Semantic Categories to Attributes

What do we mean by “Semantics?”

For Our Purposes:




Instances

furry
carnivorous
friendly
...

Semantic Attributes (PCA Components?)

dog
rabbit
snake
shark
...

Class Labels

Why Use Semantics?

Because it may be Easier.

Some Parts are Easier to Identify

The attributes “furry” “has eyes” and “sharp teeth” may be easier to recover than “dog” “snake” and “shark.”

Because it’s More Powerful.

A Richer Understanding of Objects

We can generate class labels as before

Aeroplane

A Richer Understanding of Objects

We can describe objects even if we don't understand them

Unknown
Has Wheel
Has Wood

A Richer Understanding of Objects

We can highlight differences from our expectations

Unusual attributes

Bird
No Head
No Beak

A Rich Understanding of Objects

We can describe the presence of unexpected attributes

A Richer Understanding of Objects

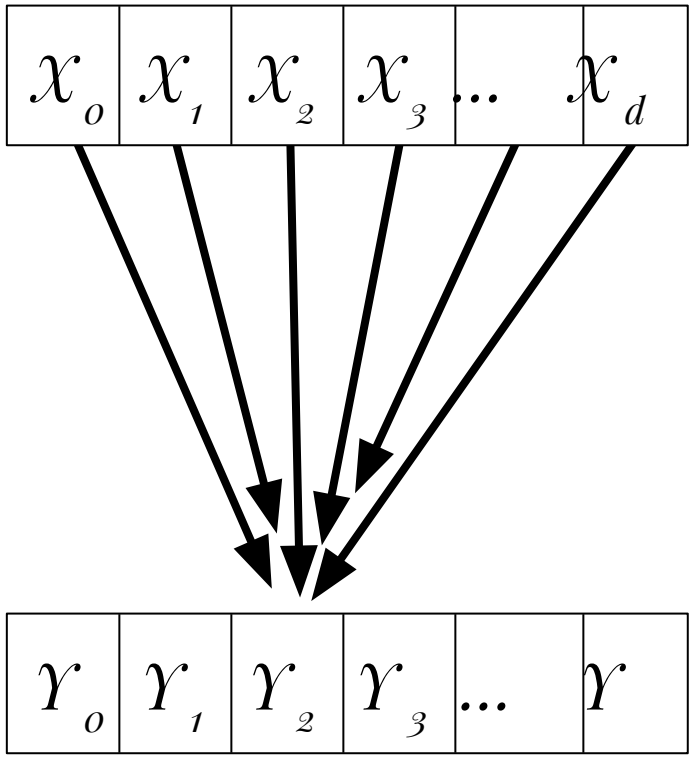
We can recognize objects that have only been described to us

Has Horn
Has leg
Has Head
Has Wool

Because that's how Brains Work.

(More on this Later.)

Single Classifier:

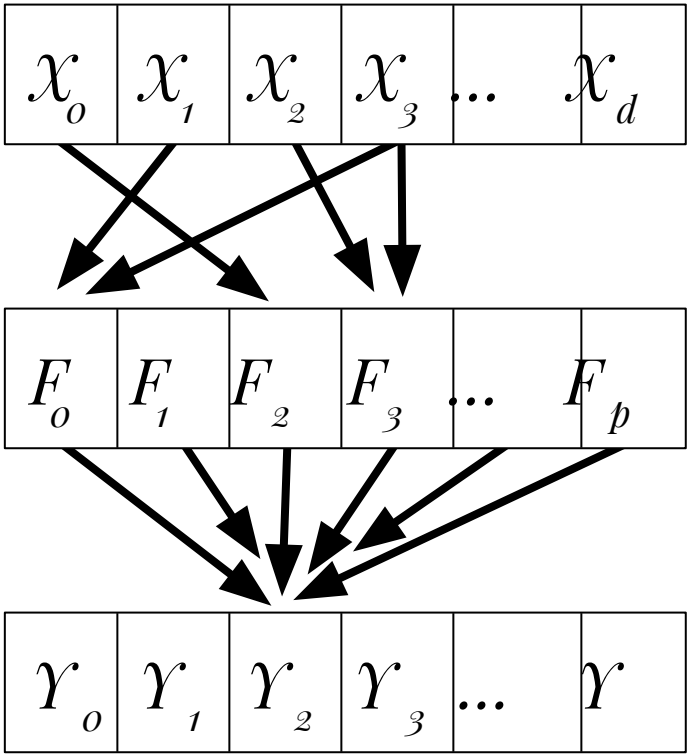


Raw Input

Single Classifier

Class Label

Semantic Classifier:



Raw Input

First Stage

Semantic Feature Space

Second Stage

Class Label

Knowledge Base:

		Y_0 dog	Y_1 snake	Y_2 rabbit	Y_3 shark	
F_0	*furry?*	1	0	1	0	
F_1	*has a tail?*	1	1	1	1	
F_2	*breathe underwater?*	0	0	0	1	...
F_3	*carnivorous?*	1	1	0	1	
F_4	*slow-moving?*	0	0	0	0	

Training Data:




dog




rabbit




snake




shark

Training:




1	furry
1	tail
0	underwater
1	carnivore
0	slow




1	furry
1	tail
0	underwater
0	carnivore
0	slow




0	furry
1	tail
0	underwater
1	carnivore
0	slow




0	furry
1	tail
1	underwater
1	carnivore
0	slow

Dogs:

F_0	*furry?*	1
F_1	*has a tail?*	1
F_2	*breathe underwater?*	0
F_3	*carnivorous?*	1
F_4	*slow-moving?*	0

dog

Dogs:

F_0	*furry?*	1
F_1	*has a tail?*	1
F_2	*breathe underwater?*	0
F_3	*carnivorous?*	1
F_4	*slow-moving?*	0

dog

Dogs:

F_0	*furry?*	1
F_1	*has a tail?*	1
F_2	*breathe underwater?*	0
F_3	*carnivorous?*	1
F_4	*slow-moving?*	0

dog

Dogs:

F_0	*furry?*	1
F_1	*has a tail?*	1
F_2	*breathe underwater?*	0
F_3	*carnivorous?*	1
F_4	*slow-moving?*	0

dog

Non-Dogs:

F_0	*furry?*	0
F_1	*has a tail?*	1
F_2	*breathe underwater?*	0
F_3	*carnivorous?*	1
F_4	*slow-moving?*	0

snake
(not furry)

Non-Dogs:

F_0	*furry?*	1
F_1	*has a tail?*	1
F_2	*breathe underwater?*	0
F_3	*carnivorous?*	0
F_4	*slow-moving?*	0

rabbit
(clearly vegetarian)

Non-Dogs:

F_0	*furry?*	1
F_1	*has a tail?*	1
F_2	*breathe underwater?*	1
F_3	*carnivorous?*	1
F_4	*slow-moving?*	0

ambiguous
(furry shark? aquatic dog?)

How can we fix this?

Add Features to Disambiguate

F_5	*Red*
F_6	*Bushy Tail*

→ *fox* Y_5

F_7	*Long Whiskers*
F_8	*Grumpy*

→ *cat* Y_6

Oh No! (Good Features are Hard)

F_5 *Red*

F_6 *Bushy Tail*

→ *fox* Y_5

F_7 *Long Whiskers*

F_8 *Grumpy*

→ *cat* Y_6

A Further Problem:

male russet sparrow

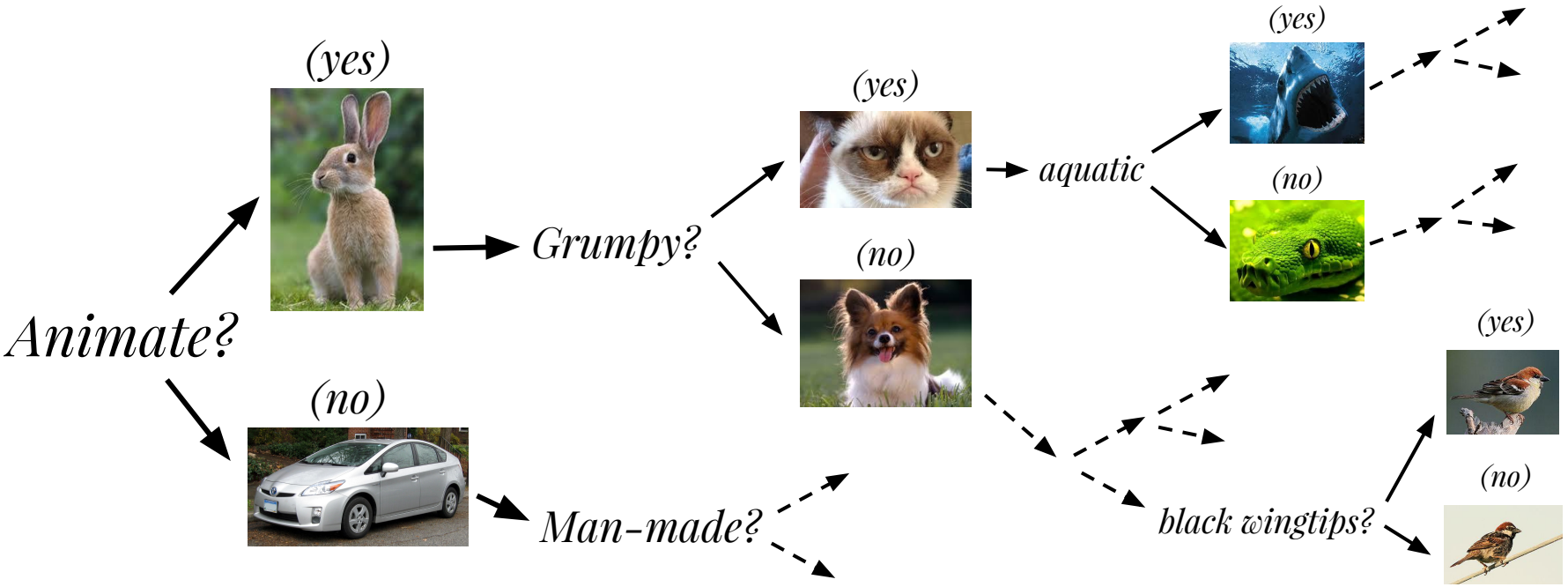
male spanish sparrow

Will the features we use to disambiguate these be useful for anything else?

Are Features Universally Applicable?

Carnivorous? Friendly? What color are its feathers?

Does this motivate a hierarchy?



Thoughts or Questions?

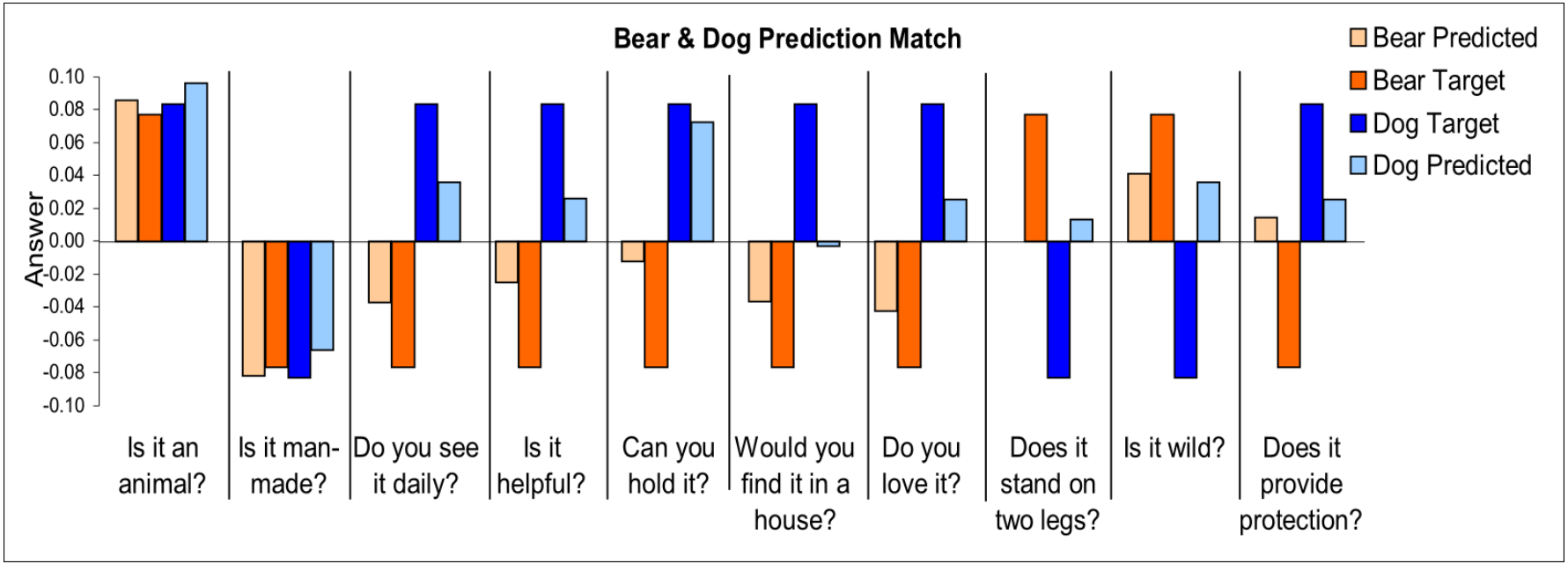
Results in Neural Decoding:

Training Data:
fMRI scans of 9 Human Subjects
    Shown a word from a corpus of 60 and a line drawing
    Instructed to think about the object's properties.

Knowledge Base:
corpus5000:
    5000 words that most often co-occurs with a word
human218:
    Mechanical Turk rated nouns based on 218 properties

Results in Neural Decoding:

Remove two words and train the attribute classifier on the rest. Can we distinguish between the held-out words?



Results in Neural Decoding:

Remove one word and train the attribute classifier on the rest. At test time, what word is predicted using the knowledge base?

Bear (1)	Foot (1)	Screwdriver (1)	Train (1)	Truck (2)	Celery (5)	House (6)	Pants (21)
bear	foot	screwdriver	train	jeep	beet	supermarket	clothing
fox	feet	pin	jet	truck	artichoke	hotel	vest
wolf	ankle	nail	jail	minivan	grape	theater	t-shirt
yak	knee	wrench	factory	bus	cabbage	school	clothes
gorilla	face	dagger	bus	sedan	celery	factory	panties

Results in Computer Vision:

Attributes:

- Color and Texture (To Describe Material)
- Visual Words (Parts of Objects)
- Edges (Shape)
- Add Discriminative Features Designed to Learn
  - Differences Between Subtle Categories

Data Set:

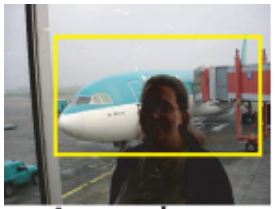
- Hand-Labelled Attributes on Pascal VOC-2008 Images

Results in Computer Vision:

Identify Attributes

Results in Computer Vision:

Report Missing Attributes



Aeroplane
No “wing”

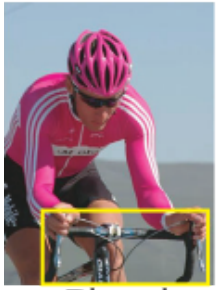
Car
No “window”

Boat
No “sail”

Aeroplane
No “jet engine”

Motorbike
No “side mirror”

Car
No “door”

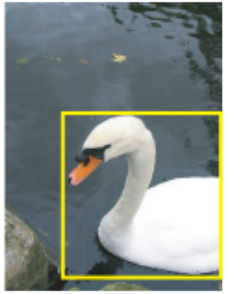


Bicycle
No “wheel”

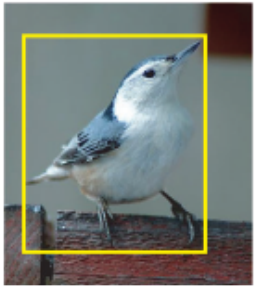
Sheep
No “wool”

Train
No “window”

Sofa
No “wood”



Bird
No “tail”



Bird
No “leg”

Bus
No “door”

Results in Computer Vision:

Report Unexpected Attributes

Bird
"Leaf"

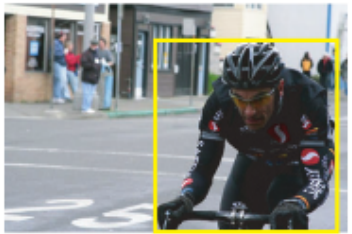
Bus
"face"

Motorbike
"cloth"

DiningTable
"skin"

People
"Furn. back"

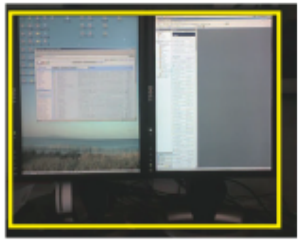
Aeroplane
"beak"



People
"label"

Sofa
"wheel"

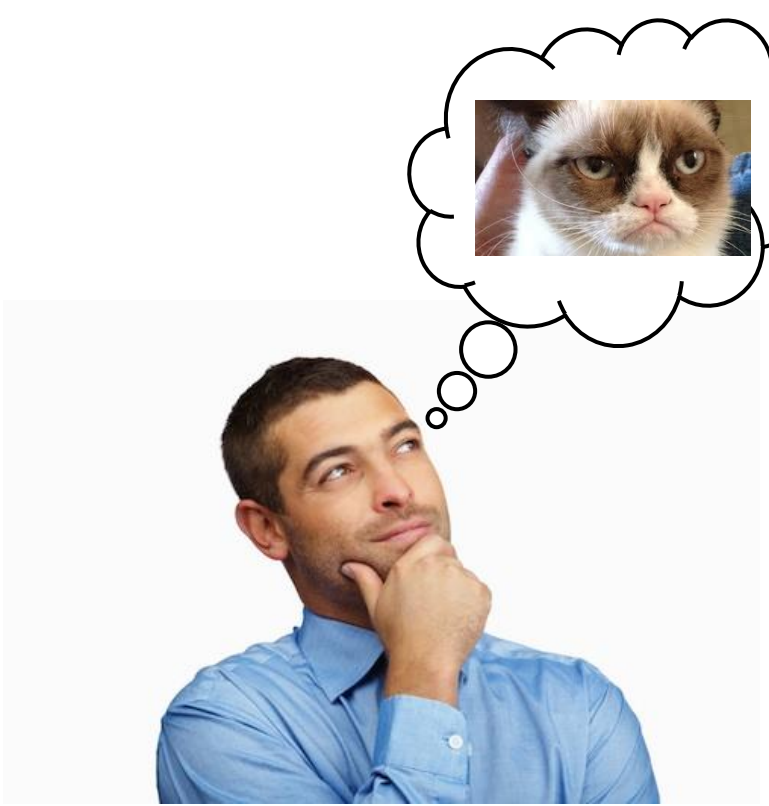
Bike
"Horn"



Monitor
window"

Thoughts or Questions?

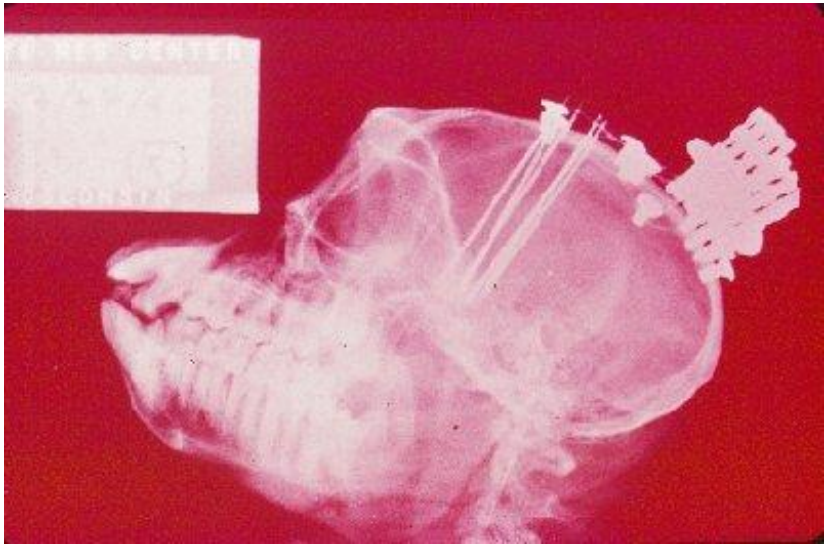
Is this how Brains Work?



How Similar are Different Species?

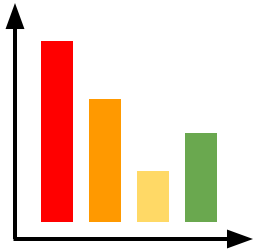
fMRI (human)

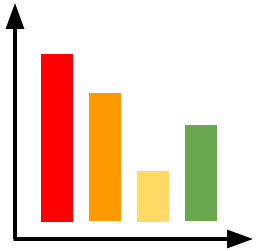
brain electrodes (monkey)



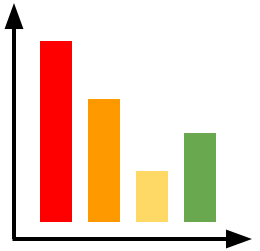
how can we possibly compare this data?

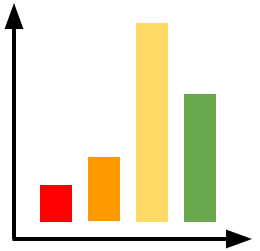
Compare Categories in Same Subject





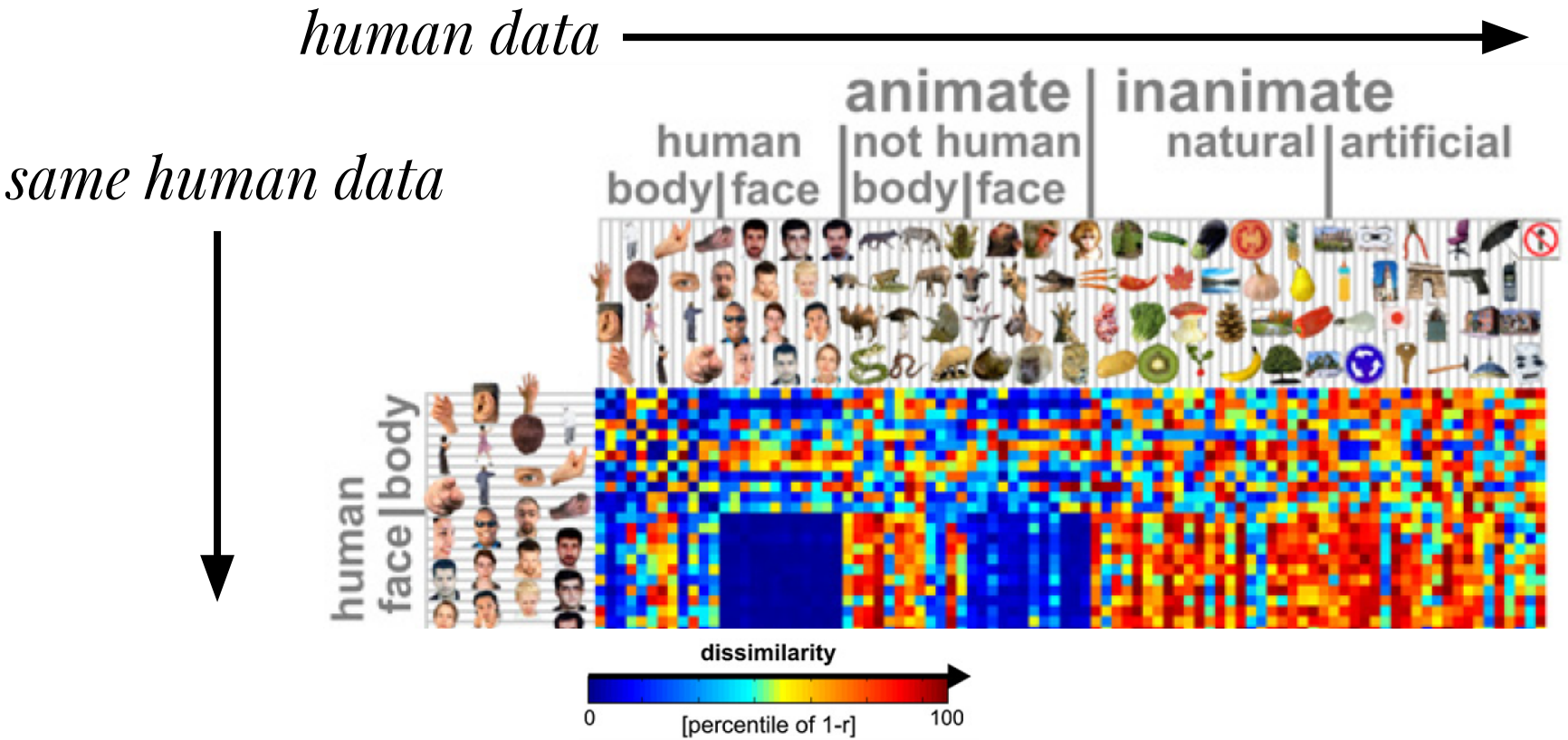
similar response



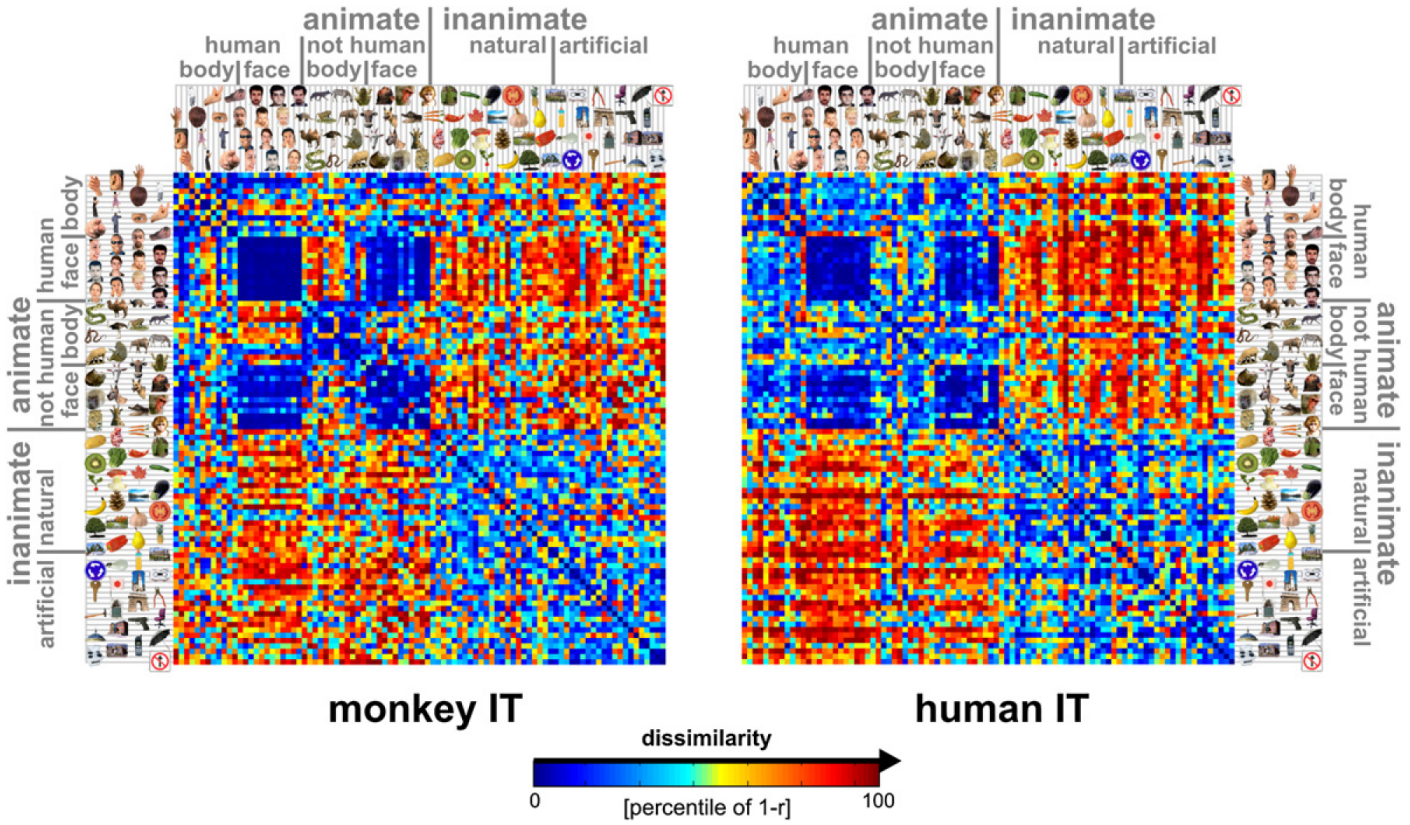


different response

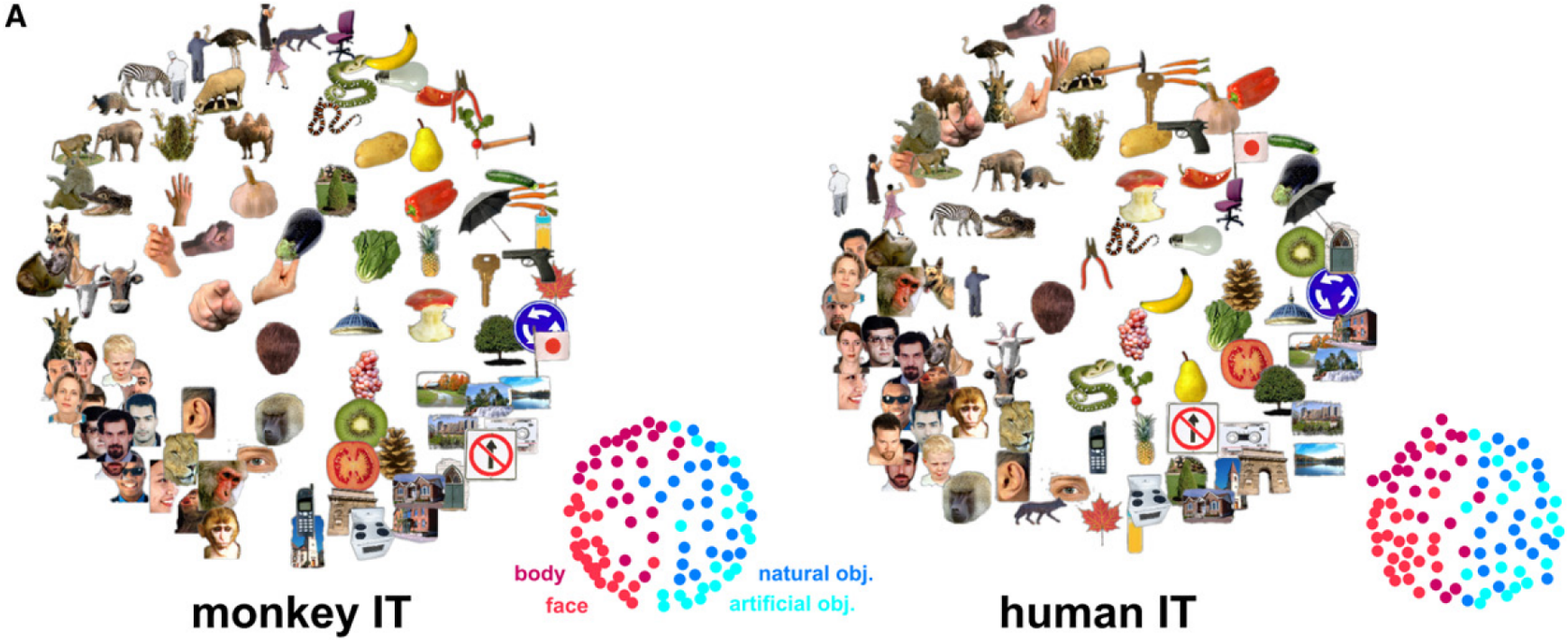
Representational Dissimilarity Matrix



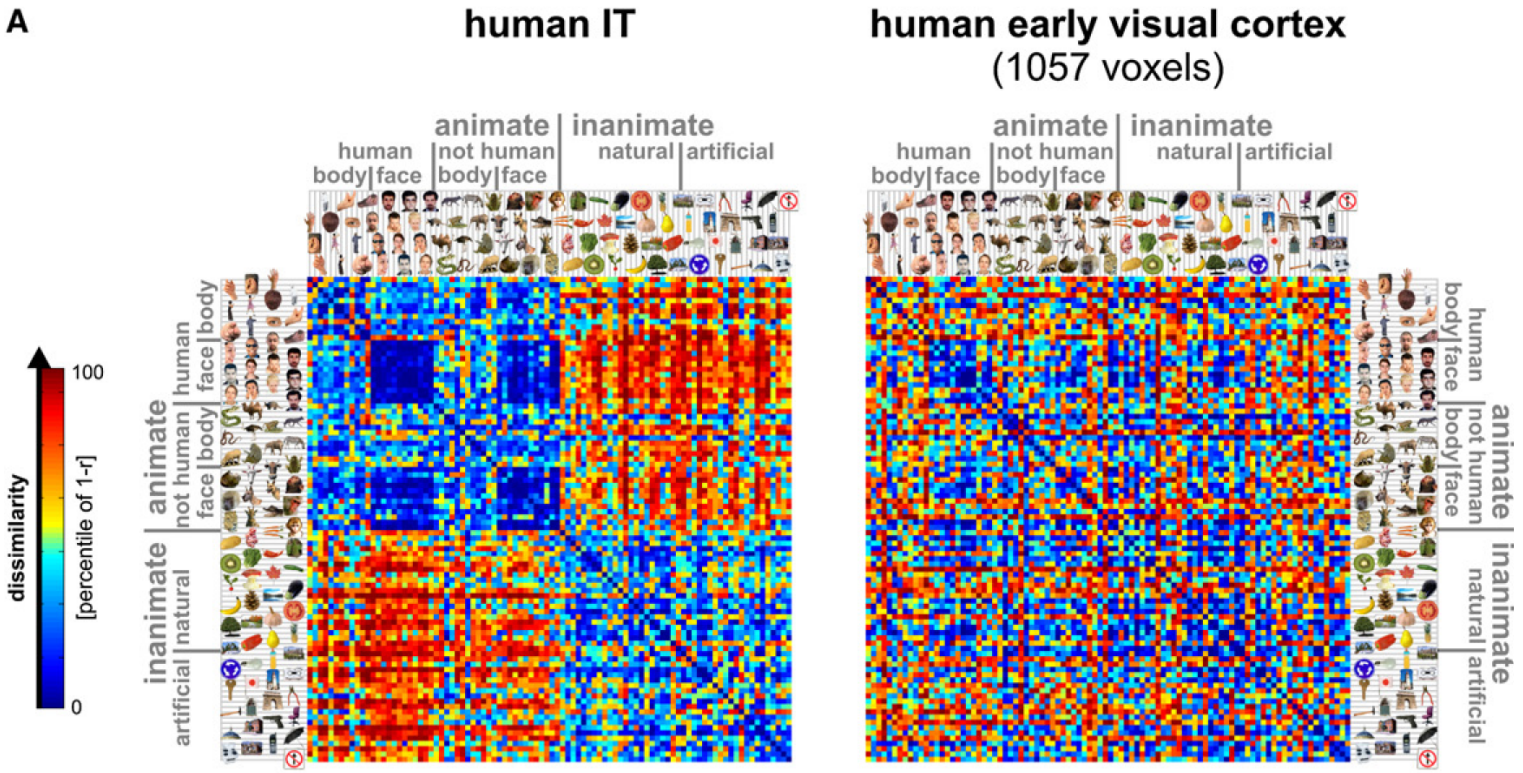
Representational Dissimilarity Matrix



Clustering Based on Similarity



Visual Appearance or Something Else?



Thoughts or Questions?