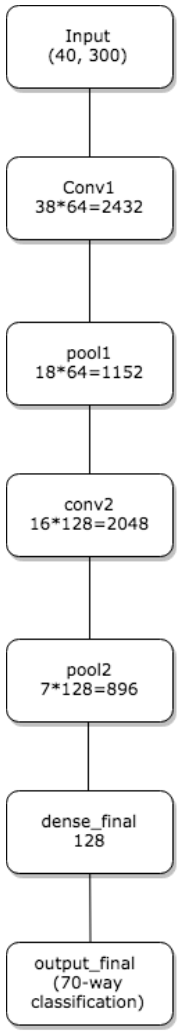
Stimuli

## 1. Model



```
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
input_1 (InputLayer)         (None, 40)                0         
_________________________________________________________________
embedding_1 (Embedding)      (None, 40, 300)           61667400  
_________________________________________________________________
reshape_1 (Reshape)          (None, 40, 300, 1)        0         
_________________________________________________________________
conv_1 (Conv2D)              (None, 38, 1, 64)         57664     
_________________________________________________________________
pool_1 (MaxPooling2D)        (None, 18, 1, 64)         0         
_________________________________________________________________
pool_1_reshaped (Reshape)    (None, 18, 64, 1)         0         
_________________________________________________________________
conv_2 (Conv2D)              (None, 16, 1, 128)        24704     
_________________________________________________________________
pool_2 (MaxPooling2D)        (None, 7, 1, 128)         0         
_________________________________________________________________
pool_2_reshaped (Reshape)    (None, 7, 128, 1)         0         
_________________________________________________________________
flatten_1 (Flatten)          (None, 896)               0         
_________________________________________________________________
dropout_1 (Dropout)          (None, 896)               0         
_________________________________________________________________
dense_final (Dense)          (None, 128)               114816    
_________________________________________________________________
dropout_2 (Dropout)          (None, 128)               0         
_________________________________________________________________
output_final (Dense)         (None, 70)                9030      
=================================================================
Total params: 61,873,614
Trainable params: 61,873,614
Non-trainable params: 0
_________________________________________________________________
```

## 2. Results

Classification report

```
{} &                  class &  f1\_score &  precision &  recall &  support \\
0  &          MusicalArtist &      0.46 &       0.52 &    0.41 &    960.0 \\
1  &                  River &      0.76 &       0.75 &    0.77 &    960.0 \\
2  &                 Island &      0.64 &       0.69 &    0.60 &    960.0 \\
3  &                Species &      0.75 &       0.74 &    0.76 &    960.0 \\
4  &             Automobile &      0.78 &       0.74 &    0.83 &    960.0 \\
5  &           RacingDriver &      0.76 &       0.77 &    0.75 &    960.0 \\
6  &                    Dog &      0.81 &       0.79 &    0.83 &    960.0 \\
7  &              Newspaper &      0.65 &       0.66 &    0.65 &    960.0 \\
8  &       ReligiousBuilding &      0.56 &       0.55 &    0.57 &    960.0 \\
9  &                Mineral &      0.90 &       0.93 &    0.86 &    960.0 \\
10 &         AthleticsPlayer &      0.68 &       0.68 &    0.68 &    960.0 \\
11 &                Company &      0.45 &       0.58 &    0.37 &    960.0 \\
12 &                  Album &      0.55 &       0.61 &    0.49 &    960.0 \\
13 &      CyclingCompetition &      0.85 &       0.82 &    0.89 &    960.0 \\
14 &                Artwork &      0.61 &       0.54 &    0.70 &    960.0 \\
15 &         ChristianBishop &      0.42 &       0.55 &    0.34 &    960.0 \\
16 &                   Film &      0.50 &       0.59 &    0.44 &    960.0 \\
17 &           MetroStation &      0.80 &       0.76 &    0.84 &    960.0 \\
18 &         MotorcycleRider &      0.82 &       0.83 &    0.81 &    960.0 \\
19 &               Building &      0.49 &       0.52 &    0.47 &    960.0 \\
20 &        VolleyballPlayer &      0.82 &       0.81 &    0.84 &    960.0 \\
21 &               Aircraft &      0.72 &       0.74 &    0.71 &    960.0 \\
22 &                Diocese &      0.81 &       0.81 &    0.82 &    960.0 \\
23 &                   Road &      0.81 &       0.79 &    0.82 &    960.0 \\
24 &                Disease &      0.72 &       0.67 &    0.78 &    960.0 \\
25 &             SoccerClub &      0.51 &       0.49 &    0.53 &    960.0 \\
26 &          RailwayStation &      0.80 &       0.84 &    0.78 &    960.0 \\
27 &          IceHockeyPlayer &      0.81 &       0.82 &    0.80 &    960.0 \\
28 &             MusicGenre &      0.72 &       0.71 &    0.74 &    960.0 \\
29 &          MilitaryPerson &      0.41 &       0.53 &    0.34 &    960.0 \\
30 &             EthnicGroup &      0.47 &       0.54 &    0.42 &    960.0 \\
31 &           TennisPlayer &      0.86 &       0.87 &    0.84 &    960.0 \\
32 &  AmericanFootballPlayer &      0.89 &       0.90 &    0.88 &    960.0 \\
33 &             SportsTeam &      0.88 &       0.86 &    0.89 &    960.0 \\
34 &          TelevisionShow &      0.64 &       0.57 &    0.71 &    960.0 \\
35 &             Politician &      0.44 &       0.42 &    0.46 &    960.0 \\
36 &        BasketballPlayer &      0.69 &       0.74 &    0.66 &    960.0 \\
37 &               Cardinal &      0.57 &       0.56 &    0.59 &    960.0 \\
38 &        MilitaryConflict &      0.39 &       0.43 &    0.36 &    960.0 \\
39 &                  Saint &      0.47 &       0.48 &    0.46 &    960.0 \\
40 &                Airport &      0.80 &       0.84 &    0.77 &    960.0 \\
41 &                Athlete &      0.56 &       0.51 &    0.61 &    960.0 \\
42 &               Software &      0.78 &       0.72 &    0.85 &    960.0 \\
43 &        ChemicalCompound &      0.77 &       0.78 &    0.76 &    960.0 \\
44 &           CelestialBody &      0.90 &       0.87 &    0.94 &    960.0 \\
45 &                   Game &      0.66 &       0.62 &    0.71 &    960.0 \\
46 &           MilitaryUnit &      0.49 &       0.50 &    0.49 &    960.0 \\
47 &                 Museum &      0.50 &       0.49 &    0.52 &    960.0 \\
48 &                  Sport &      0.58 &       0.56 &    0.59 &    960.0 \\
49 &           SportFacility &      0.69 &       0.75 &    0.64 &    960.0 \\
50 &      FictionalCharacter &      0.46 &       0.47 &    0.45 &    960.0 \\
51 &                Swimmer &      0.71 &       0.73 &    0.70 &    960.0 \\
52 &        TelevisionSeason &      0.44 &       0.48 &    0.40 &    960.0 \\
53 &           SoccerPlayer &      0.62 &       0.60 &    0.64 &    960.0 \\
54 &           SerialKiller &      0.66 &       0.59 &    0.74 &    960.0 \\
55 &                Cyclist &      0.77 &       0.80 &    0.74 &    960.0 \\
56 &           SportsSeason &      0.66 &       0.74 &    0.59 &    960.0 \\
57 &                   Book &      0.35 &       0.32 &    0.39 &    960.0 \\
58 &               Mountain &      0.70 &       0.73 &    0.68 &    960.0 \\
59 &             Decoration &      0.81 &       0.79 &    0.83 &    960.0 \\
60 &                Monarch &      0.48 &       0.40 &    0.59 &    960.0 \\
61 &                   Ship &      0.73 &       0.70 &    0.76 &    960.0 \\
62 &          PopulatedPlace &      0.47 &       0.44 &    0.50 &    960.0 \\
63 &             University &      0.68 &       0.71 &    0.66 &    960.0 \\
64 &               Language &      0.69 &       0.63 &    0.76 &    960.0 \\
65 &             SportsEvent &      0.57 &       0.53 &    0.62 &    960.0 \\
66 &                Country &      0.38 &       0.35 &    0.40 &    960.0 \\
67 &                Referee &      0.84 &       0.84 &    0.84 &    960.0 \\
68 &                   Song &      0.57 &       0.56 &    0.58 &    960.0 \\
69 &              VideoGame &      0.48 &       0.55 &    0.43 &    960.0 \\
70 &              avg/total &      0.65 &       0.65 &    0.65 &  67200.0 \\
\end{tabular}
```

Lowest: Book
Highest: Mineral

See cm.csv for confusion matrix (y axis=truth, x axis=prediction).
Most confused:

| True label | Predicted | Count |
|---|---|---|
| MusicalArtist | Album | 120 |
| Album | MusicalArtist | 137 |
| Album | Song | 172 |

| | | |
|---|---|---|
| ChristianBishop | Cardinal | 224 |
| ChristianBishop | Saint | 93 |

**Correlation between layers**

| | conv1 | pool1 | conv2 | pool2 | dense_final |
|---|---|---|---|---|---|
| conv1 | 1 | 0.79 | 0.67 | 0.54 | 0.21 |
| pool1 | 0.79 | 1 | 0.81 | 0.74 | 0.44 |
| conv2 | 0.67 | 0.81 | 1 | 0.89 | 0.67 |
| pool2 | 0.54 | 0.74 | 0.89 | 1 | 0.72 |
| dense_final | **0.21** | 0.44 | **0.67** | 0.72 | 1 |

So we would use conv1, conv2 and dense_final as our three layers (I'm going to run a deeper CNN to compare).

## 3. Stimuli

So we're going to obtain stimuli from the prototypical sentences.

Method for obtaining prototypical sentences:

- Find prototypical sentences of categories: the ones that, on average, correlate the most with other sentences of their category .
- Choose **20** random sentences from top **300** prototypical sentences per category
- Correlation matrix of 20sentences*70categories = matrix 70*70
- Correlate correlation matrix of each layer (method=Spearman)

Notes:

- I've only been using the validation set for everything, so these sentences will not be the final ones. The final sentences should come from the test set (because we'll show those sentences to humans in the fMRI and to the neural network, and we don't want the neural network to have seen them).
- Remember numbers are replaced by numer signs #, but these can be recovered easily.
- I removed commas from dataset, but again we can put them back on the stimuli, they'll just be ignored by the model.
- I removed the class AdultActor because sentences like "una delle sue specialita hard e il sesso anale"  will make people laugh in the scanner. So we're left with 70 categories.

Sentences between 8-14 words from a list of the top **300** prototypical sentences ranked by prototpycality and with Google translations for some and good example stimuli in bold, also for some. since this isn't the final list, i won't go through all of them : prototypical_sentences_8_14_translations.csv

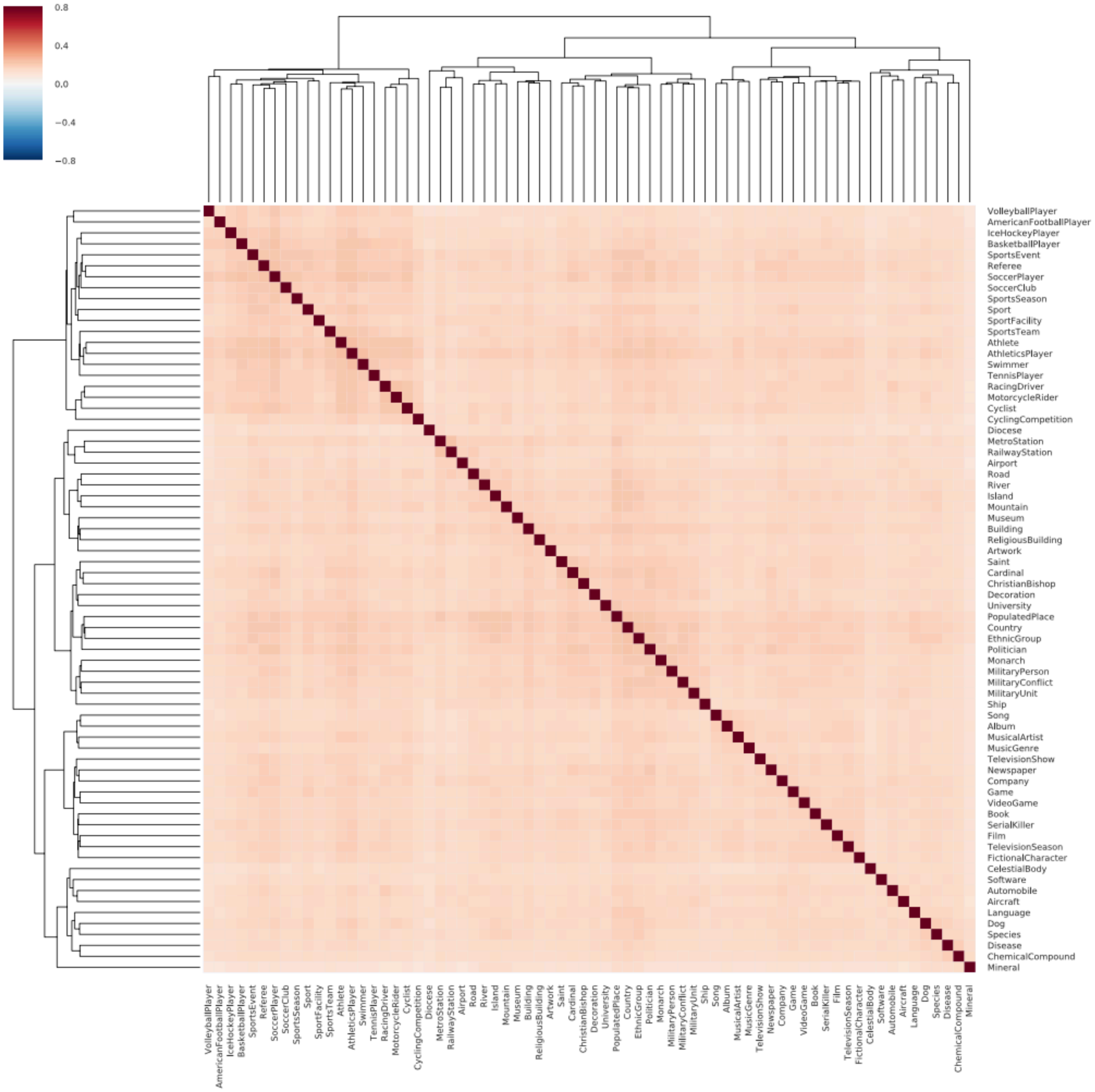
For the final stimuli I'll start from the top (most prototypical) and work my way down trying to get 3-6 sentences that contain different words.

So I wrote to Ev this morning and she'll get back to me tomorrow regarding the stimuli. We'll see what she says, but I would only make sure sentence are between 8-14, and have them be active voice. Of course controlling every variable would be nice, but most are difficult to control and no one does it with fmri unless they're showing a specific effect (concrete nouns vs. abstract nouns).

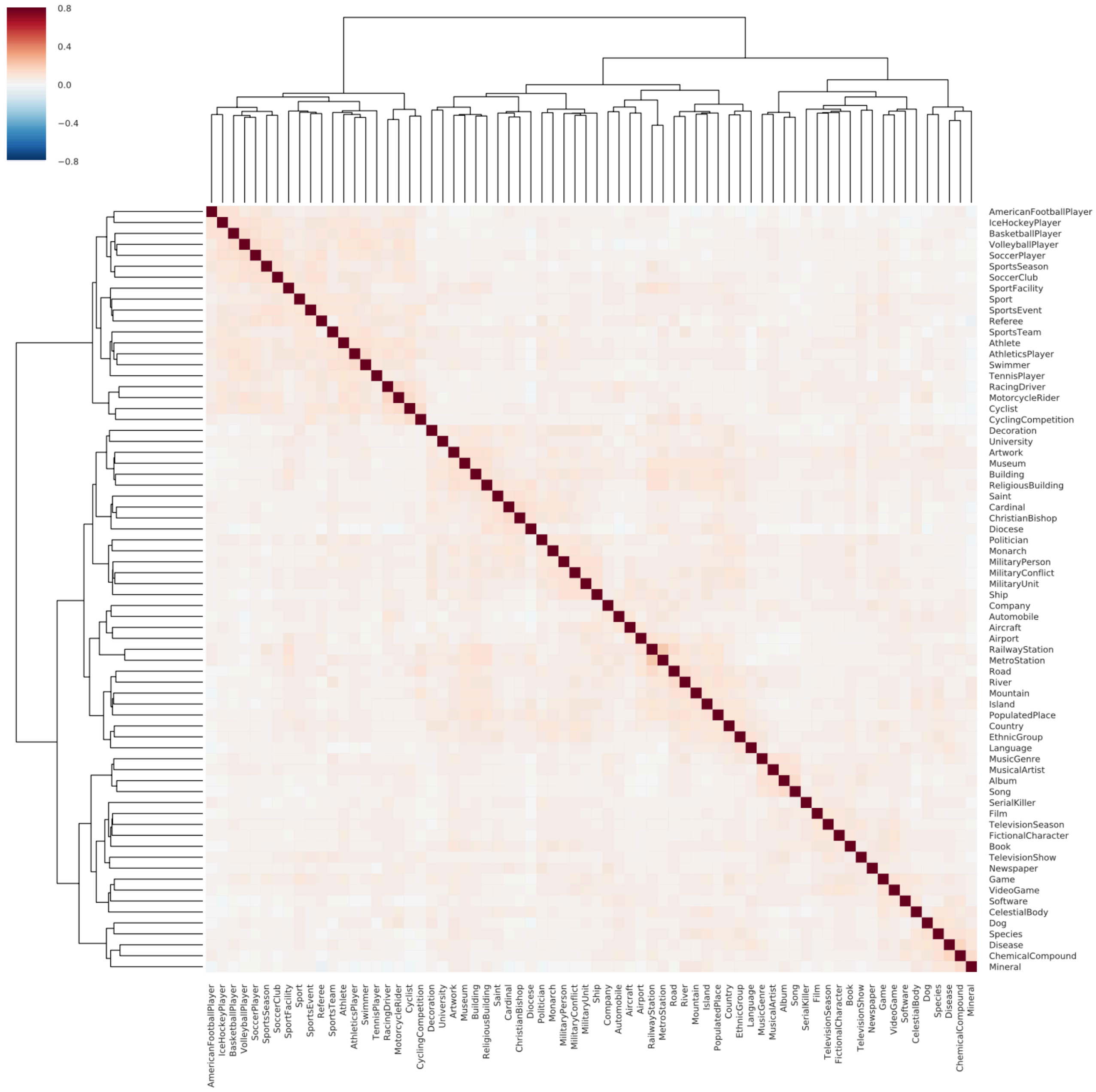
## 4. RSA

### 4.1. RSM of validation set (960 sentences per category)

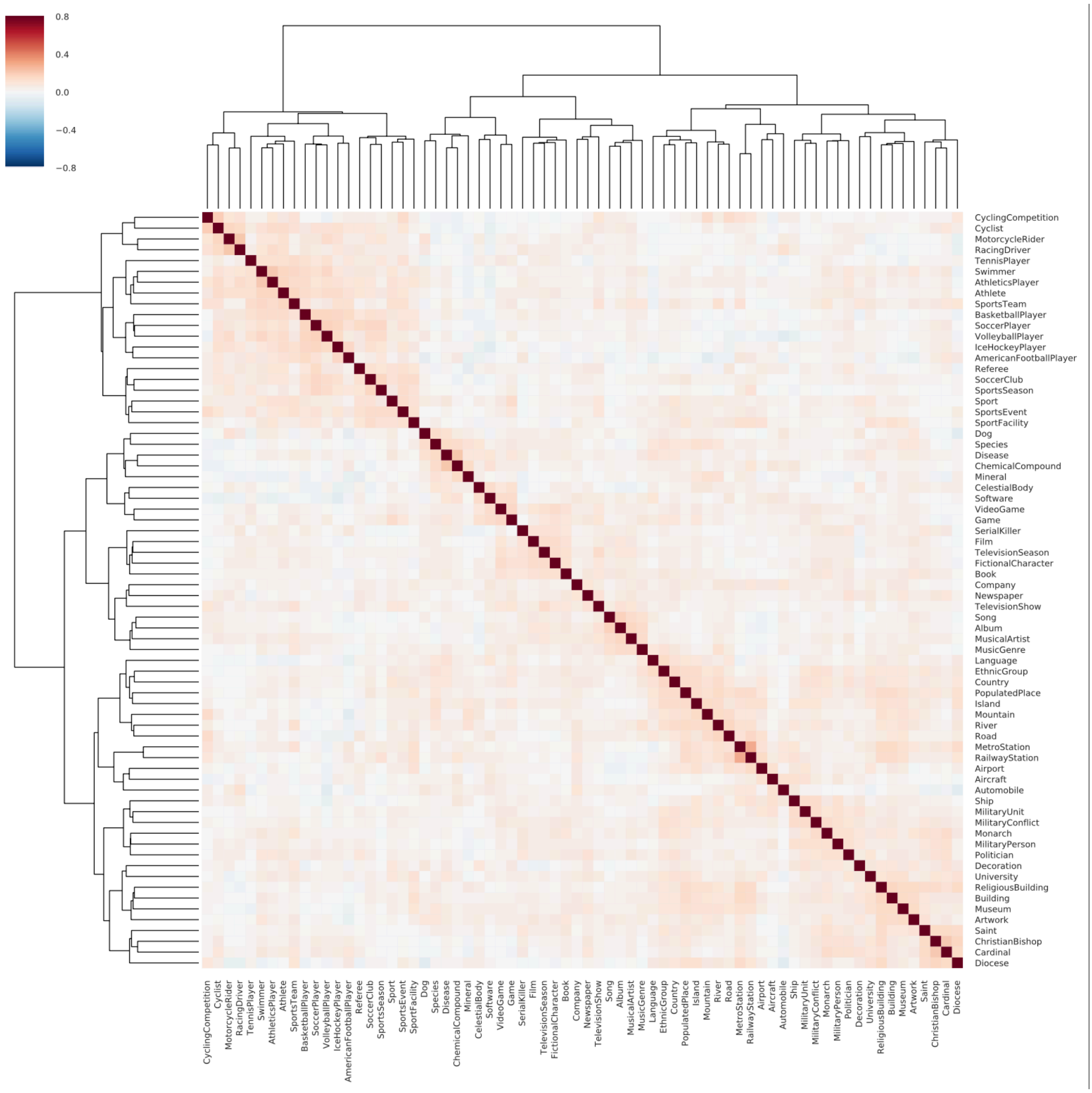
### Conv1

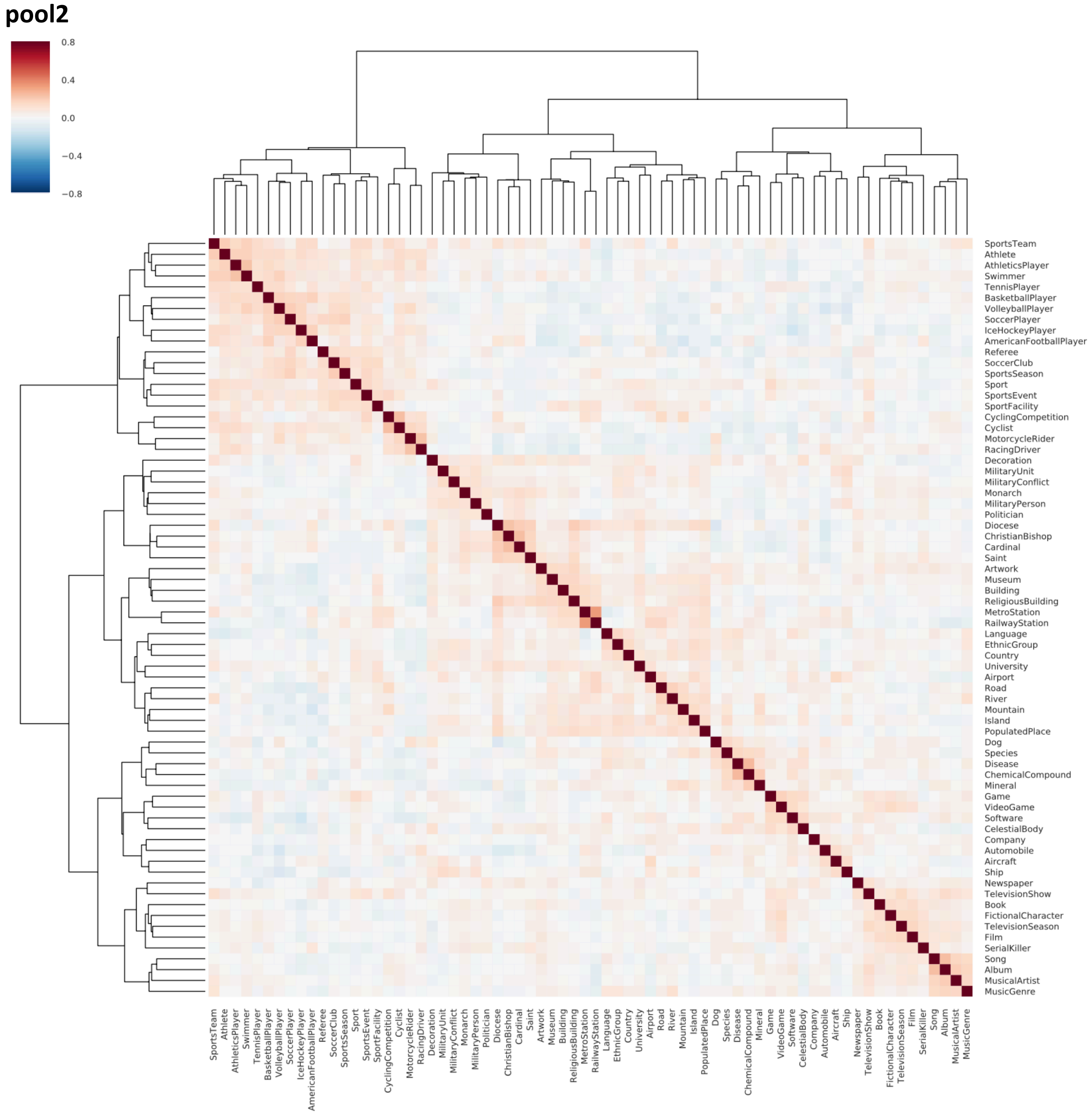


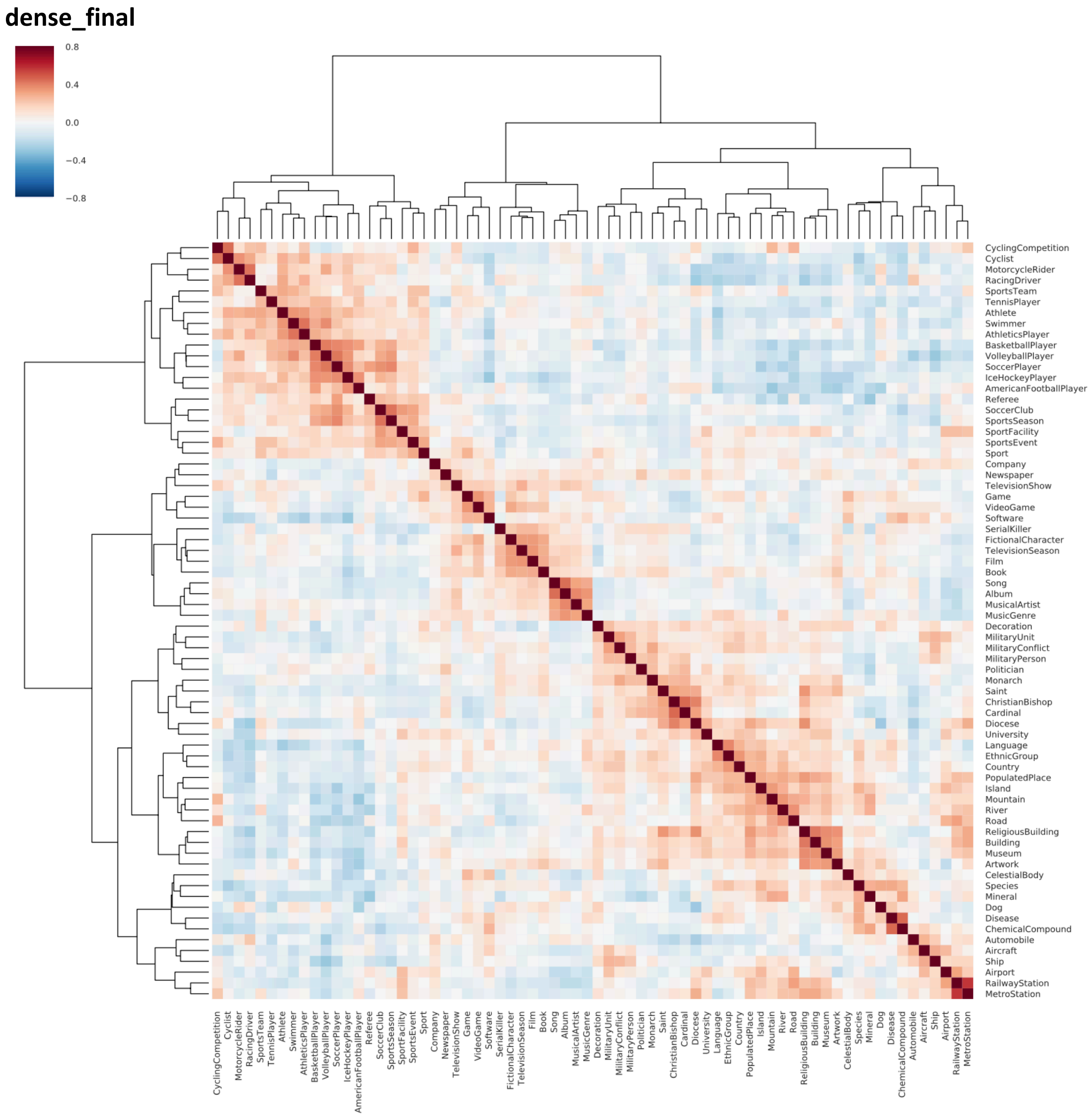
**pool1**


0.8
0.4
0.0
−0.4
−0.8
AmericanFootballPlayer
IceHockeyPlayer
BasketballPlayer
VolleyballPlayer
SoccerPlayer
SportsSeason
SoccerClub
SportFacility
Sport
SportsEvent
Referee
SportsTeam
Athlete
AthleticsPlayer
Swimmer
TennisPlayer
RacingDriver
MotorcycleRider
Cyclist
CyclingCompetition
Decoration
University
Artwork
Museum
Building
ReligiousBuilding
Saint
Cardinal
ChristianBishop
Diocese
Politician
Monarch
MilitaryPerson
MilitaryConflict
MilitaryUnit
Ship
Company
Automobile
Aircraft
Airport
RailwayStation
MetroStation
Road
River
Mountain
Island
PopulatedPlace
Country
EthnicGroup
Language
MusicGenre
MusicalArtist
Album
Song
SerialKiller
Film
TelevisionSeason
FictionalCharacter
Book
TelevisionShow
Newspaper
Game
VideoGame
Software
CelestialBody
Dog
Species
Disease
ChemicalCompound
Mineral

## conv2


0.8
0.4
0.0
−0.4
−0.8
CyclingCompetition
Cyclist
MotorcycleRider
RacingDriver
TennisPlayer
Swimmer
AthleticsPlayer
Athlete
SportsTeam
BasketballPlayer
SoccerPlayer
VolleyballPlayer
IceHockeyPlayer
AmericanFootballPlayer
Referee
SoccerClub
SportsSeason
Sport
SportsEvent
SportFacility
Dog
Species
Disease
ChemicalCompound
Mineral
CelestialBody
Software
VideoGame
Game
SerialKiller
Film
TelevisionSeason
FictionalCharacter
Book
Company
Newspaper
TelevisionShow
Song
Album
MusicalArtist
MusicGenre
Language
EthnicGroup
Country
PopulatedPlace
Island
Mountain
River
Road
MetroStation
RailwayStation
Airport
Aircraft
Automobile
Ship
MilitaryUnit
MilitaryConflict
Monarch
MilitaryPerson
Politician
Decoration
University
ReligiousBuilding
Building
Museum
Artwork
Saint
ChristianBishop
Cardinal
Diocese

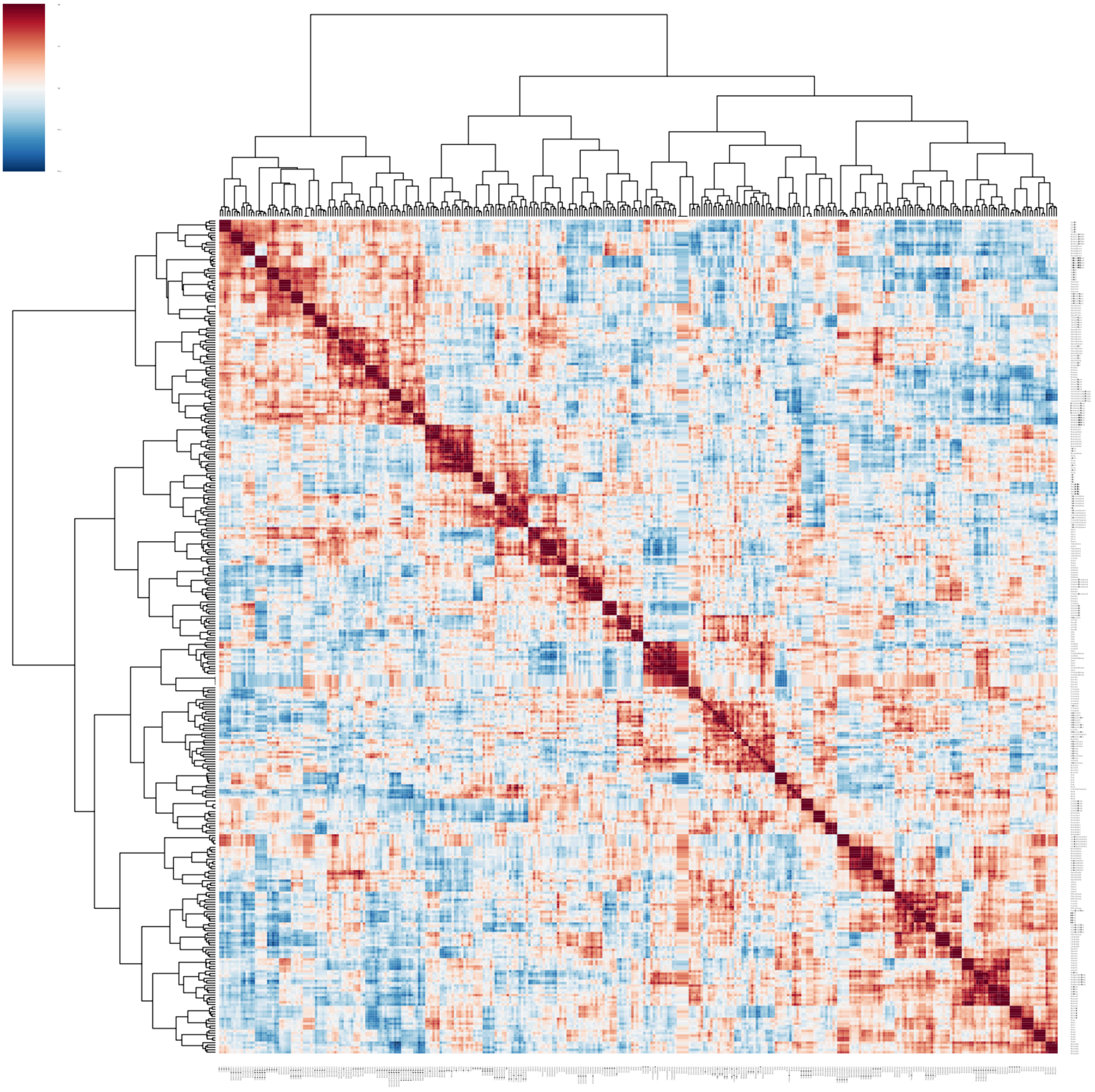

pool2
0.8
0.4
0.0
−0.4
−0.8
SportsTeam
Athlete
AthleticsPlayer
Swimmer
TennisPlayer
BasketballPlayer
VolleyballPlayer
SoccerPlayer
IceHockeyPlayer
AmericanFootballPlayer
Referee
SoccerClub
SportsSeason
Sport
SportsEvent
SportFacility
CyclingCompetition
Cyclist
MotorcycleRider
RacingDriver
Decoration
MilitaryUnit
MilitaryConflict
Monarch
MilitaryPerson
Politician
Diocese
ChristianBishop
Cardinal
Saint
Artwork
Museum
Building
ReligiousBuilding
MetroStation
RailwayStation
Language
EthnicGroup
Country
University
Airport
Road
River
Mountain
Island
PopulatedPlace
Dog
Species
Disease
ChemicalCompound
Mineral
Game
VideoGame
Software
CelestialBody
Company
Automobile
Aircraft
Ship
Newspaper
TelevisionShow
Book
FictionalCharacter
TelevisionSeason
Film
SerialKiller
Song
Album
MusicalArtist
MusicGenre

dense_final
0.8
0.4
0.0
−0.4
−0.8
CyclingCompetition
Cyclist
MotorcycleRider
RacingDriver
SportsTeam
TennisPlayer
Athlete
Swimmer
AthleticsPlayer
BasketballPlayer
VolleyballPlayer
SoccerPlayer
IceHockeyPlayer
AmericanFootballPlayer
Referee
SoccerClub
SportsSeason
SportFacility
SportsEvent
Sport
Company
Newspaper
TelevisionShow
Game
VideoGame
Software
SerialKiller
FictionalCharacter
TelevisionSeason
Film
Book
Song
Album
MusicalArtist
MusicGenre
Decoration
MilitaryUnit
MilitaryConflict
MilitaryPerson
Politician
Monarch
Saint
ChristianBishop
Cardinal
Diocese
University
Language
EthnicGroup
Country
PopulatedPlace
Island
Mountain
River
Road
ReligiousBuilding
Building
Museum
Artwork
CelestialBody
Species
Mineral
Dog
Disease
ChemicalCompound
Automobile
Aircraft
Ship
Airport
RailwayStation
MetroStation
CyclingCompetition
Cyclist
MotorcycleRider
RacingDriver
SportsTeam
TennisPlayer
Athlete
Swimmer
AthleticsPlayer
BasketballPlayer
VolleyballPlayer
SoccerPlayer
IceHockeyPlayer
AmericanFootballPlayer
Referee
SoccerClub
SportsSeason
SportFacility
SportsEvent
Sport
Company
Newspaper
TelevisionShow
Game
VideoGame
Software
SerialKiller
FictionalCharacter
TelevisionSeason
Film
Book
Song
Album
MusicalArtist
MusicGenre
Decoration
MilitaryUnit
MilitaryConflict
MilitaryPerson
Politician
Monarch
Saint
ChristianBishop
Cardinal
Diocese
University
Language
EthnicGroup
Country
PopulatedPlace
Island
Mountain
River
Road
ReligiousBuilding
Building
Museum
Artwork
CelestialBody
Species
Mineral
Dog
Disease
ChemicalCompound
Automobile
Aircraft
Ship
Airport
RailwayStation
MetroStation

### 4.2. RSM of individual sentences

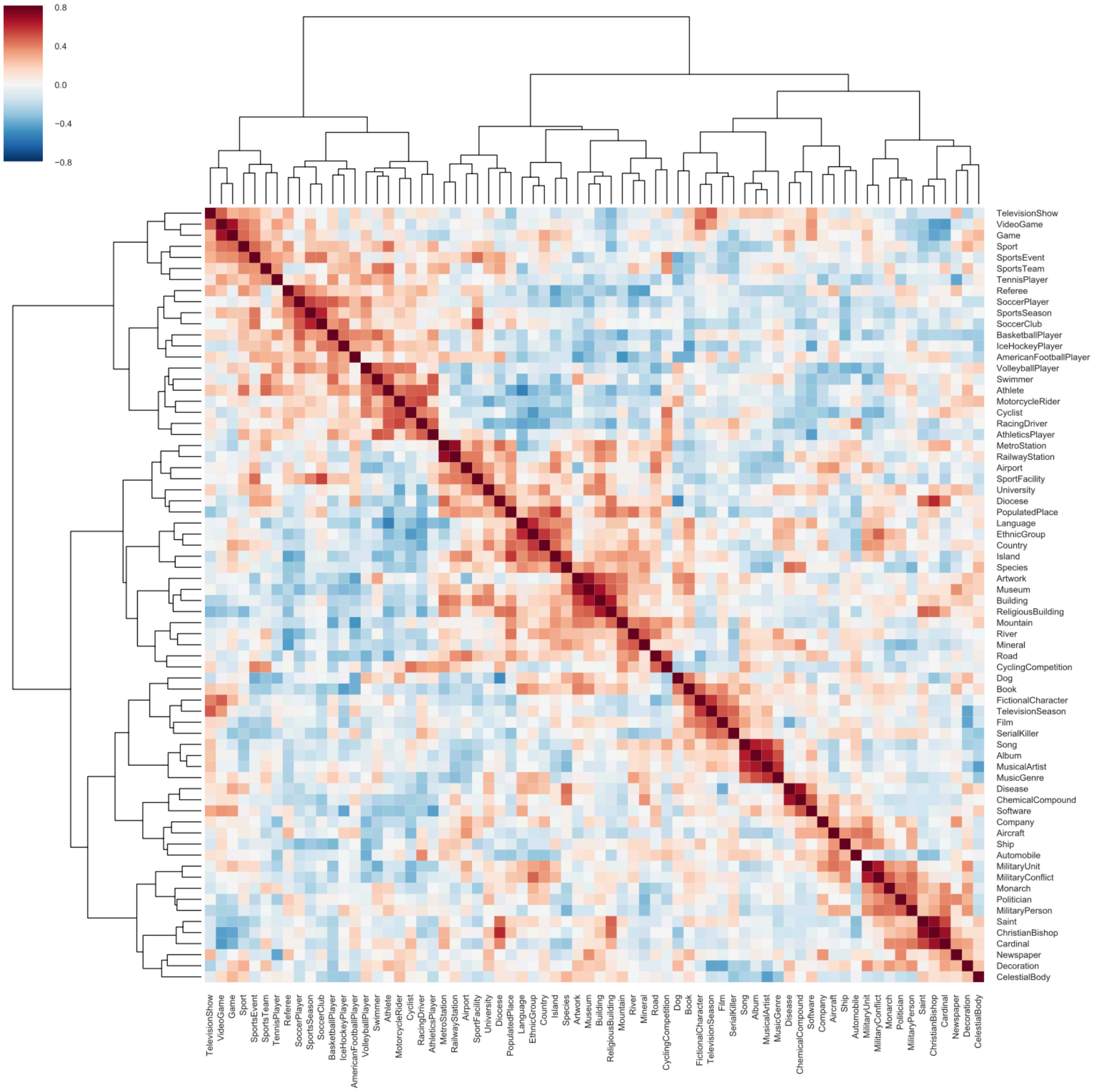
I understand this is the most relevant clustermap. It’s individual sentences. dense_final: 5 random sentences per catgory (you can see it large here RSA_ward_randomN_clustermap.eps):

And of course this might change when we try our final stimuli.



**Dense_final: mean of those 5 random sentences per category).**
Compare to dense_final using all sentences.

So if we compare this one to the previous one, we could see benefits of averaging the response from each category.



Have a look at prototypical_sentences_8_14_translations.csv and then:

**Questions:**

1. We could also just use sentences that are the first sentence in an article so they're more understandable like: "La Fiat 132 è una berlina tre volumi 4 porte con motore anteriore longitudinale e trazione posteriore prodotta dalla FIAT a partire dal 1972, che ha sostituito il modello "125" nella gamma aziendale."
    a. And I could stop them when I see a comma.
2. We could remove relative clauses and/or adjuncts. So this sentence starts with an adjunct "With the Colts".
    a. **With the Colts, Parker soon became the best blocker for quarterback Johnny Unitas**
    b. We could A) not use it (but we'll be left with very few sentences), B) use it as is (may complecate reading) or C) remove the adjunct (may chance prototypically, but perhaps that's not a big deal).
3. Should I always try to get sentences with different words? If I choose sentences from cardinal without the word cardinal, the semantic space changes quite a bit.
4. Sentences with proper nouns are easy to understand:
    a. xi draconis is a star of the constellation of the dragon **vs.** it is a star located in the southern celestial hemisphere
    b. Any thoughts on preferring sentences without proper nouns?
5. Look at 4. RSA. (both 4.1. and 4.2). Is there any reason to choose pool layers over conv layers from how they cluster?
6. 4.2. may give us a hint as to how many sentences we want per category in order to obtain a good clustering between categories: if you use 5 sentences, 1 or 2 may cluster more with another category, so 3 may be too little. I wouldn't go with non-prototypical because these will be all over the place semantically. See below:

8-14 words per sentence
120 miliseconds per word: 960-1680 ms per sentence, mean: 1320 ms (although there are more sentence with 14 than 8 so, this will be higher. To reach 6 seconds, we have: 4680 seconds. I think we may need 150 ms per word.
So:
1. stimulus presentation - 960 to 1680 ms.
2. Variable fixation cross (4680 +- 240 = 4440-4920 msec)
3. Experimental runs start and stop with 8-10 seconds of fixation cross.
4. Divide into 4 or so runs (+ start and stop the scanner and the script)

70 categories***3 sentences** = 210 sentences
210 sentences * 6 seconds = 1260/60. = 21 minutes. + pauses between runs.

**6 sentences** = 420 sentences = 42 minutes+ pauses between runs.