in the VTC-ant. Meaning, the sum of their correlation values with the fMRI RDM reaches the noise ceiling. Importantly, VTC-ant shows a preference for the lookalike-animal model. This model has a highly significant correlation (p=0.00001) compared to the lookalike-object one (p=0.001). Finally, the pattern of activity in VTC-post is only explainable by the lookalike-animal model (p=0.0002). However, it cannot explain all the variance in this region. In conclusion, we can state that visual appearance and animacy properties drive the object space organization in VTC-ant. However, only information related to visual appearance is encoded in VTC-post.

Figure 3

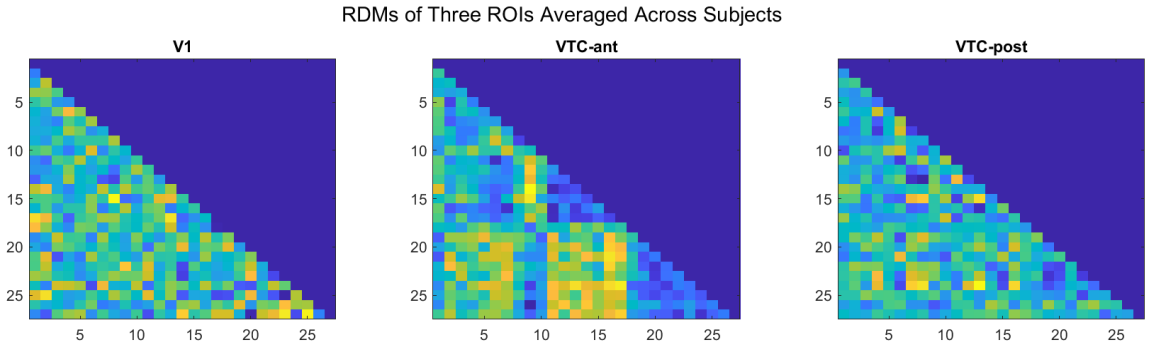
Representational Dissimilarity Matrices for Two Alternative Models



Note. Two alternative models to test object space in the ventral temporal cortex (VTC) and the primary visual cortex (V1). (A) The lookalike-animal model reflects visual appearance. (B) The lookalike-object model indicates animacy properties. Lookalike objects = 1:9, animals = 10:18 and inanimate objects = 19:27.

Figure 4

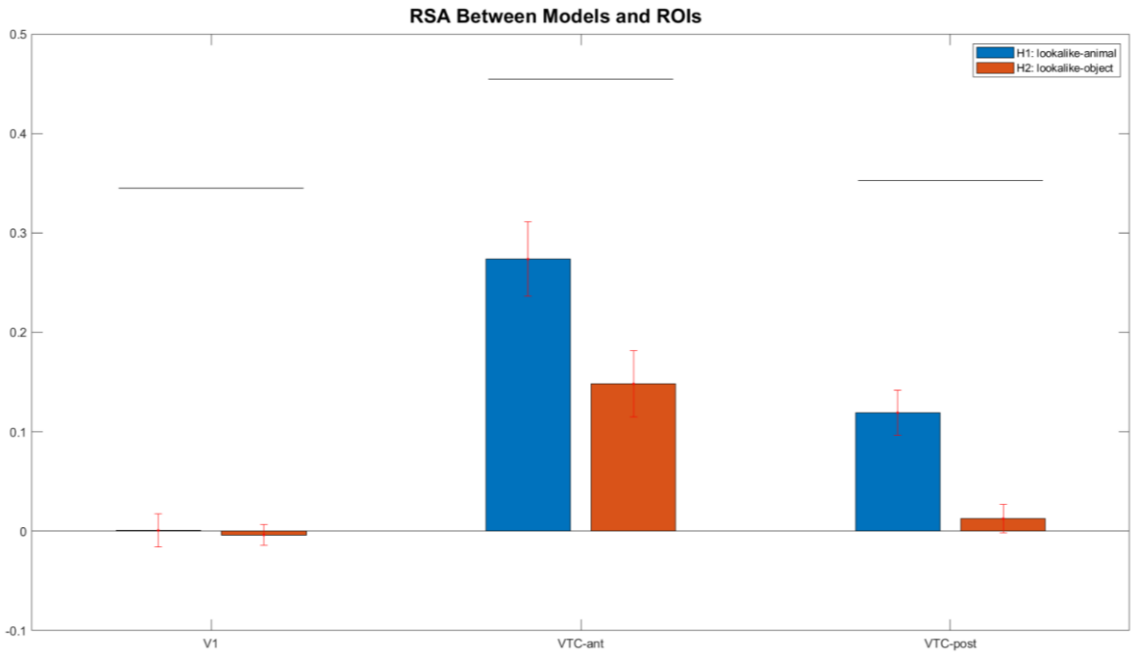
Representational Dissimilarity Matrices for Three ROIs



Note. Representational dissimilarity matrices (RDM) for the primary visual cortex (V1), anterior ventral temporal cortex (VTC-ant) and posterior ventral temporal cortex (VTC-post). For each region, the pairwise comparison was computed based on their functional magnetic resonance imaging (fMRI) data and averaged across subjects. Lookalike objects = 1:9, animals = 10:18 and inanimate objects = 19:27.

Figure 5

Results for Representational Similarity Analysis



Note. The figure shows the predictive power of two alternative models (H1 and H2) in explaining the blood-oxygen-level-dependent (BOLD) activity in the primary visual cortex (V1), anterior ventral temporal cortex (VTC-ant) and posterior ventral temporal cortex (VTC-post). H1 and H2 correspond to the models in Figure 3A and Figure 3B respectively. The

three black lines are the noise ceilings for three regions. The y-axis shows the correlation values between the models and fMRI data per region.

Figure 6

Significance Test for Figure 5

ROI	**H1**	**P1**	**H2**	**P2**
V1	0	0.962118	0	0.722197
VTC_ant	1	0.000015	1	0.001029
VTC_post	1	0.000254	0	0.398636

Note. The significance test for the representational similarity analysis (RSA) in Figure 5. ROI - region of interest; H1 - Figure 3A is significant or not; P1 - Figure 3A's p-value; H2 - Figure 3B is significant or not; P2 - Figure 3B's p-value.