Cognitive Modeling - lab 2

Group 15 **December 20, 2021**

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Question 1 (4 points):

Discuss with your group, then describe to your teacher, some reasons why each method may be more suitable for different data types or research questions. In other words, in which situations is it best to ignore differences in mean response, and when are they important to consider? Give examples of such situations.

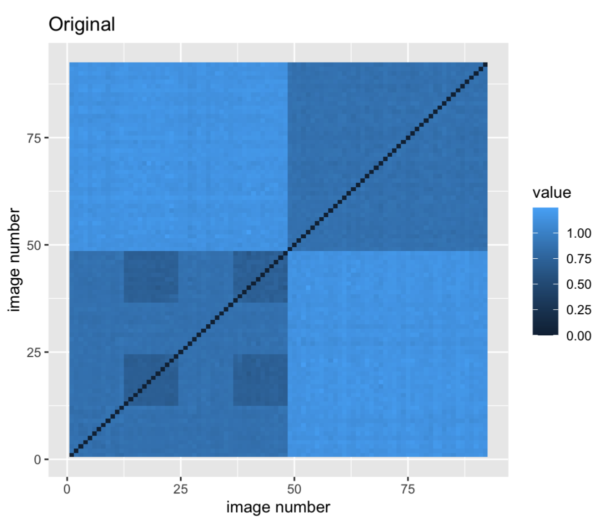
Luca:

- Difference in mean response may be useful when we want to know responses at specific locations and which stimulus causes a bigger response in that location. When we want to compare stimuli
- 1-correlation is more meaningful when the pattern of responses is relevant for the stimulus.
- When not on the same scales, 1-correlation is more impactful (human judgement vs data).

Yanming: For fMRI data, it is better to use 1-correlation, because the response of different brain regions may have different magnitudes. And for the data about behavior, the stimulus signals may be on the same scale, it is better to use Euclidean distance.

Question 2 (5 points):

After you have calculated RDMs for each of the 12 'subjects' and for the original data, make an image of the RDM for a single example subject and for the original data. Include a legend to show the scale. Discuss with your group, then describe to your teacher: how do these two RDMs differ?



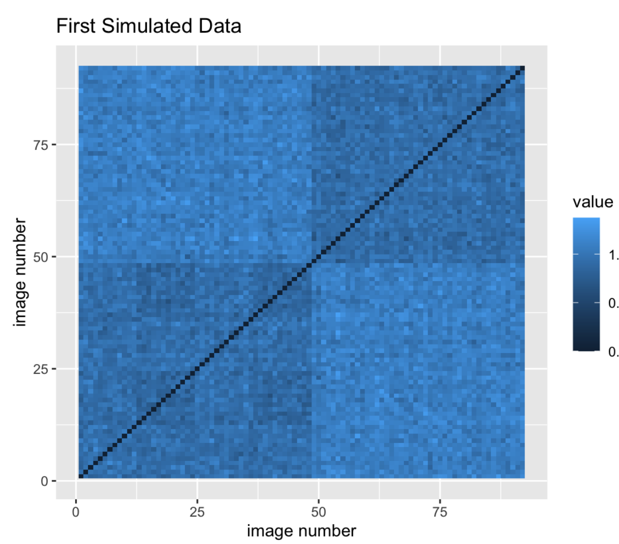


Figure 2.1 RDM for the original data **Figure 2.2 RDM for the first subject's data**

Both graphs show that the data after around the 50th are with high relevance to the first 50 ones. But for the graph of original data, it shows more details in the first 50s data like the data from the 37th to the 50th are with less relevance to the data from the 12th to the 25th.

Why add noise?

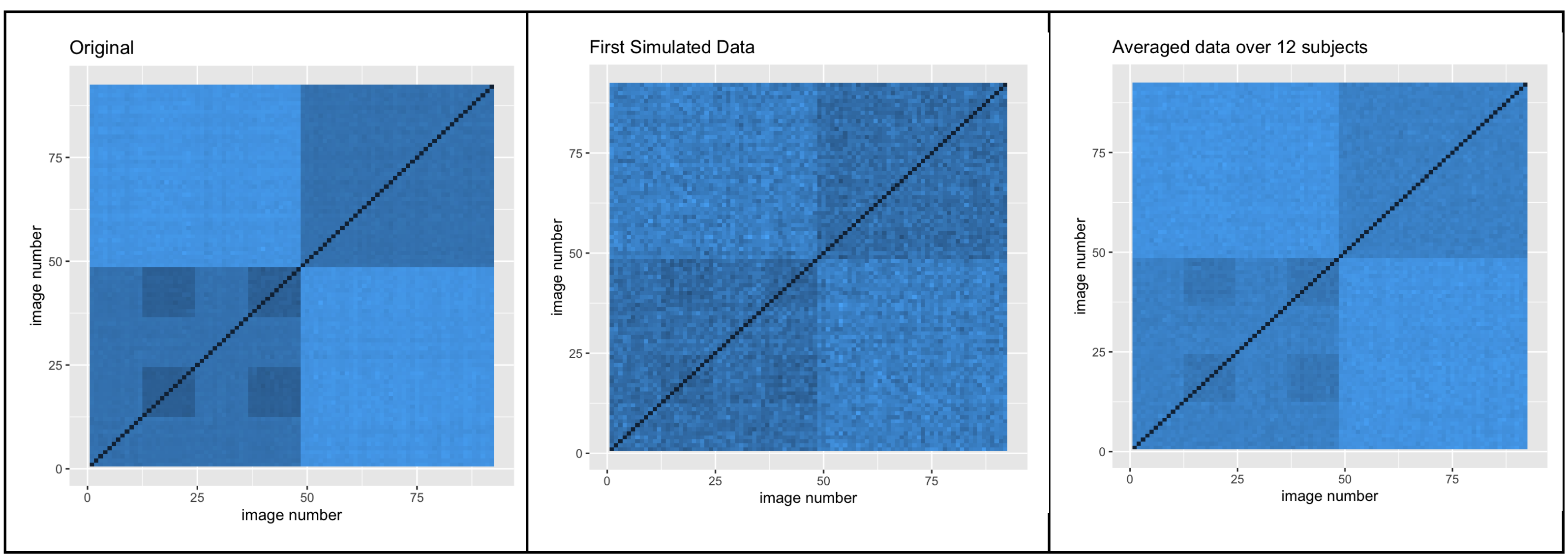
Noise means that new samples are drawn from domains near known samples, thus smoothing the structure of the input space.

Luca answer:

- Single simulation more blurry, because of added noise. Effects less visible
- Adding noise simulates multiple subjects/brains
- **Adding noise adds standard deviation to single subjects (1 vs 1.4)**

Question 3 (2 points):

Average together the RDMs from all 12 'subjects' and compare these averaged RDMs to the RDMs from a single example subject and from the original data. Discuss with your group, then describe to your teacher: How do these differ, and why? Keep the resulting 'average subject' RDM for later.



Unlike what we discuss above, these two graphs both show relevance and details, but the average one is with less distinction (because of the noises)

Question 4 (1 point):

What values of the t-statistic and probability (p) do you find for an effect of animacy on the original data's pattern of representational dissimilarity?

The result after the computer calculation is below:

Welch Two Sample t-test
data: diss_same and diss_different
t = -230.35, df = 2740.1, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-0.3043685 -0.2992304
sample estimates:
mean of x mean of y
0.8504482 1.1522476

Question 5 (3 points):

Compare the t and p values you find for an example individual subject and for the 'average subject' RDM. Write these values in your answers document. Discuss with your group, then describe to your teacher: how do they differ, and why?

The result after the computer calculation is below:

(a). The 'average subject' RDM **Welch Two Sample t-test** **data: same and diff** **t = -149.63, df = 3770.5, p-value < 2.2e-16** **alternative hypothesis: true difference in means is not equal to 0** **95 percent confidence interval:** **-0.1527459 -0.1487948** **sample estimates:** **mean of x mean of y** **0.9246669 1.0754373**	**(b). Single subject RDM** **Welch Two Sample t-test** **data: same and diff** **t = -55.959, df = 4178.9, p-value < 2.2e-16** **alternative hypothesis: true difference in means is not equal to 0** **95 percent confidence interval:** **-0.1556856 -0.1451460** **sample estimates:** **mean of x mean of y** **0.9219008 1.0723166**

Firstly, we already know that "the first subject RDM" data, in some terms, is the subset of "the 'average' subject RDM" data. Which means that their variances may be approximately equal. According to the calculation formula of the t-test, the only difference between these is the value of *df = mean x- mean y* (when they have a similar variance), which leads to a different *t* and *95 percent confidence interval*.

Luca answer:
Single: t = **-55.959**, df = 4178.9, p-value < 2.2e-16
Average: t = **-149.63**, df = 3770.5, p-value < 2.2e-16
The single subject has lower average dissimilarity for animacy, as indicated by the t-statistic. The obvious answer is that the noise contributed to greater variance and thus lower t-value and effect. The bigger the absolute value of t, the smaller the value of p.

Question 6 (1 point):
Following the same principles, make an RDM that predicts the pattern of dissimilarity predicted by a hypothesised response to faces. Then test whether the 'face-ness' of objects affects the original data's pattern of representational dissimilarity. What values do you find for t and p?
The result after the computer calculation is below:

Welch Two Sample t-test
data: diss_same and diss_different
t = **-18.693**, df = 3819, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-0.09572642 -0.07755278
sample estimates:
mean of x mean of y
0.9689395 1.0555791

Question 7 (3 points):
Now repeat this test for effects of face-ness on response similarity using only the part of the RDM where animated objects are compared. What values do you find for t and p? Discuss with your group, then describe to your teacher: how do these compare to the values over the whole RDM, and why?
The result after the computer calculation is below:
Faces, animate-animate

Welch Two Sample t-test

data: diss_same_face_an and diss_different_face_an
t = **-22.586**, df = 592.1, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:
-0.08414440 -0.07068147
sample estimates:
mean of x mean of y
0.793767 0.871180

The p value of the '*face-ness*' RDM and the 'whole' RDM are both lower than 0.05, which means that the two sets of samples of each RDM data are different (alternative hypothesis). This time, they hold the different *mean and variance* and these lead to a different result.

Luca answer: the brain responses are different for face vs non-face objects whether you look at the whole data, or only at animate-animate data. However, the effect seems to be slightly bigger for animate-animate data (t=-18.693 vs t=-22.586). This indicates that faces are more distinguishable between animate-animate objects. Higher t-value = lower p-value and therefore stronger effect.

Question 8 (2 points):

Repeat this procedure to test for an effect of whether an object was human (column 3 of the CategoryVectors). Does humanity have an effect on the similarity of response patterns when all data objects are included in the comparison? Is this also true when only animated objects are included? What t and p values do you find for this effect of humanity in each case? Discuss with your group, then describe to your teacher how you interpret these answers.

The result after the computer calculation is below:

(a). human data

Welch Two Sample t-test

data: diss_same_human and diss_different_human
t = -13.12, df = 3298.8, **p-value < 2.2e-16**
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-0.07447192 -0.05510768
sample estimates:
mean of x mean of y
0.9774581 1.0422479

(b). human and animate data

Welch Two Sample t-test

data: diss_same_human_an and diss_different_human_an

t = -0.45633, df = 1120, **p-value = 0.6482**
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-0.009863570 0.006141256
sample estimates:
mean of x mean of y
0.8323467 0.8342078

Humanity has an effect on the similarity of response patterns when all data objects are included in the comparison(because p is lower than 0.05), but not when only animated objects are included(which p is 0.6482).

Luca answer: difference in dissimilarities between humanity of objects significant when including the whole dataset (p<0.05), but not when only looking at subset of responses with only animate-animate objects (p=0.6482). This indicates that within the animate-animate comparisons, the difference in dissimilarities between human and non-human is insignificant.

Question 9 (3 points):

Use these two predictors separately to make either an ANOVA or a general linear model to test the hypothesis that both animacy and face-ness both have effects. **In this combined model, do animacy and face-ness both have effects, and what statistical values and probabilities are found for each?**

Lucas answer

X1 and x2 are the masks for q4 and q7 (inanimate-inanimate and animate-inanimate set to 0)
y=q4 RDM, matrix of dissimilarities

Df Sum Sq Mean Sq F value Pr(>F) x1 1 95.31 95.31 56341.6 <2e-16 *** x2 1 0.34 0.34 202.6 <2e-16 *** Residuals 4183 7.08 0.00 --- Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1	Call: glm(formula = y ~ x1 + x2, data = df) Deviance Residuals: Min 1Q Median 3Q Max -0.216883 -0.012507 0.006332 0.025172 0.094817 Coefficients: Estimate Std. Error t value Pr(>|t|) (Intercept) 0.842477 0.001063 792.79 <2e-16 *** x1 **0.309771** 0.001389 **222.96** **<2e-16** *** x2 **0.028703** 0.002016 **14.23** **<2e-16** *** --- Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

	(Dispersion parameter for gaussian family taken to be 0.001691651) Null deviance: 102.7293 on 4185 degrees of freedom Residual deviance: 7.0762 on 4183 degrees of freedom AIC: -14831 Number of Fisher Scoring iterations: 2

Question 10 (2 points):

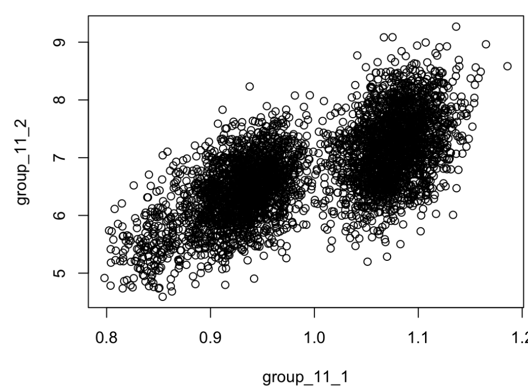
What are the relative effect sizes for these two effects?

Animacy effect is much larger than faceness.

Question 11 (2 points):

Determine the correlation between this macaque neuron data RDM and the 'average subject' RDM we made earlier, using Pearson's correlation. Are these RDMs significantly correlated? What correlation coefficient (r) and probability (p) do you find?

Macaque vs Average subject

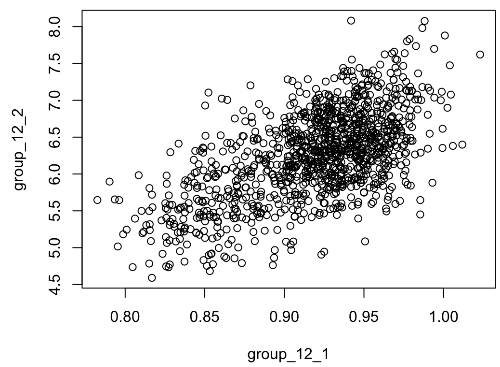
Welch Two Sample t-test	**Pearson's product-moment correlation**	
data: group_11_1 and group_11_2 t = -506.14, df = 4291.5, p-value < 2.2e-16 alternative hypothesis: true difference in means is not equal to 0 95 percent confidence interval: -5.804207 -5.759415 sample estimates: mean of x mean of y 1.001685 6.783497	data: group_11_1 and group_11_2 t = 59.938, df = 4184, **p-value < 2.2e-16** alternative hypothesis: true correlation is not equal to 0 95 percent confidence interval: 0.6630421 0.6956551 sample estimates: **cor** **0.6796844**	

These RDMs are correlated.

Question 12 (3 points):

Now take the part of both RDMs where all pairs are both ***ANIMATE*** *(i.e. the upper left quarter of the RDM). Following the same principle as Question 11, determine whether the patterns of representational dissimilarity among these animate objects are still significantly correlated. What does this tell us?*

Macaque vs Average subject

Welch Two Sample t-test	Pearson's product-moment correlation	
data: group_12_1 and group_12_2 t = -298.87, df = 1138.5, p-value < 2.2e-16 alternative hypothesis: true difference in means is not equal to 0 95 percent confidence interval: -5.370762 -5.300704 sample estimates: mean of x mean of y 0.9187548 6.2544879	data: group_12_1 and group_12_2 t = 25.437, df = 1126, **p-value < 2.2e-16** alternative hypothesis: true correlation is not equal to 0 95 percent confidence interval: 0.5656736 0.6399017 sample estimates: **cor** **0.6040963**	

Luca's answer:

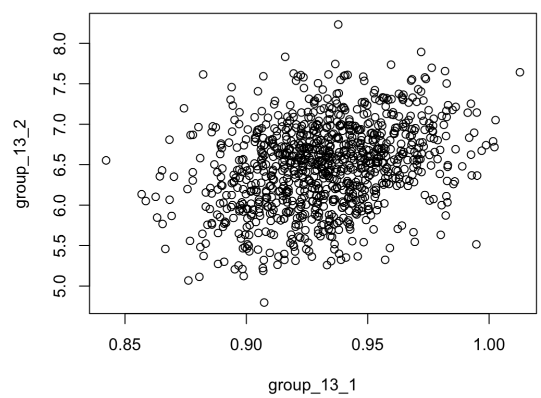
- Still correlated, lower correlation and t-value.
- Macaques have similar dissimilarity matrices
- Need to answer: where does the correlation effect come from?

Question 13 (2 points):

And take the part of both RDMs where the pairs are both ***INANIMATE****. Are the patterns of dissimilarity significantly correlated here? Discuss with your group, then describe to your teacher: Why might this be different from the result seen in the previous question?*

Macaque vs Average subject

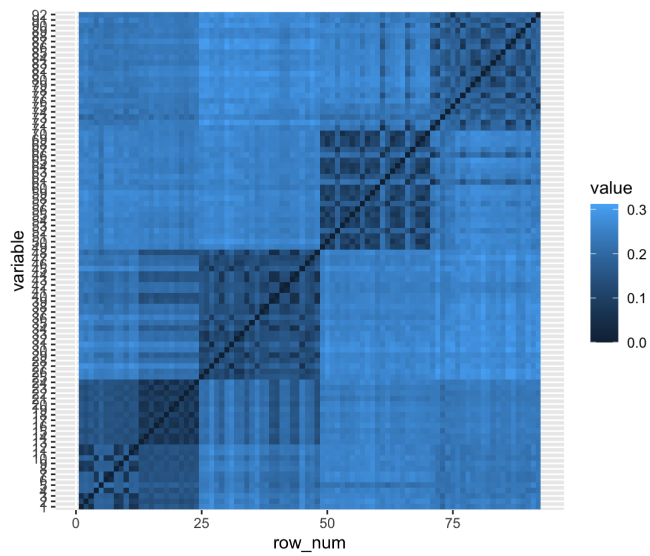
Welch Two Sample t-test	Pearson's product-moment correlation	

data: group_13_1 and group_13_2 t = -318.79, df = 949.71, p-value < 2.2e-16 alternative hypothesis: true difference in means is not equal to 0 95 percent confidence interval: -5.579698 -5.511422 sample estimates: mean of x mean of y 0.9319701 6.4775305	data: group_13_1 and group_13_2 t = 10.048, df = 944, p-value < 2.2e-16 alternative hypothesis: true correlation is not equal to 0 95 percent confidence interval: 0.2520831 0.3672896 sample estimates: **cor** **0.3108276**	

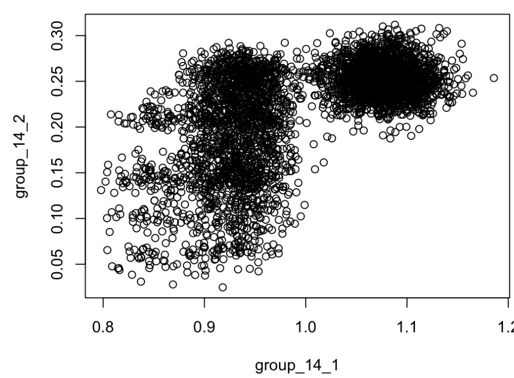
Luca's answer: *the representation of inanimate objects may not be well developed in macaques. Perhaps because they have had no exposure to inanimate objects in their lifetime, for example.*
I'm not sure what the ***INANIMATE*** *things here are, artificial things like cars or natural things like stones? If the former, I hold the same reason as Luca, if the latter, the reason might be like humans hold different structural and biological parameters of the eyeball or some other biological structure that makes humans get different information when we observe the world. And those things lead to different responses when possessing information.*

Question 14 (3 points):

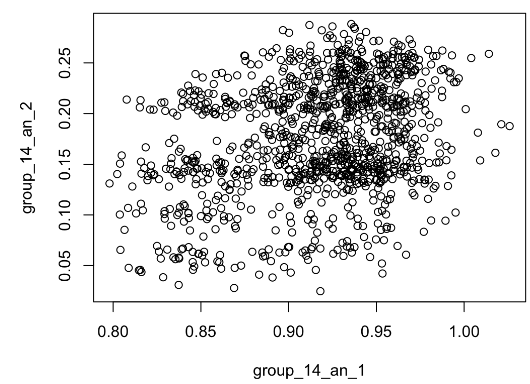
How well does the behavioural RDM correlate to our 'average subject' RDM? How about when using only animated objects? And when using only inanimate objects? Discuss with your group, then describe to your teacher: What does this tell us, and can you think of a possible explanation for this result?

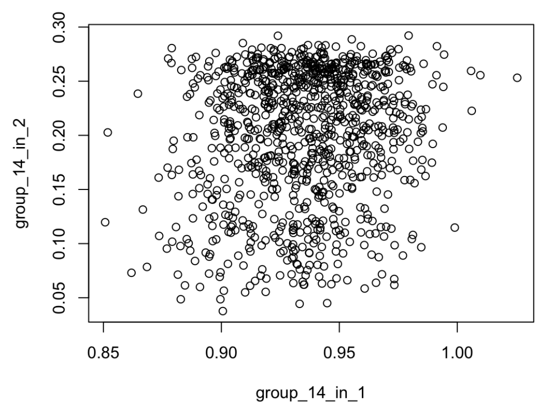


Behavioral (human judgement) vs average subject

Welch Two Sample t-test	**Pearson's product-moment correlation**	**1.Full RDMs**
data: group_14_1 and group_14_2 t = 508.23, df = 7279.3, p-value < 2.2e-16 alternative hypothesis: true difference in means is not equal to 0 95 percent confidence interval: 0.7786326 0.7846623 sample estimates: mean of x mean of y 1.0016853 0.2200379	data: group_14_1 and group_14_2 t = 50.12, df = 4184, p-value < 2.2e-16 alternative hypothesis: true correlation is not equal to 0 95 percent confidence interval: 0.5932066 0.6310793 sample estimates: **cor** **0.6124943**	

Welch Two Sample t-test	**Pearson's product-moment correlation**	**2.ANIMATE**

data: group_14_an_1 and group_14_an_2 t = 349.34, df = 2122.3, p-value < 2.2e-16 alternative hypothesis: true difference in means is not equal to 0 95 percent confidence interval: 0.7365551 0.7448713 sample estimates: mean of x mean of y 0.9166885 0.1759753	data: group_14_an_1 and group_14_an_2 t = 10.755, df = 1126, p-value < 2.2e-16 alternative hypothesis: true correlation is not equal to 0 95 percent confidence interval: 0.2513125 0.3572089 sample estimates: **cor** **0.3052039**	

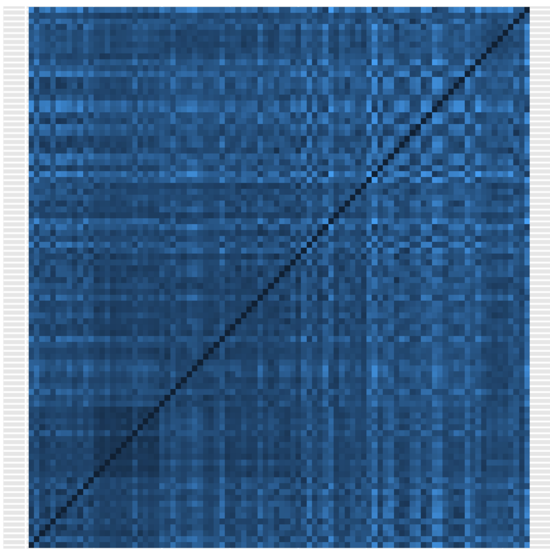
Welch Two Sample t-test	**Pearson's product-moment correlation**	**3. INANIMATE**
data: group_14_in_1 and group_14_in_2 t = 340.07, df = 1278.8, p-value < 2.2e-16 alternative hypothesis: true difference in means is not equal to 0 95 percent confidence interval: 0.7308409 0.7393220 sample estimates: mean of x mean of y 0.9348919 0.1998104	Pearson's product-moment correlation data: avg and brdm t = 3.6717, df = 944, p-value = 0.0002544 alternative hypothesis: true correlation is not equal to 0 95 percent confidence interval: 0.05534082 0.18103044 sample estimates: **cor** **0.1186609**	

Q:*What does this tell us, and can you think of a possible explanation for this result?*
Luca's answer:

- High correlation between average subject and human judgement.
- Low correlation when conditioning on animate-animate and inanimate-inanimate
- Possible explanation: humans take information from other parts of the brain (top-down processing) to make a judgement whether something is similar to something else, whereas for the average subject, we measured brain activity at specific recording sites.

- Animate-inanimate dissimilarities are very distinct, whereas differences within animate and inanimate subsets grey areas that require more nuance.

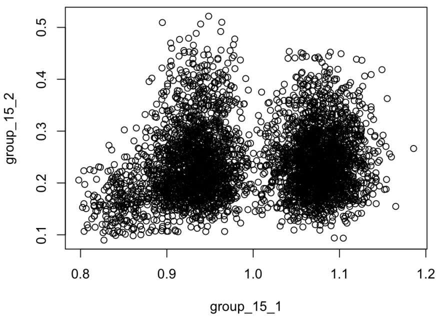
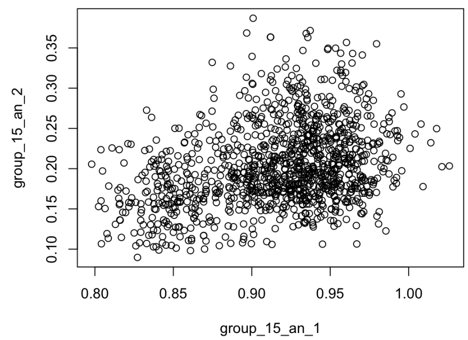
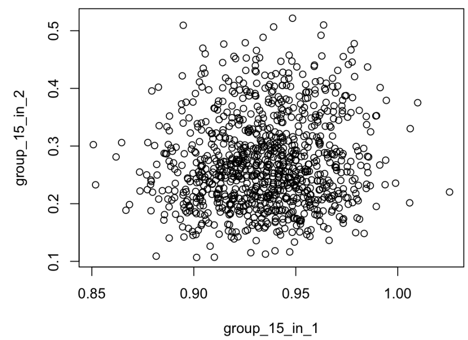
Another explanation:
When making judgments, the human process is based on the context, but for the brain, we have a bad "cache" system, which means that we cannot remember things with every detail and when remembering we have to "imagine" losing details. So for this, we have to "scan" what we see before and find the similar objects to make a decision. That's why it correlates to "average" RDMs, not some certain ones.



Question 15 (3 points):
How well does the HMAX RDM correlate to our 'average subject' RDM? How about when using only animated objects? And when using only inanimate objects? Discuss with your group, then describe to your teacher: What does this tell us about the limitations of HMAX as a model of human object processing?

HMAX vs average subject

1. Full RDM's	2. animate-animate	3. inanimate-inanimate
Pearson's product-moment correlation data: group_15_1 and group_15_2 t = 8.6948, df = 4184, p-value < 2.2e-16 alternative hypothesis: true correlation is not equal to 0 95 percent confidence interval: 0.1033443 0.1628599 sample estimates: **cor**	**Pearson's product-moment correlation** data: group_15_an_1 and group_15_an_2 t = 11.658, df = 1126, p-value < 2.2e-16 alternative hypothesis: true correlation is not equal to 0 95 percent confidence interval: 0.2750874 0.3792892 sample estimates: **cor**	**Pearson's product-moment correlation** **data: avg and hmax** **t = 1.5613, df = 944, p-value = 0.1188** **alternative hypothesis: true correlation is not equal to 0** **95 percent confidence interval:** **-0.01302897 0.11412137** **sample estimates:**

0.1332222	**0.3281863**	**cor 0.05075186**
		

Q:*What does this tell us about the limitations of HMAX as a model of human object processing?*

Luca's answer:
observations:

- Dissimilarities between hmax and average subjects have low correlations.
- Slightly higher correlation for animate-animate
- Hmax seems to not be a good model to approximate human brain responses.