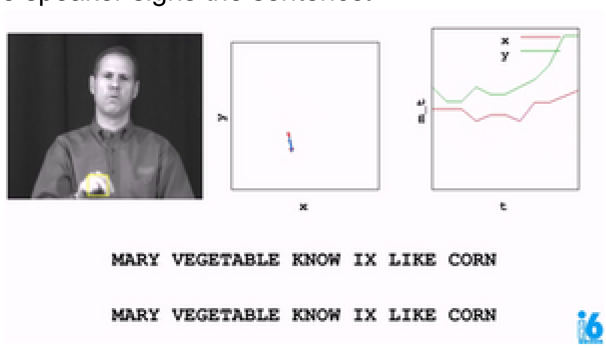
Artificial Intelligence Engineer Nanodegree - Probabilistic Models

Project: Sign Language Recognition System

Introduction

The overall goal of this project is to build a word recognizer for American Sign Language video sequences, demonstrating the power of probabalistic models. In particular, this project employs hidden Markov models (HMM's) (https://en.wikipedia.org/wiki/Hidden_Markov_model) to analyze a series of measurements taken from videos of American Sign Language (ASL) collected for research (see the RWTH-BOSTON-104 Database (http://www-i6.informatik.rwth-aachen.de/~dreuw/database-rwth-boston-104.php)). In this video, the right-hand x and y locations are plotted as the speaker signs the sentence.



(https://drive.google.com/open?id=0B_5qGuFe-wbhUXRuVnNZVnMtam8)

The raw data, train, and test sets are pre-defined. You will derive a variety of feature sets (explored in Part 1), as well as implement three different model selection criterion to determine the optimal number of hidden states for each word model (explored in Part 2). Finally, in Part 3 you will implement the recognizer and compare the effects the different combinations of feature sets and model selection criteria.

At the end of each Part, complete the submission cells with implementations, answer all questions, and pass the unit tests. Then submit the completed notebook for review!

PART 1: Data

Features Tutorial

Load the initial database

A data handler designed for this database is provided in the student codebase as the `AslDb` class in the `asl_data` module. This handler creates the initial pandas (http://pandas.pydata.org/pandas-docs/stable/) dataframe from the corpus of data included in the `data` directory as well as dictionaries suitable for extracting data in a format friendly to the hmmlearn (https://hmmlearn.readthedocs.io/en/latest/) library. We'll use those to create models in Part 2.

To start, let's set up the initial database and select an example set of features for the training set. At the end of Part 1, you will create additional feature sets for experimentation.

In [1]:
```
import numpy as np
import pandas as pd
from asl_data import AslDb






asl = AslDb() # initializes the database
asl.df.head() # displays the first five rows of the asl database, indexed by v
ideo and frame
```

Out[1]:

		left-x	left-y	right-x	right-y	nose-x	nose-y	speaker
video	**frame**							
98	**0**	149	181	170	175	161	62	woman-1
	1	149	181	170	175	161	62	woman-1
	2	149	181	170	175	161	62	woman-1
	3	149	181	170	175	161	62	woman-1
	4	149	181	170	175	161	62	woman-1

In [2]:
```
asl.df.ix[98,1]  # look at the data available for an individual frame
```

Out[2]:
```
left-x         149
left-y         181
right-x        170
right-y        175
nose-x         161
nose-y          62
speaker    woman-1
Name: (98, 1), dtype: object
```

The frame represented by video 98, frame 1 is shown here:

Feature selection for training the model

The objective of feature selection when training a model is to choose the most relevant variables while keeping the model as simple as possible, thus reducing training time. We can use the raw features already provided or derive our own and add columns to the pandas dataframe `asl.df` for selection. As an example, in the next cell a feature named `'grnd-ry'` is added. This feature is the difference between the right-hand y value and the nose y value, which serves as the "ground" right y value.

In [3]:

```
asl.df['grnd-ry'] = asl.df['right-y'] - asl.df['nose-y']
asl.df.head()  # the new feature 'grnd-ry' is now in the frames dictionary
```

Out[3]:

		left-x	left-y	right-x	right-y	nose-x	nose-y	speaker	grnd-ry
video	frame								
98	0	149	181	170	175	161	62	woman-1	113
	1	149	181	170	175	161	62	woman-1	113
	2	149	181	170	175	161	62	woman-1	113
	3	149	181	170	175	161	62	woman-1	113
	4	149	181	170	175	161	62	woman-1	113

Try it!

In [4]:
```
from asl_utils import test_features_tryit
# TODO add df columns for 'grnd-rx', 'grnd-ly', 'grnd-lx' representing differe
nces between hand and nose locations
asl.df['grnd-rx']=asl.df['right-x'] - asl.df['nose-x']
asl.df['grnd-ly']=asl.df['left-y'] - asl.df['nose-y']
asl.df['grnd-lx']=asl.df['left-x'] - asl.df['nose-x']
# test the code
test_features_tryit(asl)
```

asl.df sample

		left-x	left-y	right-x	right-y	nose-x	nose-y	speaker	grnd-ry	grnd-rx	grnd-ly	grnd-lx
video	**frame**											
98	**0**	149	181	170	175	161	62	woman-1	113	9	119	-12
	1	149	181	170	175	161	62	woman-1	113	9	119	-12
	2	149	181	170	175	161	62	woman-1	113	9	119	-12
	3	149	181	170	175	161	62	woman-1	113	9	119	-12
	4	149	181	170	175	161	62	woman-1	113	9	119	-12

Out[4]: Correct!

In [5]:
```
# collect the features into a list
features_ground = ['grnd-rx','grnd-ry','grnd-lx','grnd-ly']
 #show a single set of features for a given (video, frame) tuple
[asl.df.ix[98,1][v] for v in features_ground]
```

Out[5]: [9, 113, -12, 119]

Build the training set

Now that we have a feature list defined, we can pass that list to the `build_training` method to collect the features for all the words in the training set. Each word in the training set has multiple examples from various videos. Below we can see the unique words that have been loaded into the training set:

In [6]:
```
training = asl.build_training(features_ground)
print("Training words: {}".format(training.words))
```

```
Training words: ['JOHN', 'WRITE', 'HOMEWORK', 'IX-1P', 'SEE', 'YESTERDAY', 'I
X', 'LOVE', 'MARY', 'CAN', 'GO', 'GO1', 'FUTURE', 'GO2', 'PARTY', 'FUTURE1',
 'HIT', 'BLAME', 'FRED', 'FISH', 'WONT', 'EAT', 'BUT', 'CHICKEN', 'VEGETABL
E', 'CHINA', 'PEOPLE', 'PREFER', 'BROCCOLI', 'LIKE', 'LEAVE', 'SAY', 'BUY',
 'HOUSE', 'KNOW', 'CORN', 'CORN1', 'THINK', 'NOT', 'PAST', 'LIVE', 'CHICAGO',
'CAR', 'SHOULD', 'DECIDE', 'VISIT', 'MOVIE', 'WANT', 'SELL', 'TOMORROW', 'NEX
T-WEEK', 'NEW-YORK', 'LAST-WEEK', 'WILL', 'FINISH', 'ANN', 'READ', 'BOOK', 'C
HOCOLATE', 'FIND', 'SOMETHING-ONE', 'POSS', 'BROTHER', 'ARRIVE', 'HERE', 'GIV
E', 'MAN', 'NEW', 'COAT', 'WOMAN', 'GIVE1', 'HAVE', 'FRANK', 'BREAK-DOWN', 'S
EARCH-FOR', 'WHO', 'WHAT', 'LEG', 'FRIEND', 'CANDY', 'BLUE', 'SUE', 'BUY1',
 'STOLEN', 'OLD', 'STUDENT', 'VIDEOTAPE', 'BORROW', 'MOTHER', 'POTATO', 'TEL
L', 'BILL', 'THROW', 'APPLE', 'NAME', 'SHOOT', 'SAY-1P', 'SELF', 'GROUP', 'JA
NA', 'TOY1', 'MANY', 'TOY', 'ALL', 'BOY', 'TEACHER', 'GIRL', 'BOX', 'GIVE2',
 'GIVE3', 'GET', 'PUTASIDE']
```

The training data in `training` is an object of class `WordsData` defined in the `asl_data` module. in addition to the `words` list, data can be accessed with the `get_all_sequences`, `get_all_Xlengths`, `get_word_sequences`, and `get_word_Xlengths` methods. We need the `get_word_Xlengths` method to train multiple sequences with the `hmmlearn` library. In the following example, notice that there are two lists; the first is a concatenation of all the sequences(the X portion) and the second is a list of the sequence lengths(the Lengths portion).

In [7]:
```
training.get_word_Xlengths('CHOCOLATE')
```

Out[7]:
```
(array([[-11,  48,   7, 120],
        [-11,  48,   8, 109],
        [ -8,  49,  11,  98],
        [ -7,  50,   7,  87],
        [ -4,  54,   7,  77],
        [ -4,  54,   6,  69],
        [ -4,  54,   6,  69],
        [-13,  52,   6,  69],
        [-13,  52,   6,  69],
        [ -8,  51,   6,  69],
        [ -8,  51,   6,  69],
        [ -8,  51,   6,  69],
        [ -8,  51,   6,  69],
        [ -8,  51,   6,  69],
        [-10,  59,   7,  71],
        [-15,  64,   9,  77],
        [-17,  75,  13,  81],
        [ -4,  48,  -4, 113],
        [ -2,  53,  -4, 113],
        [ -4,  55,   2,  98],
        [ -4,  58,   2,  98],
        [ -1,  59,   2,  89],
        [ -1,  59,  -1,  84],
        [ -1,  59,  -1,  84],
        [ -7,  63,  -1,  84],
        [ -7,  63,  -1,  84],
        [ -7,  63,   3,  83],
        [ -7,  63,   3,  83],
        [ -7,  63,   3,  83],
        [ -7,  63,   3,  83],
        [ -7,  63,   3,  83],
        [ -7,  63,   3,  83],
        [ -7,  63,   3,  83],
        [ -4,  70,   3,  83],
        [ -4,  70,   3,  83],
        [ -2,  73,   5,  90],
        [ -3,  79,  -4,  96],
        [-15,  98,  13, 135],
        [ -6,  93,  12, 128],
        [ -2,  89,  14, 118],
        [  5,  90,  10, 108],
        [  4,  86,   7, 105],
        [  4,  86,   7, 105],
        [  4,  86,  13, 100],
        [ -3,  82,  14,  96],
        [ -3,  82,  14,  96],
        [  6,  89,  16, 100],
        [  6,  89,  16, 100],
        [  7,  85,  17, 111]], dtype=int64), [17, 20, 12])
```

More feature sets

So far we have a simple feature set that is enough to get started modeling. However, we might get better results if we manipulate the raw values a bit more, so we will go ahead and set up some other options now for experimentation later. For example, we could normalize each speaker's range of motion with grouped statistics using Pandas stats (http://pandas.pydata.org/pandas-docs/stable/api.html#api-dataframe-stats) functions and pandas groupby (http://pandas.pydata.org/pandas-docs/stable/generated/pandas.DataFrame.groupby.html). Below is an example for finding the means of all speaker subgroups.

In [8]:
```
df_means = asl.df.groupby('speaker').mean()
df_means
```

Out[8]:

	left-x	left-y	right-x	right-y	nose-x	nose-y	grnd-ry
speaker							
man-1	206.248203	218.679449	155.464350	150.371031	175.031756	61.642600	88.7284
woman-1	164.661438	161.271242	151.017865	117.332462	162.655120	57.245098	60.0873
woman-2	183.214509	176.527232	156.866295	119.835714	170.318973	58.022098	61.8136

To select a mean that matches by speaker, use the pandas map (http://pandas.pydata.org/pandas-docs/stable/generated/pandas.Series.map.html) method:

In [9]:
```
asl.df['left-x-mean']= asl.df['speaker'].map(df_means['left-x'])
asl.df.head()
```

Out[9]:

		left-x	left-y	right-x	right-y	nose-x	nose-y	speaker	grnd-ry	grnd-rx	grnd-ly	grnd-lx	le m
video	**frame**												
98	**0**	149	181	170	175	161	62	woman-1	113	9	119	-12	1(
	1	149	181	170	175	161	62	woman-1	113	9	119	-12	1(
	2	149	181	170	175	161	62	woman-1	113	9	119	-12	1(
	3	149	181	170	175	161	62	woman-1	113	9	119	-12	1(
	4	149	181	170	175	161	62	woman-1	113	9	119	-12	1(

Try it!

In [10]:
```
from asl_utils import test_std_tryit
# TODO Create a dataframe named `df_std` with standard deviations grouped by s
peaker
df_std = asl.df.groupby('speaker').std()
#asl.df['df_std']= asl.df['speaker'].map(df_std['left-x'])

# test the code
test_std_tryit(df_std)
```

df_std

	left-x	left-y	right-x	right-y	nose-x	nose-y	grnd-ry	grn
speaker								
man-1	15.154425	36.328485	18.901917	54.902340	6.654573	5.520045	53.487999	20.:
woman-1	17.573442	26.594521	16.459943	34.667787	3.549392	3.538330	33.972660	16.:
woman-2	15.388711	28.825025	14.890288	39.649111	4.099760	3.416167	39.128572	16.:

Out[10]: Correct!

Features Implementation Submission

Implement four feature sets and answer the question that follows.

- normalized Cartesian coordinates
  - use *mean* and *standard deviation* statistics and the standard score (https://en.wikipedia.org/wiki/Standard_score) equation to account for speakers with different heights and arm length
- polar coordinates
  - calculate polar coordinates with Cartesian to polar equations (https://en.wikipedia.org/wiki/Polar_coordinate_system#Converting_between_polar_and_Cartesian_coorc
  - use the np.arctan2 (https://docs.scipy.org/doc/numpy-1.10.0/reference/generated/numpy.arctan2.html) function and *swap the x and y axes* to move the 0 to 2π discontinuity to 12 o'clock instead of 3 o'clock; in other words, the normal break in radians value from 0 to 2π occurs directly to the left of the speaker's nose, which may be in the signing area and interfere with results. By swapping the x and y axes, that discontinuity move to directly above the speaker's head, an area not generally used in signing.
- delta difference
  - as described in Thad's lecture, use the difference in values between one frame and the next frames as features
  - pandas diff method (http://pandas.pydata.org/pandas-docs/stable/generated/pandas.DataFrame.diff.html) and fillna method (http://pandas.pydata.org/pandas-docs/stable/generated/pandas.DataFrame.fillna.html) will be helpful for this one
- custom features
  - These are your own design; combine techniques used above or come up with something else entirely. We look forward to seeing what you come up with! Some ideas to get you started:
    - normalize using a feature scaling equation (https://en.wikipedia.org/wiki/Feature_scaling)
    - normalize the polar coordinates
    - adding additional deltas

In [11]:
```
# TODO add features for normalized by speaker values of left, right, x, y
# Name these 'norm-rx', 'norm-ry', 'norm-lx', and 'norm-ly'
# using Z-score scaling (X-Xmean)/Xstd

#asl.df['left-x-mean']= asl.df['speaker'].map(df_means['left-x']) # already do
ne above
asl.df['left-x-std']= asl.df['speaker'].map(df_std['left-x'])
asl.df['norm-lx']= (asl.df['left-x'] - asl.df['left-x-mean']) / asl.df['left-x
-std']

asl.df['left-y-mean']= asl.df['speaker'].map(df_means['left-y'])
asl.df['left-y-std']= asl.df['speaker'].map(df_std['left-y'])
asl.df['norm-ly']= (asl.df['left-y'] - asl.df['left-y-mean']) / asl.df['left-y
-std']

asl.df['right-x-mean']= asl.df['speaker'].map(df_means['right-x'])
asl.df['right-x-std']= asl.df['speaker'].map(df_std['right-x'])
asl.df['norm-rx']= (asl.df['right-x'] - asl.df['right-x-mean']) / asl.df['righ
t-x-std']

asl.df['right-y-mean']= asl.df['speaker'].map(df_means['right-y'])
asl.df['right-y-std']= asl.df['speaker'].map(df_std['right-y'])
asl.df['norm-ry']= (asl.df['right-y'] - asl.df['right-y-mean']) / asl.df['righ
t-y-std']

features_norm = ['norm-rx', 'norm-ry', 'norm-lx','norm-ly']
```

In [12]:
```
# TODO add features for polar coordinate values where the nose is the origin
# Name these 'polar-rr', 'polar-rtheta', 'polar-lr', and 'polar-ltheta'
# Note that 'polar-rr' and 'polar-rtheta' refer to the radius and angle

asl.df['polar-rr']=  np.sqrt(asl.df['grnd-rx']**2 + asl.df['grnd-ry']**2)
asl.df['polar-rtheta']=np.arctan2(asl.df['grnd-rx'],asl.df['grnd-ry'])

asl.df['polar-lr']=  np.sqrt(asl.df['grnd-lx']**2 + asl.df['grnd-ly']**2)
asl.df['polar-ltheta']=np.arctan2(asl.df['grnd-lx'],asl.df['grnd-ly'])


features_polar = ['polar-rr', 'polar-rtheta', 'polar-lr', 'polar-ltheta']
```

In [13]:
```
# TODO add features for left, right, x, y differences by one time step, i.e. t
he "delta" values discussed in the lecture
# Name these 'delta-rx', 'delta-ry', 'delta-lx', and 'delta-ly'

asl.df['delta-rx']=asl.df['right-x'].diff().fillna(value=0)
asl.df['delta-ry']=asl.df['right-y'].diff().fillna(value=0)
asl.df['delta-lx']=asl.df['left-x'].diff().fillna(value=0)
asl.df['delta-ly']=asl.df['left-y'].diff().fillna(value=0)

features_delta = ['delta-rx', 'delta-ry', 'delta-lx', 'delta-ly']
```

In [14]:

```
# TODO add features of your own design, which may be a combination of the abov
e or something else
# Name these whatever you would like

# TODO define a list named 'features_custom' for building the training set

#distance from left to right hand, uses the normalized values
asl.df['dist-norm-left-right']=np.sqrt((asl.df['norm-rx'] - asl.df['norm-
lx'])**2+(asl.df['norm-ry'] - asl.df['norm-ly'])**2)
#change in dist from left to right hand
asl.df['delta-dist-norm-left-right']=asl.df['dist-norm-left-right'].diff().fil
lna(value=0)

features_hand_dist=['dist-norm-left-right','delta-dist-norm-left-right']

#deltas of the normalized hand positions
asl.df['delta-norm-rx'] = asl.df['norm-rx'].diff().fillna(value=0)
asl.df['delta-norm-ry'] = asl.df['norm-ry'].diff().fillna(value=0)
asl.df['delta-norm-lx'] = asl.df['norm-lx'].diff().fillna(value=0)
asl.df['delta-norm-ly'] = asl.df['norm-ly'].diff().fillna(value=0)

features_delta_norm_hand_pos=['delta-norm-rx', 'delta-norm-ry', 'delta-norm-l
x', 'delta-norm-ly']

#normalized polar coords:
asl.df['norm-polar-rr'] = (asl.df['polar-rr'] - min(asl.df['polar-
rr']))/(max(asl.df['polar-rr'])-min(asl.df['polar-rr']))
asl.df['norm-rtheta'] = (asl.df['polar-rtheta'] - min(asl.df['polar-
rtheta']))/(max(asl.df['polar-rtheta'])-min(asl.df['polar-rtheta']))
asl.df['norm-polar-lr'] = (asl.df['polar-lr'] - min(asl.df['polar-
lr']))/(max(asl.df['polar-lr'])-min(asl.df['polar-lr']))
asl.df['norm-polar-ltheta'] = (asl.df['polar-ltheta'] - min(asl.df['polar-lthe
ta']))/(max(asl.df['polar-ltheta'])-min(asl.df['polar-rr']))

#delta of norm polar coords:
asl.df['delta-norm-polar-rr'] = asl.df['norm-polar-rr'].diff().fillna(value=0)
asl.df['delta-norm-rtheta'] = asl.df['norm-rtheta'].diff().fillna(value=0)
asl.df['delta-norm-polar-lr'] = asl.df['norm-polar-lr'].diff().fillna(value=0)
asl.df['delta-norm-polar-ltheta'] = asl.df['norm-polar-
ltheta'].diff().fillna(value=0)

features_norm_polar_coords=['norm-polar-rr','norm-rtheta','norm-polar-lr','nor
m-polar-ltheta','delta-norm-polar-rr','delta-norm-rtheta','delta-norm-polar-l
r','delta-norm-polar-ltheta']

features_custom=features_hand_dist+features_delta_norm_hand_pos+features_norm_
polar_coords
asl.df.tail()
```

Out[14]:

		left-x	left-y	right-x	right-y	nose-x	nose-y	speaker	grnd-ry	grnd-rx	grnd-ly	...	delta norm lx
video	frame												
125	52	148	181	171	156	162	60	woman-1	96	9	121	...	0.0
	53	148	181	172	165	162	60	woman-1	105	10	121	...	0.0
	54	148	181	175	173	162	60	woman-1	113	13	121	...	0.0
	55	148	181	175	173	162	60	woman-1	113	13	121	...	0.0
	56	148	181	175	173	162	60	woman-1	113	13	121	...	0.0

5 rows × 45 columns

In [15]:

```
#list of the features
features_ground
features_norm
features_polar
features_delta
features_custom=features_hand_dist+features_delta_norm_hand_pos+features_norm_
polar_coords
features_best=features_norm+features_custom
```

Question 1: What custom features did you choose for the features_custom set and why?

1. Normalized distance from right to left hand and the delta of normalized distance between hands. The distance between hands may be an indicator, and the normalized value is preferred to assist in eliminating differences between speakers. in addition the speed/direction of moving together or apart may be an indicator.
2. Delta of the normalized hand position. The change in position should be based on normalized positions
3. Normalized Polar co-ordinates, again, to assist w/speaker independance
4. The related delta of the normalized Polar coords, as change in position may be helpful

Features Unit Testing

Run the following unit tests as a sanity check on the defined "ground", "norm", "polar", and 'delta" feature sets. The test simply looks for some valid values but is not exhaustive. However, the project should not be submitted if these tests don't pass.

In [16]:
```
import unittest
# import numpy as np

class TestFeatures(unittest.TestCase):

    def test_features_ground(self):
        sample = (asl.df.ix[98, 1][features_ground]).tolist()
        self.assertEqual(sample, [9, 113, -12, 119])

    def test_features_norm(self):
        sample = (asl.df.ix[98, 1][features_norm]).tolist()
        np.testing.assert_almost_equal(sample, [ 1.153,  1.663, -0.891,
0.742], 3)

    def test_features_polar(self):
        sample = (asl.df.ix[98,1][features_polar]).tolist()
        np.testing.assert_almost_equal(sample, [113.3578, 0.0794, 119.603, -0.
1005], 3)

    def test_features_delta(self):
        sample = (asl.df.ix[98, 0][features_delta]).tolist()
        self.assertEqual(sample, [0, 0, 0, 0])
        sample = (asl.df.ix[98, 18][features_delta]).tolist()
        self.assertTrue(sample in [[-16, -5, -2, 4], [-14, -9, 0, 0]], "Sample
 value found was {}".format(sample))

suite = unittest.TestLoader().loadTestsFromModule(TestFeatures())
unittest.TextTestRunner().run(suite)
```

```
....
----------------------------------------------------------------------
Ran 4 tests in 0.026s

OK
```

Out[16]:
```
<unittest.runner.TextTestResult run=4 errors=0 failures=0>
```

PART 2: Model Selection

Model Selection Tutorial

The objective of Model Selection is to tune the number of states for each word HMM prior to testing on unseen data. In this section you will explore three methods:

- Log likelihood using cross-validation folds (CV)
- Bayesian Information Criterion (BIC)
- Discriminative Information Criterion (DIC)

Train a single word

Now that we have built a training set with sequence data, we can "train" models for each word. As a simple starting example, we train a single word using Gaussian hidden Markov models (HMM). By using the `fit` method during training, the Baum-Welch Expectation-Maximization (https://en.wikipedia.org/wiki/Baum%E2%80%93Welch_algorithm) (EM) algorithm is invoked iteratively to find the best estimate for the model *for the number of hidden states specified* from a group of sample seequences. For this example, we *assume* the correct number of hidden states is 3, but that is just a guess. How do we know what the "best" number of states for training is? We will need to find some model selection technique to choose the best parameter.

In [17]:
```
import warnings
from hmmlearn.hmm import GaussianHMM

def train_a_word(word, num_hidden_states, features):

    warnings.filterwarnings("ignore", category=DeprecationWarning)
    training = asl.build_training(features)
    X, lengths = training.get_word_Xlengths(word)
    model = GaussianHMM(n_components=num_hidden_states, n_iter=1000).fit(X, le
ngths)
    logL = model.score(X, lengths)
    return model, logL

demoword = 'BOOK'
model, logL = train_a_word(demoword, 3, features_ground)
print("Number of states trained in model for {} is {}".format(demoword,
model.n_components))
print("logL = {}".format(logL))
```

```
Number of states trained in model for BOOK is 3
logL = -2331.113812743319
```

The HMM model has been trained and information can be pulled from the model, including means and variances for each feature and hidden state. The log likelihood (http://math.stackexchange.com/questions/892832/why-we-consider-log-likelihood-instead-of-likelihood-in-gaussian-distribution) for any individual sample or group of samples can also be calculated with the `score` method.

In [18]:
```
def show_model_stats(word, model):
    print("Number of states trained in model for {} is {}".format(word, model.n_components))
    variance=np.array([np.diag(model.covars_[i]) for i in range(model.n_components)])
    for i in range(model.n_components):  # for each hidden state
        print("hidden state #{}".format(i))
        print("mean = ", model.means_[i])
        print("variance = ", variance[i])
        print()

show_model_stats(demoword, model)
```

```
Number of states trained in model for BOOK is 3
hidden state #0
mean =  [ -3.46504869  50.66686933  14.02391587  52.04731066]
variance =  [ 49.12346305  43.04799144  39.35109609  47.24195772]

hidden state #1
mean =  [ -11.45300909   94.109178     19.03512475  102.2030162 ]
variance =  [  77.403668    203.35441965   26.68898447  156.12444034]

hidden state #2
mean =  [ -1.12415027  69.44164191  17.02866283  77.7231196 ]
variance =  [ 19.70434594  16.83041492  30.51552305  11.03678246]
```

Try it!

Experiment by changing the feature set, word, and/or num_hidden_states values in the next cell to see changes in values.

In [19]:
```
my_testword = 'CHOCOLATE'
model, logL = train_a_word(my_testword, 3, features_ground) # Experiment here with different parameters
show_model_stats(my_testword, model)
print("logL = {}".format(logL))
```

```
Number of states trained in model for CHOCOLATE is 3
hidden state #0
mean =  [   0.58333333   87.91666667   12.75        108.5       ]
variance =  [  39.41055556   18.74388889    9.855       144.4175    ]

hidden state #1
mean =  [ -9.30211403  55.32333876   6.92259936  71.24057775]
variance =  [ 16.16920957  46.50917372   3.81388185  15.79446427]

hidden state #2
mean =  [ -5.40587658  60.1652424    2.32479599  91.3095432 ]
variance =  [   7.95073876   64.13103127   13.68077479  129.5912395 ]

logL = -601.3291470028621
```

In [20]:
```
my_testword = 'CHOCOLATE'
model, logL = train_a_word(my_testword, 4, features_ground) # Experiment here
 with different parameters
show_model_stats(my_testword, model)
print("logL = {}".format(logL))
```

```
Number of states trained in model for CHOCOLATE is 4
hidden state #0
mean =  [   0.58333258   87.91666611   12.75000001  108.49999882]
variance =  [  39.4105671    18.74389523    9.85499958  144.41752618]

hidden state #1
mean =  [ -4.93681705  64.73171915   1.62598519  84.91459657]
variance =  [  6.1617479   28.36616959   5.47102461  13.11696032]

hidden state #2
mean =  [  -6.37712306   51.09867416    3.64009161  104.46268173]
variance =  [  10.28220014   12.44316166   27.33390004  106.91029392]

hidden state #3
mean =  [ -9.23835975  55.307463     6.92298661  71.30538347]
variance =  [ 16.30887738  45.97071639   3.76856896  15.98215464]

logL = -565.1243334331189
```

In [21]:
```
my_testword = 'CHOCOLATE'
model, logL = train_a_word(my_testword, 4, features_norm) # Experiment here wi
th different parameters
show_model_stats(my_testword, model)
print("logL = {}".format(logL))
```

```
Number of states trained in model for CHOCOLATE is 4
hidden state #0
mean =  [ 0.47581504 -0.25534057 -0.32768595 -1.7243523 ]
variance =  [ 0.042362    0.00442977  0.00152113  0.0066983 ]

hidden state #1
mean =  [ 0.49163141 -0.34766944 -0.19907141 -0.31200148]
variance =  [ 0.02973162  0.00401851  0.00934483  0.2921408 ]

hidden state #2
mean =  [ 0.9894402  -0.16006052 -1.31412901 -1.55560526]
variance =  [ 0.10711401  0.00555855  0.03518414  0.09325342]

hidden state #3
mean =  [ 0.494375    0.05588065  0.10128493 -0.81554085]
variance =  [ 0.05344461  0.02787475  0.01792018  0.07558914]

logL = 85.72111948347856
```

In [22]:
```
my_testword = 'CHOCOLATE'
model, logL = train_a_word(my_testword, 4, features_hand_dist) # Experiment he
re with different parameters
show_model_stats(my_testword, model)
print("logL = {}".format(logL))
```

```
Number of states trained in model for CHOCOLATE is 4
hidden state #0
mean =  [ 0.70326771  0.00393284]
variance =  [ 0.05846787  0.12020401]

hidden state #1
mean =  [ 1.67115958  0.08294104]
variance =  [ 0.01077021  0.05687346]

hidden state #2
mean =  [ 2.79182418  0.08961714]
variance =  [ 0.09747049  0.09519826]

hidden state #3
mean =  [ 1.01845213  0.02174606]
variance =  [ 0.01126724  0.01299081]

logL = 17.011107817911498
```

In [23]:
```
my_testword = 'CHOCOLATE'
model, logL = train_a_word(my_testword, 4, features_delta_norm_hand_pos) # Exp
eriment here with different parameters
show_model_stats(my_testword, model)
print("logL = {}".format(logL))
```

```
Number of states trained in model for CHOCOLATE is 4
hidden state #0
mean =  [-0.0480411   0.02301395  0.33806905 -0.28418428]
variance =  [ 0.00750924  0.00480335  0.00794685  0.05676355]

hidden state #1
mean =  [-0.05712648  0.09690884  0.02703457  0.09635826]
variance =  [ 0.08911966  0.01143685  0.03057315  0.0131411 ]

hidden state #2
mean =  [  6.59754455e-11   4.32756245e-03   9.77124970e-22   2.51896024e-21]
variance =  [ 0.00050009  0.00085585  0.00050009  0.00050009]

hidden state #3
mean =  [ 0.15715851 -0.00802616 -0.07882145 -0.30428311]
variance =  [ 0.02499005  0.00381481  0.02226397  0.01054853]

logL = 257.9532970856098
```

In [24]:
```
my_testword = 'CHOCOLATE'
model, logL = train_a_word(my_testword, 4, features_norm_polar_coords) # Exper
iment here with different parameters
show_model_stats(my_testword, model)
print("logL = {}".format(logL))
```

```
Number of states trained in model for CHOCOLATE is 4
hidden state #0
mean =  [  3.30979923e-01   4.64138086e-01   3.51761236e-01  -2.08758453e-01
   7.52665677e-03   3.16500921e-04  -1.01021772e-03   2.40865789e-03]
variance =  [ 0.00142054  0.00063018  0.00138223  0.00091643  0.00073207  0.0
0061309
  0.00103423  0.00096823]

hidden state #1
mean =  [ 0.45726054  0.47821239  0.49519442 -0.27765755 -0.00885866  0.00393
144
 -0.01907447 -0.00223042]
variance =  [ 0.00142803  0.00096031  0.00606245  0.0013628   0.00120702  0.0
0090085
  0.00244372  0.00109839]

hidden state #2
mean =  [ 0.25693787  0.45443133  0.48646859 -0.2187799   0.00718578  0.00283
913
 -0.0502764  -0.00990431]
variance =  [ 0.00178148  0.00174985  0.00454189  0.00304516  0.00168599  0.0
016301
  0.00291674  0.00189159]

hidden state #3
mean =  [ 0.28427069  0.44999872  0.27170853 -0.26126657  0.01053902 -0.00080
419
 -0.00609619 -0.00281184]
variance =  [ 0.00216161  0.00081977  0.00180867  0.00091722  0.00112796  0.0
0081907
  0.0015595   0.00083108]

logL = 877.5737285688424
```

In [25]:
```
my_testword = 'CHOCOLATE'
model, logL = train_a_word(my_testword, 4, features_custom) # Experiment here
 with different parameters
show_model_stats(my_testword, model)
print("logL = {}".format(logL))
```

```
Number of states trained in model for CHOCOLATE is 4
hidden state #0
mean =  [ 0.68894685 -0.06726488  0.04545047  0.02671352  0.04150469 -0.43023
168
  0.25772443  0.44983789  0.45341639 -0.24243443  0.00438785  0.00264511
 -0.07385162 -0.00940697]
variance =  [ 0.06099841  0.14440328  0.01315092  0.00229277  0.04798564  0.0
0710977
  0.00214024  0.00206358  0.00662637  0.00240703  0.00197695  0.00199185
  0.00206876  0.00243771]

hidden state #1
mean =  [  2.70040186e+00   1.36252009e-01   1.19035544e-01  -2.12498531e-02
  -5.49894403e-03  -7.79920592e-02   4.57260544e-01   4.78212389e-01
   4.95194423e-01  -2.77657546e-01  -8.85866356e-03   3.93144328e-03
  -1.90744719e-02  -2.23041942e-03]
variance =  [ 0.18128913  0.11118816  0.06340054  0.00447343  0.03237197  0.0
3364657
  0.00142803  0.00096031  0.00606245  0.0013628   0.00120702  0.00090085
  0.00244372  0.00109839]

hidden state #2
mean =  [  1.66934760e+00   3.93829880e-02  -5.16630049e-02   4.85017537e-02
   2.99923837e-02  -1.60076676e-02   2.85946802e-01   4.49787986e-01
   2.66464363e-01  -2.61850817e-01   1.08918419e-02  -1.07368615e-03
  -2.45048058e-03  -4.23092216e-03]
variance =  [ 0.01155148  0.03468306  0.04944696  0.00972004  0.00701598  0.0
2087937
  0.00223606  0.00086659  0.00141099  0.00096409  0.00119124  0.00086532
  0.00140807  0.00084167]

hidden state #3
mean =  [  9.85866138e-01   3.88707098e-02   8.72844129e-03   4.41029173e-02
  -1.80595855e-02  -2.28400816e-03   3.23267776e-01   4.64368449e-01
   3.69229341e-01  -2.04686504e-01   8.13778195e-03   6.62010383e-04
  -3.48913286e-04   2.29660018e-03]
variance =  [ 0.0239748   0.01655754  0.01258632  0.00496133  0.01904336  0.0
1430976
  0.00182059  0.00056857  0.00386049  0.00096373  0.00067952  0.00055369
  0.00088989  0.0008661 ]

logL = 1032.0617289350384
```

In [26]:

```
my_testword = 'CHOCOLATE'
model, logL = train_a_word(my_testword, 4, features_norm+features_custom) # Ex
periment here with different parameters
show_model_stats(my_testword, model)
print("logL = {}".format(logL))
```

```
Number of states trained in model for CHOCOLATE is 4
hidden state #0
mean =  [  3.96427827e-01  -1.89866022e-01  -2.78868852e-01  -1.67283647e+00
   1.66934706e+00   3.93872892e-02  -5.16604607e-02   4.85022802e-02
   2.99920823e-02  -1.60109936e-02   2.85946693e-01   4.49788134e-01
   2.66464708e-01  -2.61850781e-01   1.08919296e-02  -1.07356630e-03
  -2.45106441e-03  -4.23095236e-03]
variance =  [ 0.07442649  0.02997019  0.01666081  0.01991189  0.01155139  0.0
3468456
  0.04944711  0.00971997  0.00701592  0.02088026  0.00223604  0.00086659
  0.00141099  0.00096408  0.00119123  0.00086531  0.00140809  0.00084166]

hidden state #1
mean =  [  5.52775770e-01   5.85133921e-02   1.12964413e-01  -7.76093053e-01
   9.76746406e-01   4.40507571e-02   3.57790738e-03   4.06647112e-02
  -2.01092386e-02  -4.42867042e-03   3.31092050e-01   4.64138718e-01
   3.51638001e-01  -2.08757778e-01   7.52906570e-03   3.38985208e-04
  -6.93103104e-04   2.54923467e-03]
variance =  [ 0.02227333  0.02484758  0.01734906  0.03061802  0.02571509  0.0
1883522
  0.01340227  0.0048066   0.02116338  0.01655802  0.00141609  0.0006312
  0.00137512  0.0009179   0.00073333  0.00061394  0.00100719  0.00096378]

hidden state #2
mean =  [  9.89440201e-01  -1.60060522e-01  -1.31412901e+00  -1.55560526e+00
   2.70040186e+00   1.36252009e-01   1.19035544e-01  -2.12498531e-02
  -5.49894403e-03  -7.79920592e-02   4.57260544e-01   4.78212389e-01
   4.95194423e-01  -2.77657546e-01  -8.85866356e-03   3.93144328e-03
  -1.90744719e-02  -2.23041942e-03]
variance =  [ 0.10711401  0.00555855  0.03518414  0.09325342  0.18128913  0.1
1118816
  0.06340054  0.00447343  0.03237197  0.03364657  0.00142803  0.00096031
  0.00606245  0.0013628   0.00120702  0.00090085  0.00244372  0.00109839]

hidden state #3
mean =  [ 0.50337677 -0.3301064  -0.14973033 -0.28993689  0.7924637  -0.05067
418
  0.04782438  0.03979799  0.0301157  -0.30760774  0.25679133  0.45438067
  0.47285298 -0.2222306   0.00688855  0.00288183 -0.05284861 -0.00680614]
variance =  [ 0.02653053  0.00568306  0.02155259  0.22949723  0.07298732  0.1
0390137
  0.01040835  0.00357152  0.03516102  0.04329804  0.00158058  0.00155523
  0.00553362  0.00280777  0.00149858  0.00144919  0.0026252   0.00178664]

logL = 1104.998275794775
```

In [27]:
```
my_testword = 'CHOCOLATE'
model, logL = train_a_word(my_testword, 4, features_norm+features_delta_norm_h
and_pos+features_norm_polar_coords) # Experiment here with different parameter
s
show_model_stats(my_testword, model)
print("logL = {}".format(logL))
```

```
Number of states trained in model for CHOCOLATE is 4
hidden state #0
mean =  [ 0.9894402  -0.16006052 -1.31412901 -1.55560526  0.11903554 -0.02124
985
 -0.00549894 -0.07799206  0.45726054  0.47821239  0.49519442 -0.27765755
 -0.00885866  0.00393144 -0.01907447 -0.00223042]
variance =  [ 0.10711401  0.00555855  0.03518414  0.09325342  0.06340054  0.0
0447343
  0.03237197  0.03364657  0.00142803  0.00096031  0.00606245  0.0013628
  0.00120702  0.00090085  0.00244372  0.00109839]

hidden state #1
mean =  [  4.79037344e-01   7.91367367e-02   9.79743592e-02  -8.62146688e-01
  -2.61161494e-02   5.73367891e-02   2.71901101e-03   2.15305168e-02
   3.36697578e-01   4.61142063e-01   3.45034007e-01  -2.17819152e-01
   1.15537939e-02  -3.72086568e-04   3.99250687e-03   6.77476387e-05]
variance =  [ 0.05608837  0.02488282  0.01968713  0.05893709  0.01851001  0.0
076717
  0.02490391  0.01636512  0.00148742  0.00065105  0.00123304  0.0015544
  0.00085338  0.00058095  0.0009923   0.00096877]

hidden state #2
mean =  [  4.78777521e-01  -2.54985059e-01  -3.27098990e-01  -1.72163831e+00
  -1.85668704e-02   2.05427458e-02  -3.32030160e-07  -5.01223406e-02
   2.71180329e-01   4.51717217e-01   2.57443253e-01  -2.56525556e-01
   4.54078560e-03  -4.48924444e-04  -8.74369300e-03  -1.13362971e-03]
variance =  [ 0.04269708  0.00439304  0.00153578  0.00729357  0.04936689  0.0
0539733
  0.00167877  0.01666253  0.00106447  0.00100048  0.00110928  0.00091575
  0.00111172  0.0010149   0.00139575  0.00092013]

hidden state #3
mean =  [ 0.52341442 -0.30554653 -0.11814343 -0.30920449  0.05061843  0.04260
394
  0.02658597 -0.28784369  0.26149914  0.4560152   0.46494611 -0.22087881
  0.0074364   0.00298905 -0.04930237 -0.0060901 ]
variance =  [ 0.0275096   0.00974941  0.0270948   0.21093919  0.01019394  0.0
0331733
  0.03125428  0.04450303  0.00157315  0.00140023  0.00548449  0.00250507
  0.00133326  0.00128546  0.00250475  0.00158687]

logL = 1111.2326279733452
```

In [28]:
```
my_testword = 'FUTURE1'
model, logL = train_a_word(my_testword, 4, features_ground) # Experiment here
 with different parameters
show_model_stats(my_testword, model)
print("logL = {}".format(logL))
```

```
Number of states trained in model for FUTURE1 is 4
hidden state #0
mean =  [ -17.33333333   28.33333333  -18.33333333  124.        ]
variance =  [ 2.89222222  0.22555556  2.89222222  0.67      ]

hidden state #1
mean =  [ -28.33333333   35.66666667   24.66666667  176.33333333]
variance =  [ 0.22555556  0.89222222  0.22555556  0.22555556]

hidden state #2
mean =  [ -24.66666667   27.33333333   28.33333333  174.66666667]
variance =  [ 1.55888889  0.22555556  0.22555556  0.89222222]

hidden state #3
mean =  [ -20.   34.  -22.  125.]
variance =  [ 0.01  0.01  0.01  0.01]

logL = -38.19119712135632
```

In [29]:
```
my_testword = 'FUTURE1'
model, logL = train_a_word(my_testword, 4, features_norm+features_delta_norm_h
and_pos+features_norm_polar_coords) # Experiment here with different parameter
s
show_model_stats(my_testword, model)
print("logL = {}".format(logL))
```

```
Number of states trained in model for FUTURE1 is 4
hidden state #0
mean =  [-0.45662122 -1.06014359 -0.42330008  0.48136381 -0.00881745 -0.02732
124
 -0.03299366  0.00458777  0.2056612   0.35982762  0.90954941 -0.29961143
 -0.010471   -0.0030763  -0.00169276 -0.00149803]
variance =  [ 0.00858618  0.00447737  0.00662576  0.00227705  0.01231806  0.0
0285546
  0.0114639   0.00303476  0.00223105  0.00170947  0.00169562  0.00172922
  0.00195986  0.00167683  0.00172709  0.00173072]

hidden state #1
mean =  [ -5.28283580e-01  -7.02051402e-01  -2.35331659e+00   2.24553767e-01
  -1.34315737e-01  -2.52212462e-02  -1.94948102e-01   3.46920779e-02
   1.96286884e-01   3.88278656e-01   6.02232933e-01  -7.35164870e-02
   4.76159305e-04  -9.44452806e-03   8.95608707e-03   1.54666406e-02]
variance =  [ 0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.0
1  0.01
  0.01  0.01  0.01  0.01]

hidden state #2
mean =  [-0.42754626 -0.84076828 -2.09338593  0.17251577  0.03357946 -0.06305
303
  0.19494724 -0.01734592  0.16697648  0.3809603   0.58947641 -0.09406567
 -0.01280151 -0.00401991 -0.00575153 -0.01600631]
variance =  [ 0.00612765  0.00515902  0.02189097  0.00530088  0.01514799  0.0
1279234
  0.00922307  0.00770795  0.00501373  0.00500051  0.00500156  0.0051314
  0.00540868  0.00500663  0.00506819  0.00504789]

hidden state #3
mean =  [-0.19249424 -0.85337888 -2.15836849  0.22455377  0.26863147 -0.02522
125
 -0.1949481   0.03469208  0.15511124  0.39492573  0.5992832  -0.08981874
 -0.01557265  0.01468697  0.00855339  0.01571052]
variance =  [ 0.01000004  0.01000004  0.01000004  0.01000004  0.01000004  0.0
1000004
  0.01000004  0.01000004  0.01000004  0.01000004  0.01000004  0.01000004
  0.01000004  0.01000004  0.01000004  0.01000004]

logL = 260.6685445714538
```

In [30]:
```
my_testword = 'FUTURE1'
model, logL = train_a_word(my_testword, 4, features_norm+features_custom) # Ex
periment here with different parameters
show_model_stats(my_testword, model)
print("logL = {}".format(logL))
```

```
Number of states trained in model for FUTURE1 is 4
hidden state #0
mean =  [ -4.56621224e-01  -1.06014359e+00  -4.23300079e-01   4.81363812e-01
   1.54200037e+00   2.95729979e-02  -8.81744771e-03  -2.73212398e-02
  -3.29936642e-02   4.58776819e-03   2.05661200e-01   3.59827620e-01
   9.09549414e-01  -2.99611432e-01  -1.04710035e-02  -3.07629647e-03
  -1.69275994e-03  -1.49803443e-03]
variance =  [ 0.00858618  0.00447737  0.00662576  0.00227705  0.00647859  0.0
0399676
  0.01231806  0.00285546  0.0114639   0.00303476  0.00223105  0.00170947
  0.00169562  0.00172922  0.00195986  0.00167683  0.00172709  0.00173072]

hidden state #1
mean =  [-0.19249424 -0.85337888 -2.15836849  0.22455377  2.24200811  0.42727
6
  0.26863147 -0.02522125 -0.1949481   0.03469208  0.15511124  0.39492573
  0.5992832  -0.08981874 -0.01557265  0.01468697  0.00855339  0.01571052]
variance =  [ 0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.0
1  0.01
  0.01  0.01  0.01  0.01  0.01  0.01]

hidden state #2
mean =  [ -4.61125711e-01  -7.77715140e-01  -2.28833389e+00   1.89861689e-01
   2.06788132e+00   6.16005180e-02   2.62818242e-20  -8.82743615e-02
  -3.24913503e-02  -1.73460390e-02   1.79778010e-01   3.84980224e-01
   5.95227949e-01  -7.80592955e-02  -1.62707951e-02  -8.02069591e-03
  -2.52694032e-03   3.19051175e-03]
variance =  [ 0.00951018  0.010725    0.00922275  0.00620354  0.00544491  0.0
0537693
  0.02304072  0.0089757   0.0313922   0.00770797  0.00527254  0.00501088
  0.00504907  0.00502064  0.00528046  0.00500203  0.00513186  0.0051507 ]

hidden state #3
mean =  [ -4.61125711e-01  -8.28157633e-01  -1.96342039e+00   1.89861689e-01
   1.81473211e+00  -2.74242156e-01  -6.71578683e-02   2.52212462e-02
   2.59930803e-01   3.46920779e-02   1.70683886e-01   3.80238751e-01
   5.90729810e-01  -1.05529256e-01   7.41475106e-03  -1.44304070e-03
   2.50684527e-03  -2.29271518e-02]
variance =  [ 0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.0
1  0.01
  0.01  0.01  0.01  0.01  0.01  0.01]

logL = 286.6984478044842
```

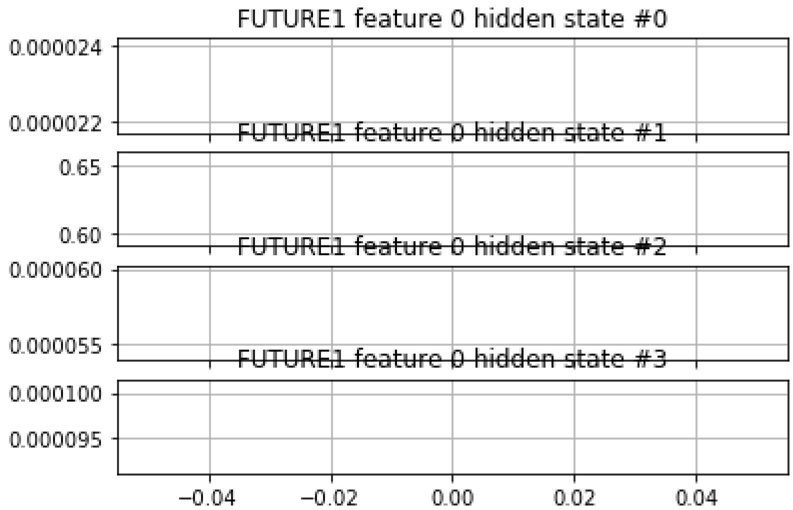
Visualize the hidden states

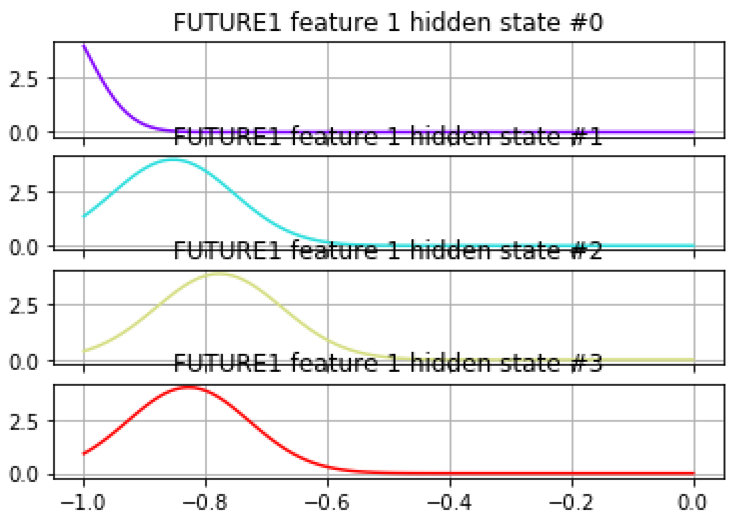
We can plot the means and variances for each state and feature. Try varying the number of states trained for the HMM model and examine the variances. Are there some models that are "better" than others? How can you tell? We would like to hear what you think in the classroom online.

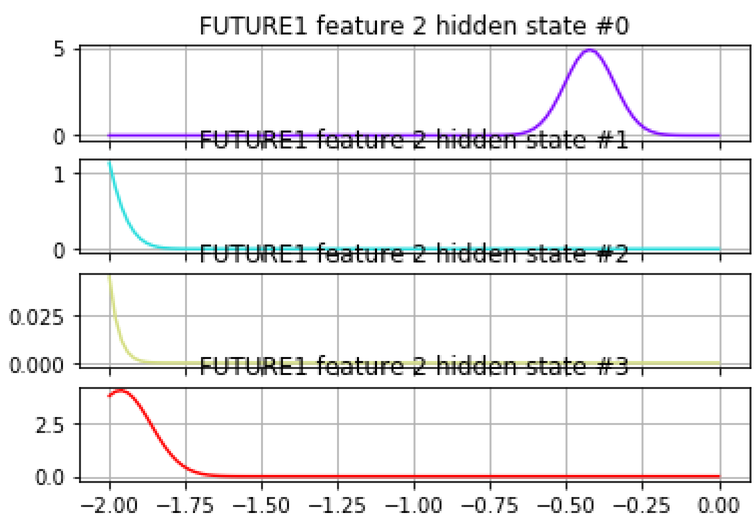
In [31]:
```
%matplotlib inline
```

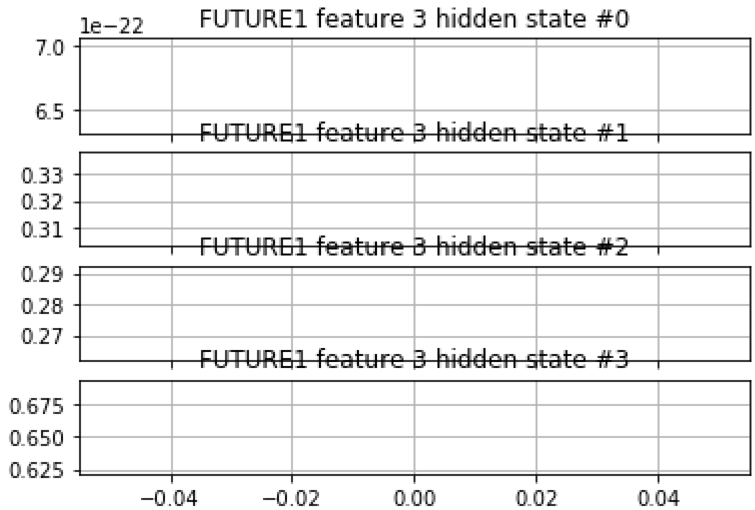
In [32]:

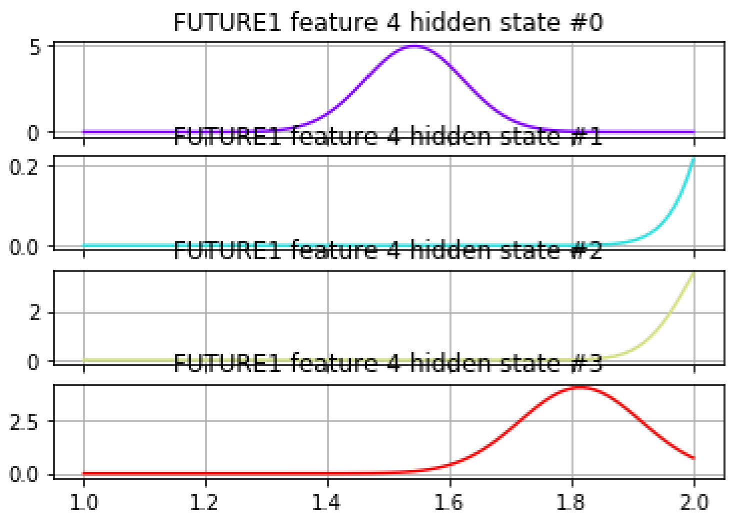
```
import math
from matplotlib import (cm, pyplot as plt, mlab)

def visualize(word, model):
    """ visualize the input model for a particular word """
    variance=np.array([np.diag(model.covars_[i]) for i in range(model.n_compon
ents)])
    figures = []
    for parm_idx in range(len(model.means_[0])):
        xmin = int(min(model.means_[:,parm_idx]) - max(variance[:,parm_idx]))
        xmax = int(max(model.means_[:,parm_idx]) + max(variance[:,parm_idx]))
        fig, axs = plt.subplots(model.n_components, sharex=True, sharey=False)
        colours = cm.rainbow(np.linspace(0, 1, model.n_components))
        for i, (ax, colour) in enumerate(zip(axs, colours)):
            x = np.linspace(xmin, xmax, 100)
            mu = model.means_[i,parm_idx]
            sigma = math.sqrt(np.diag(model.covars_[i])[parm_idx])
            ax.plot(x, mlab.normpdf(x, mu, sigma), c=colour)
            ax.set_title("{} feature {} hidden state #{}".format(word, parm_id
x, i))

            ax.grid(True)
        figures.append(plt)
    for p in figures:
        p.show()

visualize(my_testword, model)
```

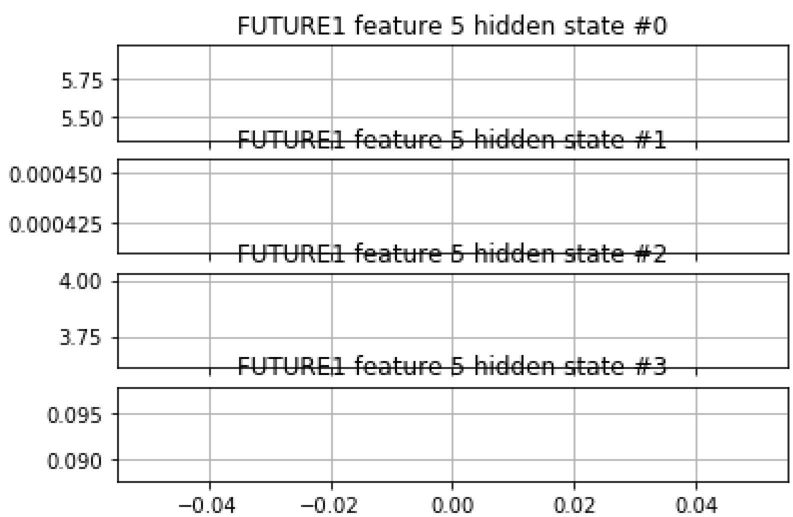

FUTURE1 feature 0 hidden state #0
0.000024
0.000022
FUTURE1 feature 0 hidden state #1
0.65
0.60
FUTURE1 feature 0 hidden state #2
0.000060
0.000055
FUTURE1 feature 0 hidden state #3
0.000100
0.000095
−0.04
−0.02
0.00
0.02
0.04

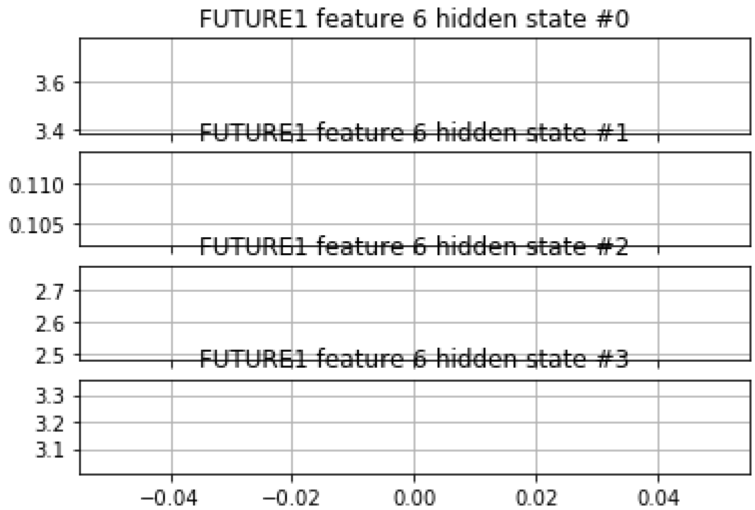

FUTURE1 feature 1 hidden state #0
2.5
0.0
FUTURE1 feature 1 hidden state #1
2.5
0.0
FUTURE1 feature 1 hidden state #2
2.5
0.0
FUTURE1 feature 1 hidden state #3
2.5
0.0
−1.0
−0.8
−0.6
−0.4
−0.2
0.0

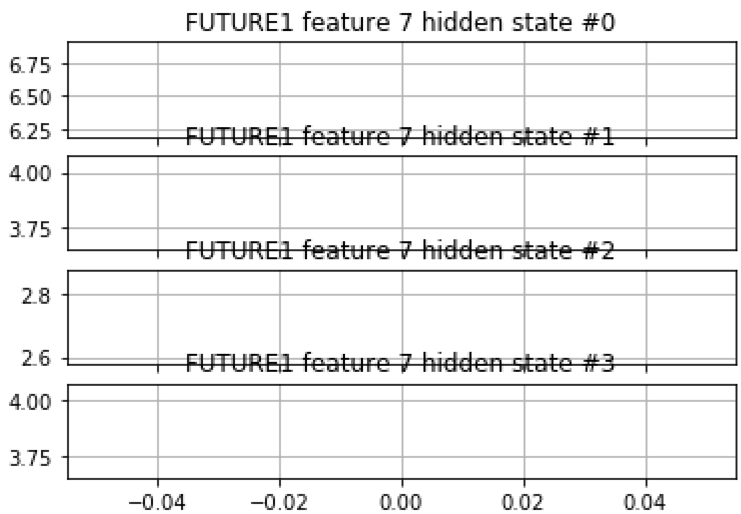

FUTURE1 feature 2 hidden state #0
5
0
FUTURE1 feature 2 hidden state #1
1
0
FUTURE1 feature 2 hidden state #2
0.025
0.000
FUTURE1 feature 2 hidden state #3
2.5
0.0
−2.00
−1.75
−1.50
−1.25
−1.00
−0.75
−0.50
−0.25
0.00

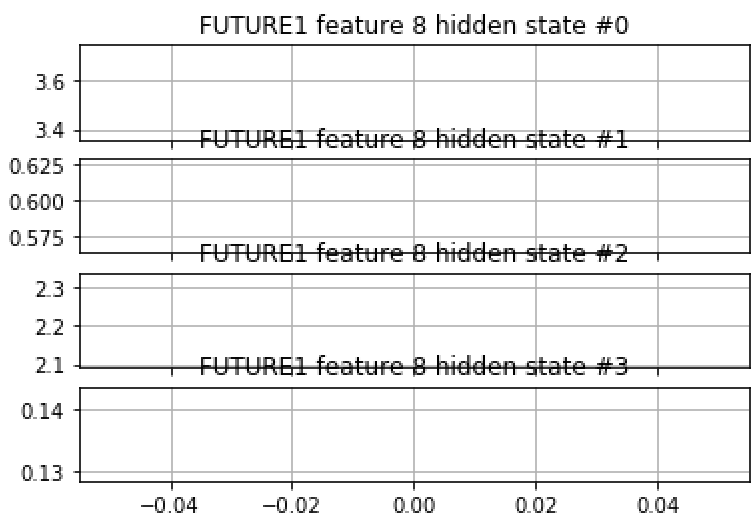

FUTURE1 feature 3 hidden state #0
1e−22
7.0
6.5
FUTURE1 feature 3 hidden state #1
0.33
0.32
0.31
FUTURE1 feature 3 hidden state #2
0.29
0.28
0.27
FUTURE1 feature 3 hidden state #3
0.675
0.650
0.625
−0.04
−0.02
0.00
0.02
0.04

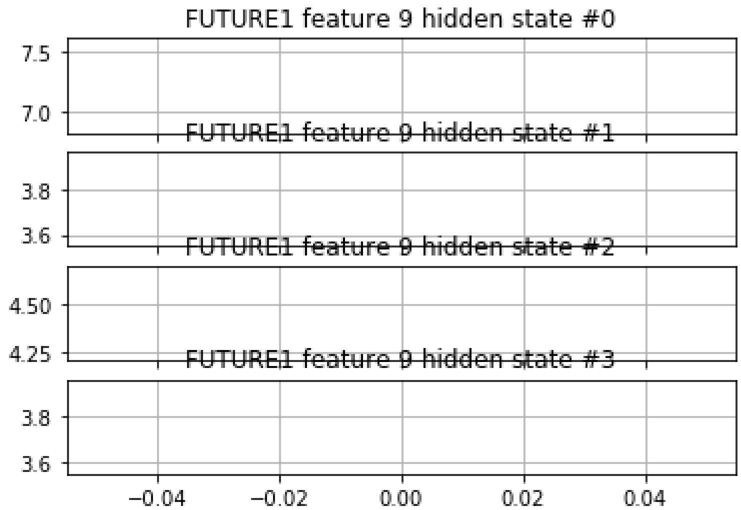

FUTURE1 feature 4 hidden state #0
5
0
FUTURE1 feature 4 hidden state #1
0.2
0.0
FUTURE1 feature 4 hidden state #2
2
0
FUTURE1 feature 4 hidden state #3
2.5
0.0
1.0
1.2
1.4
1.6
1.8
2.0


FUTURE1 feature 5 hidden state #0
5.75
5.50
FUTURE1 feature 5 hidden state #1
0.000450
0.000425
FUTURE1 feature 5 hidden state #2
4.00
3.75
FUTURE1 feature 5 hidden state #3
0.095
0.090
−0.04
−0.02
0.00
0.02
0.04

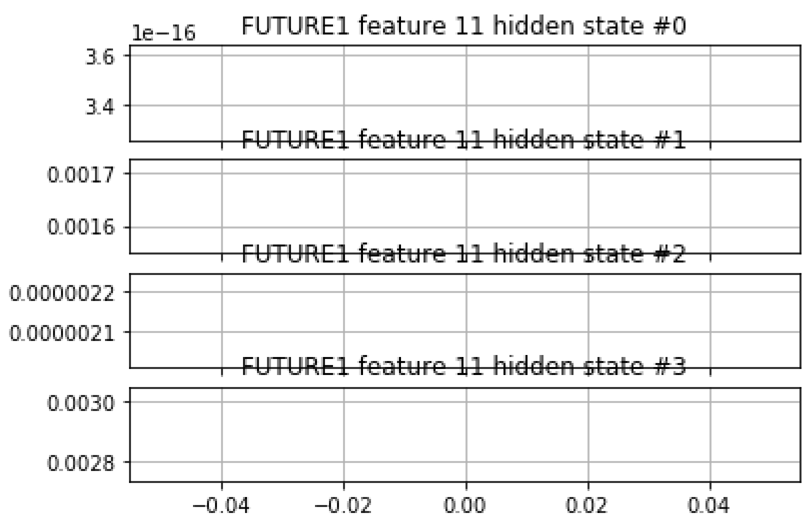

FUTURE1 feature 6 hidden state #0
3.6
3.4
FUTURE1 feature 6 hidden state #1
0.110
0.105
FUTURE1 feature 6 hidden state #2
2.7
2.6
2.5
FUTURE1 feature 6 hidden state #3
3.3
3.2
3.1
−0.04 −0.02 0.00 0.02 0.04

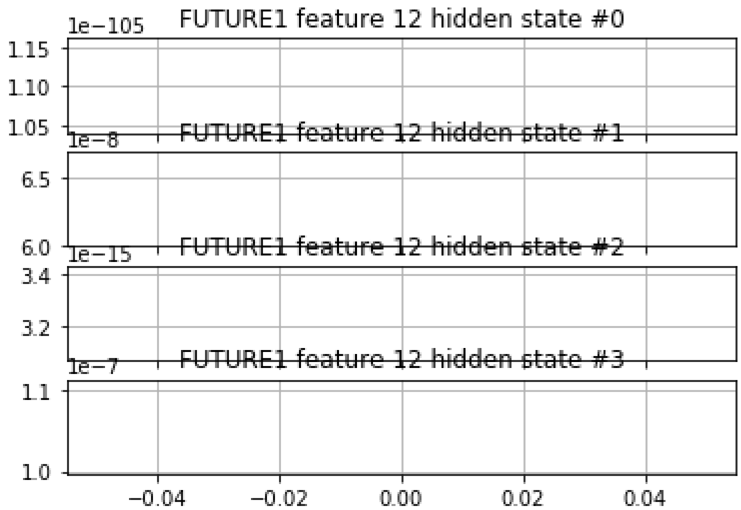

FUTURE1 feature 7 hidden state #0
6.75
6.50
6.25
FUTURE1 feature 7 hidden state #1
4.00
3.75
FUTURE1 feature 7 hidden state #2
2.8
2.6
FUTURE1 feature 7 hidden state #3
4.00
3.75
−0.04 −0.02 0.00 0.02 0.04

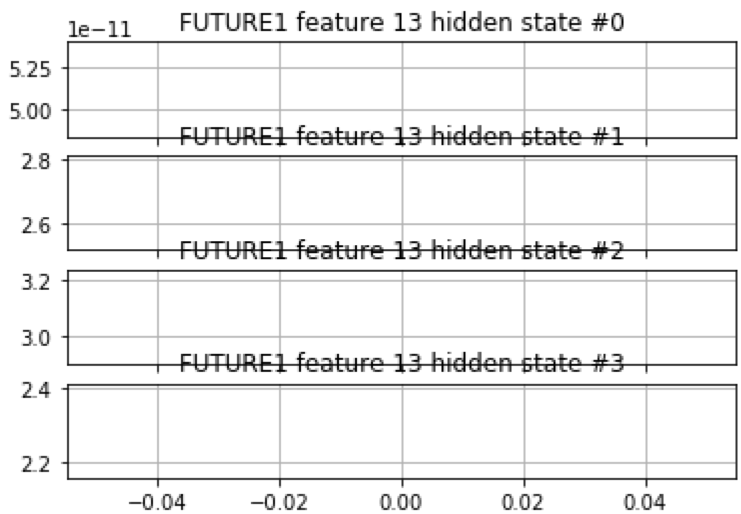

FUTURE1 feature 8 hidden state #0
3.6
3.4
FUTURE1 feature 8 hidden state #1
0.625
0.600
0.575
FUTURE1 feature 8 hidden state #2
2.3
2.2
2.1
FUTURE1 feature 8 hidden state #3
0.14
0.13
−0.04 −0.02 0.00 0.02 0.04

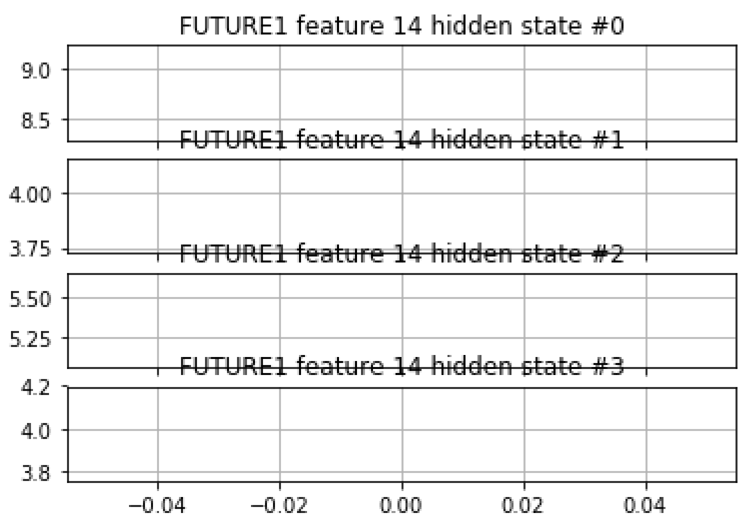

FUTURE1 feature 9 hidden state #0
7.5
7.0
FUTURE1 feature 9 hidden state #1
3.8
3.6
FUTURE1 feature 9 hidden state #2
4.50
4.25
FUTURE1 feature 9 hidden state #3
3.8
3.6
−0.04
−0.02
0.00
0.02
0.04


FUTURE1 feature 10 hidden state #0
0.000675
0.000650
0.000625
FUTURE1 feature 10 hidden state #1
1.25
1.20
1.15
FUTURE1 feature 10 hidden state #2
0.27
0.26
0.25
FUTURE1 feature 10 hidden state #3
0.95
0.90
−0.04
−0.02
0.00
0.02
0.04

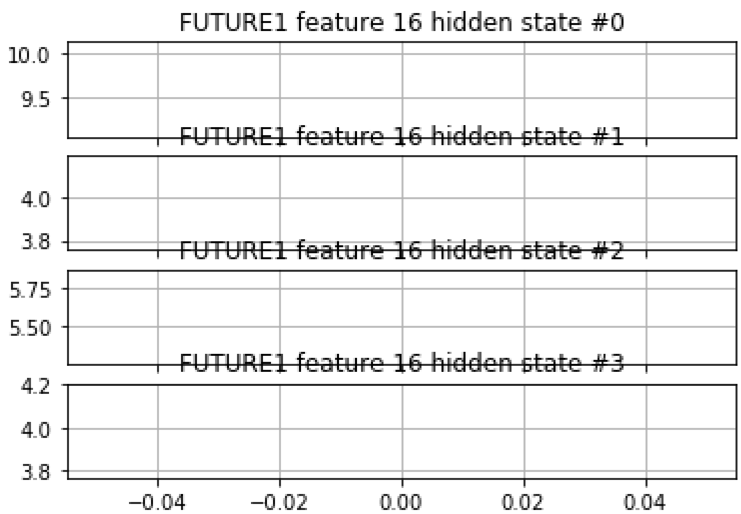

1e−16
FUTURE1 feature 11 hidden state #0
3.6
3.4
FUTURE1 feature 11 hidden state #1
0.0017
0.0016
FUTURE1 feature 11 hidden state #2
0.0000022
0.0000021
FUTURE1 feature 11 hidden state #3
0.0030
0.0028
−0.04
−0.02
0.00
0.02
0.04

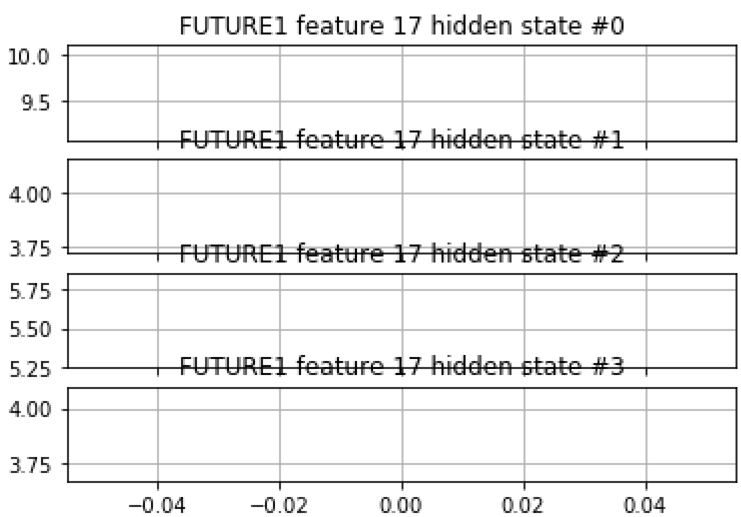

FUTURE1 feature 12 hidden state #0
FUTURE1 feature 12 hidden state #1
FUTURE1 feature 12 hidden state #2
FUTURE1 feature 12 hidden state #3
1e−105
1e−8
1e−15
1e−7
−0.04
−0.02
0.00
0.02
0.04


FUTURE1 feature 13 hidden state #0
FUTURE1 feature 13 hidden state #1
FUTURE1 feature 13 hidden state #2
FUTURE1 feature 13 hidden state #3
1e−11
−0.04
−0.02
0.00
0.02
0.04


FUTURE1 feature 14 hidden state #0
FUTURE1 feature 14 hidden state #1
FUTURE1 feature 14 hidden state #2
FUTURE1 feature 14 hidden state #3
−0.04
−0.02
0.00
0.02
0.04


FUTURE1 feature 15 hidden state #0
10.0
9.5
FUTURE1 feature 15 hidden state #1
4.00
3.75
FUTURE1 feature 15 hidden state #2
5.75
5.50
FUTURE1 feature 15 hidden state #3
4.2
4.0
3.8
−0.04
−0.02
0.00
0.02
0.04


FUTURE1 feature 16 hidden state #0
10.0
9.5
FUTURE1 feature 16 hidden state #1
4.0
3.8
FUTURE1 feature 16 hidden state #2
5.75
5.50
FUTURE1 feature 16 hidden state #3
4.2
4.0
3.8
−0.04
−0.02
0.00
0.02
0.04


FUTURE1 feature 17 hidden state #0
10.0
9.5
FUTURE1 feature 17 hidden state #1
4.00
3.75
FUTURE1 feature 17 hidden state #2
5.75
5.50
5.25
FUTURE1 feature 17 hidden state #3
4.00
3.75
−0.04
−0.02
0.00
0.02
0.04

ModelSelector class

Review the `ModelSelector` class from the codebase found in the `my_model_selectors.py` module. It is designed to be a strategy pattern for choosing different model selectors. For the project submission in this section, subclass `SelectorModel` to implement the following model selectors. In other words, you will write your own classes/functions in the `my_model_selectors.py` module and run them from this notebook:

- `SelectorCV`: Log likelihood with CV
- `SelectorBIC`: BIC
- `SelectorDIC`: DIC

You will train each word in the training set with a range of values for the number of hidden states, and then score these alternatives with the model selector, choosing the "best" according to each strategy. The simple case of training with a constant value for `n_components` can be called using the provided `SelectorConstant` subclass as follow:

In [33]:
```
from my_model_selectors import SelectorConstant

training = asl.build_training(features_ground)  # Experiment here with differe
nt feature sets defined in part 1
word = 'VEGETABLE' # Experiment here with different words
model = SelectorConstant(training.get_all_sequences(), training.get_all_Xlengt
hs(), word, n_constant=3).select()
print("Number of states trained in model for {} is {}".format(word, model.n_co
mponents))
```

```
Number of states trained in model for VEGETABLE is 3
```

Cross-validation folds

If we simply score the model with the Log Likelihood calculated from the feature sequences it has been trained on, we should expect that more complex models will have higher likelihoods. However, that doesn't tell us which would have a better likelihood score on unseen data. The model will likely be overfit as complexity is added. To estimate which topology model is better using only the training data, we can compare scores using cross-validation. One technique for cross-validation is to break the training set into "folds" and rotate which fold is left out of training. The "left out" fold scored. This gives us a proxy method of finding the best model to use on "unseen data". In the following example, a set of word sequences is broken into three folds using the scikit-learn Kfold (http://scikit-learn.org/stable/modules/generated/sklearn.model_selection.KFold.html) class object. When you implement `SelectorCV`, you will use this technique.

In [ ]:
```
```

In [34]:
```
from sklearn.model_selection import KFold

training = asl.build_training(features_ground) # Experiment here with differen
t feature sets
word = 'VEGETABLE' # Experiment here with different words
word_sequences = training.get_word_sequences(word)
split_method = KFold()
for cv_train_idx, cv_test_idx in split_method.split(word_sequences):
    print("Train fold indices:{} Test fold indices:{}".format(cv_train_idx, cv
_test_idx))  # view indices of the folds
```

```
Train fold indices:[2 3 4 5] Test fold indices:[0 1]
Train fold indices:[0 1 4 5] Test fold indices:[2 3]
Train fold indices:[0 1 2 3] Test fold indices:[4 5]
```

Tip: In order to run `hmmlearn` training using the X,lengths tuples on the new folds, subsets must be combined based on the indices given for the folds. A helper utility has been provided in the `asl_utils` module named `combine_sequences` for this purpose.

Scoring models with other criterion

Scoring model topologies with **BIC** balances fit and complexity within the training set for each word. In the BIC equation, a penalty term penalizes complexity to avoid overfitting, so that it is not necessary to also use cross-validation in the selection process. There are a number of references on the internet for this criterion. These slides (http://www2.imm.dtu.dk/courses/02433/doc/ch6_slides.pdf) include a formula you may find helpful for your implementation.

The advantages of scoring model topologies with **DIC** over BIC are presented by Alain Biem in this reference (http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.58.6208&rep=rep1&type=pdf) (also found here (https://pdfs.semanticscholar.org/ed3d/7c4a5f607201f3848d4c02dd9ba17c791fc2.pdf)). DIC scores the discriminant ability of a training set for one word against competing words. Instead of a penalty term for complexity, it provides a penalty if model liklihoods for non-matching words are too similar to model likelihoods for the correct word in the word set.

Model Selection Implementation Submission

Implement `SelectorCV`, `SelectorBIC`, and `SelectorDIC` classes in the `my_model_selectors.py` module. Run the selectors on the following five words. Then answer the questions about your results.

Tip: The `hmmlearn` library may not be able to train or score all models. Implement try/except contructs as necessary to eliminate non-viable models from consideration.

In [35]:
```
words_to_train = ['FISH', 'BOOK', 'VEGETABLE', 'FUTURE', 'JOHN']
import timeit
```

In [111]:
```
# TODO: Implement SelectorCV in my_model_selector.py
from importlib import reload
import my_model_selectors
reload(my_model_selectors)
from my_model_selectors import SelectorCV

training = asl.build_training(features_ground)  # Experiment here with differe
nt feature sets defined in part 1
sequences = training.get_all_sequences()
Xlengths = training.get_all_Xlengths()
for word in words_to_train:
    start = timeit.default_timer()
    model = SelectorCV(sequences, Xlengths, word,
                    min_n_components=2, max_n_components=15, random_state =
14).select()
    end = timeit.default_timer()-start
    if model is not None:
        print("Training complete for {} with {} states with time {} seconds".f
ormat(word, model.n_components, end))
    else:
        print("Training failed for {}".format(word))
```

```
Training failed for FISH
Training complete for BOOK with 6 states with time 2.81417334053549 seconds
Training complete for VEGETABLE with 2 states with time 1.1776731134450529 se
conds
Training complete for FUTURE with 2 states with time 2.5726160319172777 secon
ds
Training complete for JOHN with 12 states with time 28.304941846523434 second
s
```

In [112]:

```
# TODO: Implement SelectorCV in my_model_selector.py
from importlib import reload
import my_model_selectors
reload(my_model_selectors)
from my_model_selectors import SelectorCV

training = asl.build_training(features_norm+features_custom)  # Experiment her
e with different feature sets defined in part 1
sequences = training.get_all_sequences()
Xlengths = training.get_all_Xlengths()
for word in words_to_train:
    start = timeit.default_timer()
    model = SelectorCV(sequences, Xlengths, word,
                    min_n_components=2, max_n_components=15, random_state =
14).select()
    end = timeit.default_timer()-start
    if model is not None:
        print("Training complete for {} with {} states with time {} seconds".f
ormat(word, model.n_components, end))
    else:
        print("Training failed for {}".format(word))
```

```
Training complete for FISH with 7 states with time 0.4071681245986838 seconds
Training complete for BOOK with 4 states with time 2.8164064593438525 seconds
Training complete for VEGETABLE with 2 states with time 1.227136008325033 sec
onds
Training complete for FUTURE with 2 states with time 2.3431619242182933 secon
ds
Training complete for JOHN with 6 states with time 43.67166417956469 seconds
```

In [113]:
```
# TODO: Implement SelectorBIC in module my_model_selectors.py
from my_model_selectors import SelectorBIC

training = asl.build_training(features_ground)  # Experiment here with differe
nt feature sets defined in part 1
sequences = training.get_all_sequences()
Xlengths = training.get_all_Xlengths()
for word in words_to_train:
    start = timeit.default_timer()
    model = SelectorBIC(sequences, Xlengths, word,
                    min_n_components=2, max_n_components=15, random_state =
14).select()
    end = timeit.default_timer()-start
    if model is not None:
        print("Training complete for {} with {} states with time {} seconds".f
ormat(word, model.n_components, end))
    else:
        print("Training failed for {}".format(word))
```

```
Training complete for FISH with 5 states with time 0.27201277599669993 second
s
Training complete for BOOK with 8 states with time 1.4624717554543167 seconds
Training complete for VEGETABLE with 9 states with time 0.5155715345754288 se
conds
Training complete for FUTURE with 9 states with time 1.5727507313131355 secon
ds
Training complete for JOHN with 13 states with time 15.105401587614324 second
s
```

In [114]:
```
# TODO: Implement SelectorBIC in module my_model_selectors.py
from my_model_selectors import SelectorBIC

training = asl.build_training(features_norm+features_custom)  # Experiment her
e with different feature sets defined in part 1
sequences = training.get_all_sequences()
Xlengths = training.get_all_Xlengths()
for word in words_to_train:
    start = timeit.default_timer()
    model = SelectorBIC(sequences, Xlengths, word,
                    min_n_components=2, max_n_components=15, random_state =
14).select()
    end = timeit.default_timer()-start
    if model is not None:
        print("Training complete for {} with {} states with time {} seconds".f
ormat(word, model.n_components, end))
    else:
        print("Training failed for {}".format(word))
```

```
Training complete for FISH with 3 states with time 0.2737800887261983 seconds
Training complete for BOOK with 4 states with time 1.3124092013167683 seconds
Training complete for VEGETABLE with 3 states with time 0.5337541926128324 se
conds
Training complete for FUTURE with 6 states with time 1.2687507228401955 secon
ds
Training complete for JOHN with 8 states with time 25.431928486621473 seconds
```

In [115]:

```
# TODO: Implement SelectorDIC in module my_model_selectors.py
from my_model_selectors import SelectorDIC

training = asl.build_training(features_ground)  # Experiment here with differe
nt feature sets defined in part 1
sequences = training.get_all_sequences()
Xlengths = training.get_all_Xlengths()
for word in words_to_train:
    start = timeit.default_timer()
    model = SelectorDIC(sequences, Xlengths, word,
                    min_n_components=2, max_n_components=15, random_state =
14).select()
    end = timeit.default_timer()-start
    if model is not None:
        print("Training complete for {} with {} states with time {} seconds".f
ormat(word, model.n_components, end))
    else:
        print("Training failed for {}".format(word))
```

```
Training complete for FISH with 3 states with time 0.626596999092726 seconds
Training complete for BOOK with 15 states with time 4.045490319986129 seconds
Training complete for VEGETABLE with 15 states with time 2.331507956434507 se
conds
Training complete for FUTURE with 15 states with time 3.1904670896183234 seco
nds
Training complete for JOHN with 15 states with time 16.925838098366512 second
s
```

In [116]:

```
# TODO: Implement SelectorDIC in module my_model_selectors.py
from my_model_selectors import SelectorDIC

training = asl.build_training(features_norm+features_custom)  # Experiment her
e with different feature sets defined in part 1
sequences = training.get_all_sequences()
Xlengths = training.get_all_Xlengths()
for word in words_to_train:
    start = timeit.default_timer()
    model = SelectorDIC(sequences, Xlengths, word,
                    min_n_components=2, max_n_components=15, random_state =
14).select()
    end = timeit.default_timer()-start
    if model is not None:
        print("Training complete for {} with {} states with time {} seconds".f
ormat(word, model.n_components, end))
    else:
        print("Training failed for {}".format(word))
```

```
Training complete for FISH with 2 states with time 2.4782326449349057 seconds
Training complete for BOOK with 15 states with time 3.064980831783032 seconds
Training complete for VEGETABLE with 7 states with time 2.3212852580763865 se
conds
Training complete for FUTURE with 15 states with time 3.179895653796848 secon
ds
Training complete for JOHN with 15 states with time 29.18917686669738 seconds
```

Question 2: Compare and contrast the possible advantages and disadvantages of the various model selectors implemented.

Answer 2:

Selector CV shows itself to us as the slowest algorithym, in contrast with with the SelectorDIC and SelectorBIC nearly matched runtimes.BIC does come out slightly faster on our test words, even when the tested with different feature sets, but this is expected as it is slightly less complex. Our DIC selector could be further opimized by using a cache to prevent re-scoring words we have already seen, but it is unlikely this would speed it enough to beat the BIC selector. We can see the some signs that the DIC selector is overfitting, as they have tended to select models with more states. The CV selector is designed to overcome this and seems to use less states than the other selectors.

Model Selector Unit Testing

Run the following unit tests as a sanity check on the implemented model selectors. The test simply looks for valid interfaces but is not exhaustive. However, the project should not be submitted if these tests don't pass.

In [117]:
```
from asl_test_model_selectors import TestSelectors
suite = unittest.TestLoader().loadTestsFromModule(TestSelectors())
unittest.TextTestRunner().run(suite)
```

```
....
----------------------------------------------------------------------
Ran 4 tests in 48.433s

OK
```

Out[117]:
```
<unittest.runner.TextTestResult run=4 errors=0 failures=0>
```

PART 3: Recognizer

The objective of this section is to "put it all together". Using the four feature sets created and the three model selectors, you will experiment with the models and present your results. Instead of training only five specific words as in the previous section, train the entire set with a feature set and model selector strategy.

Recognizer Tutorial

Train the full training set

The following example trains the entire set with the example `features_ground` and `SelectorConstant` features and model selector. Use this pattern for you experimentation and final submission cells.

In [118]:

```
# autoreload for automatically reloading changes made in my_model_selectors an
d my_recognizer
%load_ext autoreload
%autoreload 2

from my_model_selectors import SelectorConstant

def train_all_words(features, model_selector):
    training = asl.build_training(features)  # Experiment here with different
 feature sets defined in part 1
    sequences = training.get_all_sequences()
    Xlengths = training.get_all_Xlengths()
    model_dict = {}
    for word in training.words:
        model = model_selector(sequences, Xlengths, word,
                        n_constant=3).select()
        model_dict[word]=model
    return model_dict

models = train_all_words(features_norm+features_custom, SelectorConstant)
print("Number of word models returned = {}".format(len(models)))
```

```
The autoreload extension is already loaded. To reload it, use:
  %reload_ext autoreload
Number of word models returned = 112
```

Load the test set

The `build_test` method in `ASLdb` is similar to the `build_training` method already presented, but there are a few differences:

- the object is type `SinglesData`
- the internal dictionary keys are the index of the test word rather than the word itself
- the getter methods are `get_all_sequences`, `get_all_Xlengths`, `get_item_sequences` and `get_item_Xlengths`

In [119]:

```
test_set = asl.build_test(features_norm+features_custom)
print("Number of test set items: {}".format(test_set.num_items))
print("Number of test set sentences:
{}".format(len(test_set.sentences_index)))
```

```
Number of test set items: 178
Number of test set sentences: 40
```

Recognizer Implementation Submission

For the final project submission, students must implement a recognizer following guidance in the `my_recognizer.py` module. Experiment with the four feature sets and the three model selection methods (that's 12 possible combinations). You can add and remove cells for experimentation or run the recognizers locally in some other way during your experiments, but retain the results for your discussion. For submission, you will provide code cells of **only three** interesting combinations for your discussion (see questions below). At least one of these should produce a word error rate of less than 60%, i.e. WER < 0.60 .

Tip: The hmmlearn library may not be able to train or score all models. Implement try/except contructs as necessary to eliminate non-viable models from consideration.

In [120]:
```
# TODO implement the recognize method in my_recognizer
from my_recognizer import recognize
from asl_utils import show_errors
```

In [121]:

```
# TODO Choose a feature set and model selector
features = features_norm+features_custom # change as needed
model_selector = SelectorBIC # change as needed

# TODO Recognize the test set and display the result with the show_errors meth
od
models = train_all_words(features, model_selector)
test_set = asl.build_test(features)
probabilities, guesses = recognize(models, test_set)
show_errors(guesses, test_set)
```

```
**** WER = 0.449438202247191
Total correct: 98 out of 178
Video  Recognized                                                    Correct
==============================================================================
========================
    2: JOHN WRITE HOMEWORK                                           JOHN WRI
TE HOMEWORK
    7: JOHN *CAR GO CAN                                              JOHN CAN
GO CAN
   12: JOHN CAN *GO1 CAN                                             JOHN CAN
GO CAN
   21: JOHN *NEW *VISIT *JOHN *CAR *CAR *FUTURE *FUTURE              JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX *LOVE *MARY IX                                       JOHN LIK
E IX IX IX
   28: *ANN LIKE *ANN IX IX                                          JOHN LIK
E IX IX IX
   30: *IX *MARY *MARY IX IX                                         JOHN LIK
E IX IX IX
   36: MARY *JOHN *GIRL *VISIT *JOHN *MARY                           MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN IX *JOHN *JOHN *MARY                                     JOHN IX 
 THINK MARY LOVE
   43: JOHN *JOHN BUY HOUSE                                          JOHN MUS
T BUY HOUSE
   50: *JOHN *SEE BUY CAR SHOULD                                     FUTURE J
OHN BUY CAR SHOULD
   54: JOHN SHOULD *FUTURE BUY HOUSE                                 JOHN SHO
ULD NOT BUY HOUSE
   57: *IX *JOHN *IX *IX                                             JOHN DEC
IDE VISIT MARY
   67: JOHN FUTURE NOT BUY HOUSE                                     JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FUTURE VISIT MARY                                       JOHN WIL
L VISIT MARY
   74: *IX *MARY *MARY MARY                                          JOHN NOT
VISIT MARY
   77: *JOHN BLAME MARY                                              ANN BLAM
E MARY
   84: *JOHN *NEW *HOMEWORK BOOK                                     IX-1P FI
ND SOMETHING-ONE BOOK
   89: JOHN *POSS *MAN MAN IX NEW COAT                               JOHN IX 
 GIVE MAN IX NEW COAT
   90: JOHN *GIVE1 IX *IX WOMAN BOOK                                 JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *MAN IX *IX WOMAN BOOK                                   JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                       POSS NEW
CAR BREAK-DOWN
  105: JOHN *SEE                                                     JOHN LEG
  107: *MARY *IX FRIEND *IX *JOHN                                    JOHN POS
S FRIEND HAVE CANDY
  108: *MARY *HOMEWORK                                               WOMAN AR
RIVE
  113: IX CAR *JOHN *JOHN *BUY1                                      IX CAR B
LUE SUE BUY
  119: *MARY *BUY1 IX CAR *IX                                        SUE BUY 
```

```
 IX CAR BLUE
  122: JOHN *GIVE1 BOOK                                              JOHN REA
D BOOK
  139: *IX *BUY1 WHAT YESTERDAY BOOK                                 JOHN BUY
WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                  JOHN BUY
YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                 LOVE JOH
N WHO
  167: JOHN IX *VISIT LOVE MARY                                      JOHN IX
 SAY LOVE MARY
  171: *MARY *JOHN BLAME                                             JOHN MAR
Y BLAME
  174: *CAR GROUP GIVE1 *JOHN TOY                                    PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN *VIDEOTAPE                                               JOHN ARR
IVE
  184: ALL BOY *GIVE1 TEACHER APPLE                                  ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *JOHN *PREFER *CAN                                       JOHN GIV
E GIRL BOX
  193: JOHN *IX *YESTERDAY BOX                                       JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE *JOHN                                         LIKE CHO
COLATE WHO
  201: JOHN *GIVE1 *WOMAN *WOMAN BUY HOUSE                           JOHN TEL
L MARY IX-1P BUY HOUSE
```

In [122]:

```python
#set up a function of the above for the above, for better re-use!
def recognize_and_display_result(features = features_norm+features_custom, mod
el_selector = SelectorCV):
    models = train_all_words(features, model_selector)
    test_set = asl.build_test(features)
    probabilities, guesses = recognize(models, test_set)
    show_errors(guesses, test_set)
```

In [123]:

```python
# feature sets I may use
features_ground
features_norm
features_polar
features_delta

features_custom=features_hand_dist+features_delta_norm_hand_pos+features_norm_
polar_coords
features_best=features_norm+features_custom
feature_sets=[features_ground, features_norm,features_polar,features_delta,fea
tures_hand_dist,features_delta_norm_hand_pos,features_norm_polar_coords,featur
es_custom, features_best]

# selectors I may use
selector_sets=[SelectorConstant,SelectorBIC,SelectorDIC,SelectorCV]
```

In [124]:

```
feature_model_scores=[]
for chosen_feature in feature_sets:
    for model_selector in selector_sets:
        print("----running:", chosen_feature,model_selector)
        recognize_and_display_result(chosen_feature, model_selector )
```

```
----running: ['grnd-rx', 'grnd-ry', 'grnd-lx', 'grnd-ly'] <class 'my_model_se
lectors.SelectorConstant'>

**** WER = 0.6685393258426966
Total correct: 59 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: *GO WRITE *ARRIVE                                             JOHN WRI
TE HOMEWORK
    7: *SOMETHING-ONE *GO1 *IX CAN                                   JOHN CAN
GO CAN
   12: JOHN *HAVE *WHAT CAN                                          JOHN CAN
GO CAN
   21: JOHN *HOMEWORK *NEW *PREFER *CAR *CAR *FUTURE *EAT            JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: *FRANK *TELL *LOVE *TELL *LOVE                                JOHN LIK
E IX IX IX
   28: *FRANK *TELL *LOVE *TELL *LOVE                                JOHN LIK
E IX IX IX
   30: *SHOULD LIKE *GO *GO *GO                                      JOHN LIK
E IX IX IX
   36: *VISIT VEGETABLE *YESTERDAY *GIVE *MARY *MARY                 MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: *SUE *GIVE *CORN *VEGETABLE *GO                               JOHN IX
 THINK MARY LOVE
   43: *FRANK *GO BUY HOUSE                                          JOHN MUS
T BUY HOUSE
   50: *FRANK *SEE BUY CAR *SOMETHING-ONE                            FUTURE J
OHN BUY CAR SHOULD
   54: JOHN SHOULD *WHO BUY HOUSE                                    JOHN SHO
ULD NOT BUY HOUSE
   57: *MARY *VISIT VISIT *VISIT                                     JOHN DEC
IDE VISIT MARY
   67: *LIKE FUTURE NOT BUY HOUSE                                    JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FINISH VISIT MARY                                       JOHN WIL
L VISIT MARY
   74: *IX *VISIT *GO *GO                                            JOHN NOT
VISIT MARY
   77: *JOHN BLAME *LOVE                                             ANN BLAM
E MARY
   84: *LOVE *ARRIVE *HOMEWORK BOOK                                  IX-1P FI
ND SOMETHING-ONE BOOK
   89: *GIVE *GIVE GIVE *IX IX *ARRIVE *BOOK                         JOHN IX
 GIVE MAN IX NEW COAT
   90: *SOMETHING-ONE *SOMETHING-ONE IX *IX WOMAN *COAT              JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: *FRANK GIVE *WOMAN *WOMAN WOMAN BOOK                          JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                       POSS NEW
CAR BREAK-DOWN
  105: *FRANK *VEGETABLE                                             JOHN LEG
  107: *SHOULD *IX FRIEND *GO *JANA                                  JOHN POS
S FRIEND HAVE CANDY
  108: *GIVE *LOVE                                                   WOMAN AR
RIVE
```

```
  113: IX CAR *CAR *IX *IX                                           IX CAR B
LUE SUE BUY
  119: *PREFER *BUY1 IX *BLAME *IX                                   SUE BUY
 IX CAR BLUE
  122: JOHN *GIVE1 *COAT                                             JOHN REA
D BOOK
  139: *SHOULD *BUY1 *CAR *BLAME BOOK                                JOHN BUY
WHAT YESTERDAY BOOK
  142: *FRANK *STUDENT YESTERDAY *TEACHER BOOK                       JOHN BUY
YESTERDAY WHAT BOOK
  158: LOVE *MARY WHO                                                LOVE JOH
N WHO
  167: *MARY IX *VISIT *WOMAN *LOVE                                  JOHN IX
 SAY LOVE MARY
  171: *VISIT *VISIT BLAME                                           JOHN MAR
Y BLAME
  174: *CAN *GIVE3 GIVE1 *APPLE *WHAT                                PEOPLE G
ROUP GIVE1 JANA TOY
  181: *BLAME ARRIVE                                                 JOHN ARR
IVE
  184: *GIVE1 BOY *GIVE1 TEACHER APPLE                               ALL BOY
 GIVE TEACHER APPLE
  189: *JANA *SOMETHING-ONE *YESTERDAY *WHAT                         JOHN GIV
E GIRL BOX
  193: JOHN *SOMETHING-ONE *YESTERDAY BOX                            JOHN GIV
E GIRL BOX
  199: *LOVE CHOCOLATE WHO                                           LIKE CHO
COLATE WHO
  201: JOHN *GIVE *GIVE *LOVE *ARRIVE HOUSE                          JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['grnd-rx', 'grnd-ry', 'grnd-lx', 'grnd-ly'] <class 'my_model_se
lectors.SelectorBIC'>

**** WER = 0.550561797752809
Total correct: 80 out of 178
Video  Recognized                                                    Correct
=============================================================================
=======================
    2: JOHN WRITE *NEW                                               JOHN WRI
TE HOMEWORK
    7: *SOMETHING-ONE *GO1 GO *ARRIVE                                JOHN CAN
GO CAN
   12: *IX *WHAT *CAN CAN                                            JOHN CAN
GO CAN
   21: JOHN *WRITE *JOHN *FUTURE *CAR *TEACHER *VISIT *WHO           JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX IX *LIKE IX                                          JOHN LIK
E IX IX IX
   28: JOHN *WHO IX *LIKE *LOVE                                      JOHN LIK
E IX IX IX
   30: JOHN LIKE *MARY *MARY *MARY                                   JOHN LIK
E IX IX IX
   36: *VISIT *VISIT *IX *GIVE *MARY *IX                             MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: *MARY *GO *GIVE MARY *MARY                                    JOHN IX
 THINK MARY LOVE
   43: JOHN *IX BUY HOUSE                                            JOHN MUS
```

```
T BUY HOUSE
   50: *JOHN *SEE BUY CAR *NEW                                          FUTURE J
OHN BUY CAR SHOULD
   54: JOHN SHOULD NOT BUY HOUSE                                        JOHN SHO
ULD NOT BUY HOUSE
   57: *MARY *VISIT VISIT MARY                                          JOHN DEC
IDE VISIT MARY
   67: *SHOULD *JOHN *WHO BUY HOUSE                                     JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FUTURE VISIT MARY                                          JOHN WIL
L VISIT MARY
   74: *IX *VISIT VISIT MARY                                            JOHN NOT
VISIT MARY
   77: *JOHN BLAME *LOVE                                                ANN BLAM
E MARY
   84: *JOHN *ARRIVE *GIVE1 BOOK                                        IX-1P FI
ND SOMETHING-ONE BOOK
   89: *MARY *POSS *IX *IX IX *ARRIVE *BOOK                             JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN *SOMETHING-ONE IX *IX *VISIT *ARRIVE                        JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *SHOULD IX *IX *IX BOOK                                     JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: *IX NEW CAR BREAK-DOWN                                           POSS NEW
CAR BREAK-DOWN
  105: JOHN *FRANK                                                      JOHN LEG
  107: JOHN *GO *ARRIVE HAVE *JOHN                                      JOHN POS
S FRIEND HAVE CANDY
  108: *WHO *LOVE                                                       WOMAN AR
RIVE
  113: IX CAR *CAR *MARY *BOX                                           IX CAR B
LUE SUE BUY
  119: *VISIT *BUY1 IX *BOX *GO                                         SUE BUY
 IX CAR BLUE
  122: JOHN *GIVE1 BOOK                                                 JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT *GIVE1 BOOK                                      JOHN BUY
WHAT YESTERDAY BOOK
  142: JOHN *STUDENT YESTERDAY WHAT BOOK                                JOHN BUY
YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                    LOVE JOH
N WHO
  167: JOHN *MARY *VISIT LOVE MARY                                      JOHN IX
 SAY LOVE MARY
  171: JOHN MARY BLAME                                                  JOHN MAR
Y BLAME
  174: *CAN *GIVE1 GIVE1 *YESTERDAY *WHAT                               PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN *BOX                                                        JOHN ARR
IVE
  184: *GIVE BOY *GIVE1 TEACHER APPLE                                   ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *SOMETHING-ONE *VISIT BOX                                   JOHN GIV
E GIRL BOX
  193: JOHN *SOMETHING-ONE *VISIT BOX                                   JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE *GO                                              LIKE CHO
```

```
COLATE WHO
  201: JOHN *MARY *LOVE *JOHN BUY HOUSE                            JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['grnd-rx', 'grnd-ry', 'grnd-lx', 'grnd-ly'] <class 'my_model_se
lectors.SelectorDIC'>

**** WER = 0.5730337078651685
Total correct: 76 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: JOHN *NEW *GIVE1                                              JOHN WRI
TE HOMEWORK
    7: *SOMETHING-ONE *CAR *ARRIVE *ARRIVE                           JOHN CAN
GO CAN
   12: *IX *WHAT *WHAT *CAR                                          JOHN CAN
GO CAN
   21: JOHN *GIVE1 *JOHN *FUTURE *CAR *CAR *FUTURE *MARY             JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX IX *WHO IX                                           JOHN LIK
E IX IX IX
   28: JOHN *WHO IX IX *LOVE                                         JOHN LIK
E IX IX IX
   30: JOHN *MARY *MARY *MARY *MARY                                  JOHN LIK
E IX IX IX
   36: *VISIT *VISIT *GIVE *GO *MARY *IX                             MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: *MARY *GO *GIVE MARY *MARY                                    JOHN IX
 THINK MARY LOVE
   43: JOHN *IX BUY HOUSE                                            JOHN MUS
T BUY HOUSE
   50: *JOHN *FUTURE *GIVE1 CAR *JOHN                                FUTURE J
OHN BUY CAR SHOULD
   54: JOHN SHOULD NOT BUY HOUSE                                     JOHN SHO
ULD NOT BUY HOUSE
   57: *MARY *VISIT VISIT MARY                                       JOHN DEC
IDE VISIT MARY
   67: JOHN FUTURE *MARY BUY HOUSE                                   JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FINISH VISIT MARY                                       JOHN WIL
L VISIT MARY
   74: *IX *GO *MARY MARY                                            JOHN NOT
VISIT MARY
   77: *JOHN BLAME *LOVE                                             ANN BLAM
E MARY
   84: *JOHN *GIVE1 *VISIT BOOK                                      IX-1P FI
ND SOMETHING-ONE BOOK
   89: *MARY IX *IX *IX IX *ARRIVE *BOOK                             JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN *SOMETHING-ONE IX *IX *VISIT *ARRIVE                     JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *IX IX *IX *IX BOOK                                      JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: *IX NEW CAR *ARRIVE                                           POSS NEW
CAR BREAK-DOWN
  105: JOHN *FRANK                                                   JOHN LEG
  107: JOHN *IX *HAVE *ARRIVE *JOHN                                  JOHN POS
```

```
S FRIEND HAVE CANDY
  108: *IX ARRIVE                                                     WOMAN AR
RIVE
  113: IX CAR *IX *MARY *BOX                                          IX CAR B
LUE SUE BUY
  119: *VISIT *BUY1 IX *BOX *IX                                       SUE BUY
 IX CAR BLUE
  122: JOHN *BUY BOOK                                                 JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT *MARY BOOK                                     JOHN BUY
WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                   JOHN BUY
YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                  LOVE JOH
N WHO
  167: JOHN *MARY *GO LOVE MARY                                       JOHN IX
 SAY LOVE MARY
  171: JOHN MARY BLAME                                                JOHN MAR
Y BLAME
  174: *CAR *GIVE1 GIVE1 *YESTERDAY *WHAT                             PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN ARRIVE                                                    JOHN ARR
IVE
  184: *IX BOY *GIVE1 TEACHER *YESTERDAY                              ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *SOMETHING-ONE *VISIT BOX                                 JOHN GIV
E GIRL BOX
  193: JOHN *SOMETHING-ONE *VISIT BOX                                 JOHN GIV
E GIRL BOX
  199: *JOHN *ARRIVE *GO                                              LIKE CHO
COLATE WHO
  201: JOHN *MARY *LOVE *JOHN *GIVE1 HOUSE                            JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['grnd-rx', 'grnd-ry', 'grnd-lx', 'grnd-ly'] <class 'my_model_se
lectors.SelectorCV'>

**** WER = 0.5898876404494382
Total correct: 73 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: JOHN WRITE HOMEWORK                                            JOHN WRI
TE HOMEWORK
    7: JOHN *WHAT GO *HAVE                                            JOHN CAN
 GO CAN
   12: *LAST-WEEK *TEACHER *CAN CAN                                   JOHN CAN
 GO CAN
   21: JOHN *VIDEOTAPE *HOMEWORK *FUTURE *CAR *CAR *VISIT *TOMORROW  JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX *LOVE IX IX                                           JOHN LIK
E IX IX IX
   28: JOHN *TELL IX IX *LOVE                                         JOHN LIK
E IX IX IX
   30: JOHN *IX *SHOOT *SHOOT *SHOOT                                  JOHN LIK
E IX IX IX
   36: MARY VEGETABLE *GIVE *SHOOT *MARY *MARY                        MARY VEG
ETABLE KNOW IX LIKE CORN1
```

```
   40: JOHN *GIVE *APPLE *JOHN *SHOOT                                JOHN IX
 THINK MARY LOVE
   43: JOHN *SHOULD BUY HOUSE                                        JOHN MUS
T BUY HOUSE
   50: *JOHN *SEE BUY CAR *SOMETHING-ONE                             FUTURE J
OHN BUY CAR SHOULD
   54: JOHN SHOULD *GIVE1 BUY HOUSE                                  JOHN SHO
ULD NOT BUY HOUSE
   57: *IX *VEGETABLE *MARY *IX                                      JOHN DEC
IDE VISIT MARY
   67: JOHN *JOHN NOT *ARRIVE HOUSE                                  JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FINISH *GO MARY                                         JOHN WIL
L VISIT MARY
   74: *IX *JANA *SHOOT *SHOOT                                       JOHN NOT
 VISIT MARY
   77: *JOHN BLAME *LOVE                                             ANN BLAM
E MARY
   84: *LOVE *ARRIVE *GO *WRITE                                      IX-1P FI
ND SOMETHING-ONE BOOK
   89: *FRANK *POSS GIVE *IX IX *BUY *BOOK                           JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN *SOMETHING-ONE *SOMETHING-ONE SOMETHING-ONE WOMAN *BORROW  JOHN G
IVE IX SOMETHING-ONE WOMAN BOOK
   92: JOHN GIVE IX *IX *MARY BOOK                                   JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                       POSS NEW
 CAR BREAK-DOWN
  105: JOHN *FRANK                                                   JOHN LEG
  107: JOHN *HAVE FRIEND *GO *WHO                                    JOHN POS
S FRIEND HAVE CANDY
  108: *FRANK *LOVE                                                  WOMAN AR
RIVE
  113: *HAVE CAR *GIVE *MARY *HAVE                                   IX CAR B
LUE SUE BUY
  119: *VEGETABLE *LOVE *HAVE *WHAT *GIVE                            SUE BUY
 IX CAR BLUE
  122: JOHN *HOUSE BOOK                                              JOHN REA
D BOOK
  139: JOHN *BUY1 *CAN YESTERDAY *BORROW                             JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN *NEW *CHICAGO *TEACHER BOOK                              JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                 LOVE JOH
N WHO
  167: JOHN *MARY *JANA *WOMAN *LOVE                                 JOHN IX
 SAY LOVE MARY
  171: JOHN *JOHN BLAME                                              JOHN MAR
Y BLAME
  174: *WHAT GROUP GIVE1 *APPLE TOY                                  PEOPLE G
ROUP GIVE1 JANA TOY
  181: *HAVE *BOX                                                    JOHN ARR
IVE
  184: *SOMETHING-ONE *GO *HOUSE TEACHER APPLE                       ALL BOY
 GIVE TEACHER APPLE
  189: JOHN GIVE *YESTERDAY *CAN                                     JOHN GIV
E GIRL BOX
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  193: JOHN *SOMETHING-ONE *GIVE1 BOX                                    JOHN GIV
E GIRL BOX
  199: *LOVE CHOCOLATE *TELL                                             LIKE CHO
COLATE WHO
  201: JOHN *SHOULD *WOMAN *FRANK *ARRIVE HOUSE                          JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['norm-rx', 'norm-ry', 'norm-lx', 'norm-ly'] <class 'my_model_se
lectors.SelectorConstant'>

**** WER = 0.6235955056179775
Total correct: 67 out of 178
Video  Recognized                                                        Correct
=============================================================================
========================
    2: *MARY WRITE *ARRIVE                                               JOHN WRI
TE HOMEWORK
    7: JOHN *NEW *JOHN CAN                                               JOHN CAN
 GO CAN
   12: *SHOULD *HAVE *GO1 CAN                                            JOHN CAN
 GO CAN
   21: *LIKE *NEW *HAVE *IX-1P *CAR *BLAME *CHICKEN *WRITE               JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: *IX LIKE *LIKE *LIKE IX                                           JOHN LIK
E IX IX IX
   28: *ANN LIKE *ANN *LIKE *ANN                                         JOHN LIK
E IX IX IX
   30: *SHOOT LIKE *LOVE *LIKE *MARY                                     JOHN LIK
E IX IX IX
   36: *LEAVE *NOT *YESTERDAY *VISIT LIKE *JOHN                          MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN *LEAVE *FUTURE1 *VEGETABLE LOVE                              JOHN IX
 THINK MARY LOVE
   43: JOHN *SHOULD BUY HOUSE                                            JOHN MUS
T BUY HOUSE
   50: *FRANK *SEE *ARRIVE CAR *CAR                                      FUTURE J
OHN BUY CAR SHOULD
   54: JOHN SHOULD *FUTURE *STUDENT HOUSE                                JOHN SHO
ULD NOT BUY HOUSE
   57: *MARY *MARY *MARY MARY                                            JOHN DEC
IDE VISIT MARY
   67: *IX-1P FUTURE *JOHN *ARRIVE HOUSE                                 JOHN FUT
URE NOT BUY HOUSE
   71: JOHN WILL VISIT MARY                                              JOHN WIL
L VISIT MARY
   74: *WOMAN *VISIT VISIT *FRANK                                        JOHN NOT
 VISIT MARY
   77: *IX BLAME MARY                                                    ANN BLAM
E MARY
   84: *IX *ARRIVE *NEW BOOK                                             IX-1P FI
ND SOMETHING-ONE BOOK
   89: *FUTURE *THROW *JOHN *JOHN *WOMAN *BOOK *BREAK-DOWN               JOHN IX
 GIVE MAN IX NEW COAT
   90: *SELF *GIVE1 IX *IX WOMAN *CHOCOLATE                              JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *GIVE1 IX *IX WOMAN BOOK                                     JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                           POSS NEW
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 CAR BREAK-DOWN
  105: *WHO *SEE                                                     JOHN LEG
  107: *TELL *IX *BOX *LIKE *JANA                                    JOHN POS
S FRIEND HAVE CANDY
  108: *LOVE *HOMEWORK                                               WOMAN AR
RIVE
  113: IX CAR *IX SUE *HAVE                                          IX CAR B
LUE SUE BUY
  119: *VEGETABLE *BUY1 IX CAR *GO                                   SUE BUY 
 IX CAR BLUE
  122: JOHN *HOUSE *COAT                                             JOHN REA
D BOOK
  139: JOHN *BUY1 *CAR YESTERDAY BOOK                                JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                  JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE *MARY *CORN                                              LOVE JOH
N WHO
  167: JOHN *JOHN *SAY-1P LOVE MARY                                  JOHN IX 
 SAY LOVE MARY
  171: *SHOOT *JOHN BLAME                                            JOHN MAR
Y BLAME
  174: *NEW *GIVE1 GIVE1 *WHO *CAR                                   PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN *BOX                                                     JOHN ARR
IVE
  184: *IX *IX *GIVE1 TEACHER APPLE                                  ALL BOY 
 GIVE TEACHER APPLE
  189: *JANA *SEE *PREFER *ARRIVE                                    JOHN GIV
E GIRL BOX
  193: JOHN *SEE *YESTERDAY BOX                                      JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE *JOHN                                         LIKE CHO
COLATE WHO
  201: JOHN *THINK *WOMAN *WOMAN *STUDENT HOUSE                      JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['norm-rx', 'norm-ry', 'norm-lx', 'norm-ly'] <class 'my_model_se
lectors.SelectorBIC'>

**** WER = 0.6123595505617978
Total correct: 69 out of 178
Video  Recognized                                                    Correct
==============================================================================
========================
    2: JOHN WRITE *ARRIVE                                            JOHN WRI
TE HOMEWORK
    7: *MARY *NEW GO *WHAT                                           JOHN CAN
 GO CAN
   12: *MARY *HAVE *GO1 CAN                                          JOHN CAN
 GO CAN
   21: *MARY *BOX *HAVE *GO *CAR *CAR *CHICKEN *WRITE                JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN LIKE *LOVE *LIKE IX                                      JOHN LIK
E IX IX IX
   28: *ANN *ANN *ANN *ANN *ANN                                      JOHN LIK
E IX IX IX
   30: *IX-1P *IX *MARY IX IX                                        JOHN LIK
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E IX IX IX
   36: MARY *MARY *YESTERDAY *SHOOT LIKE *IX                         MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: *MARY *JOHN *FUTURE1 *VEGETABLE *MARY                         JOHN IX
 THINK MARY LOVE
   43: JOHN *FUTURE BUY HOUSE                                        JOHN MUS
T BUY HOUSE
   50: *POSS *SEE *WRITE CAR *CAR                                    FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *FUTURE *FUTURE *STUDENT HOUSE                           JOHN SHO
ULD NOT BUY HOUSE
   57: *IX *IX *IX MARY                                              JOHN DEC
IDE VISIT MARY
   67: *MARY *IX *JOHN *ARRIVE HOUSE                                 JOHN FUT
URE NOT BUY HOUSE
   71: JOHN WILL VISIT MARY                                          JOHN WIL
L VISIT MARY
   74: *IX *BILL VISIT MARY                                          JOHN NOT
 VISIT MARY
   77: *JOHN BLAME MARY                                              ANN BLAM
E MARY
   84: *JOHN *HAVE *VISIT BOOK                                       IX-1P FI
ND SOMETHING-ONE BOOK
   89: *FUTURE *THROW *IX *IX IX *ARRIVE *BREAK-DOWN                 JOHN IX
 GIVE MAN IX NEW COAT
   90: *SELF *YESTERDAY IX *IX WOMAN *CHOCOLATE                      JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *WOMAN *WOMAN *WOMAN WOMAN BOOK                          JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                       POSS NEW
 CAR BREAK-DOWN
  105: JOHN *FUTURE                                                  JOHN LEG
  107: *MARY POSS *BOX *MARY *TOY1                                   JOHN POS
S FRIEND HAVE CANDY
  108: *IX *HOMEWORK                                                 WOMAN AR
RIVE
  113: IX CAR *IX *JOHN *BOX                                         IX CAR B
LUE SUE BUY
  119: SUE *BUY1 IX CAR *FINISH                                      SUE BUY
 IX CAR BLUE
  122: JOHN *GIVE1 BOOK                                              JOHN REA
D BOOK
  139: JOHN *BUY1 *CAR YESTERDAY BOOK                                JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                  JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE *IX WHO                                                  LOVE JOH
N WHO
  167: *MARY IX *SAY-1P LOVE *IX                                     JOHN IX
 SAY LOVE MARY
  171: *MARY *IX BLAME                                               JOHN MAR
Y BLAME
  174: *NEW *GIVE1 GIVE1 *VISIT *CAR                                 PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN *BOX                                                     JOHN ARR
IVE
  184: *IX BOY *GIVE1 TEACHER APPLE                                  ALL BOY
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 GIVE TEACHER APPLE
  189: *JANA *MARY *PREFER *ARRIVE                                  JOHN GIV
E GIRL BOX
  193: *IX *YESTERDAY *YESTERDAY BOX                                 JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE *JOHN                                        LIKE CHO
COLATE WHO
  201: JOHN *GIVE1 *WOMAN *WOMAN *STUDENT HOUSE                     JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['norm-rx', 'norm-ry', 'norm-lx', 'norm-ly'] <class 'my_model_se
lectors.SelectorDIC'>

**** WER = 0.5955056179775281
Total correct: 72 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: JOHN WRITE *ARRIVE                                           JOHN WRI
TE HOMEWORK
    7: *MARY *CAR GO CAN                                            JOHN CAN
 GO CAN
   12: JOHN *WHAT *ARRIVE CAN                                       JOHN CAN
 GO CAN
   21: *MARY *JOHN *JOHN *BLAME *CAR *CAR *FUTURE CHICKEN           JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN LIKE IX *LIKE IX                                        JOHN LIK
E IX IX IX
   28: *ANN *ANN IX *MARY IX                                        JOHN LIK
E IX IX IX
   30: *IX-1P *CHOCOLATE *MARY *LOVE *LOVE                          JOHN LIK
E IX IX IX
   36: MARY *MARY *YESTERDAY *SHOOT LIKE *IX                        MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: *MARY *JOHN *FUTURE1 *VEGETABLE *MARY                        JOHN IX
 THINK MARY LOVE
   43: JOHN *FUTURE BUY HOUSE                                       JOHN MUS
T BUY HOUSE
   50: *POSS *SEE *JOHN CAR *IX                                     FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *FUTURE *SHOULD *ARRIVE HOUSE                           JOHN SHO
ULD NOT BUY HOUSE
   57: *SHOOT *IX *JOHN *VISIT                                      JOHN DEC
IDE VISIT MARY
   67: *MARY *IX *JOHN *ARRIVE HOUSE                                JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FUTURE VISIT MARY                                      JOHN WIL
L VISIT MARY
   74: *GO *VISIT VISIT MARY                                        JOHN NOT
 VISIT MARY
   77: ANN BLAME MARY                                               ANN BLAM
E MARY
   84: *JOHN *ARRIVE *VISIT BOOK                                    IX-1P FI
ND SOMETHING-ONE BOOK
   89: *MARY *POSS *IX *IX IX *ARRIVE *BREAK-DOWN                   JOHN IX
 GIVE MAN IX NEW COAT
   90: *SELF *IX IX *IX WOMAN BOOK                                  JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
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   92: JOHN *IX IX *IX *LOVE BOOK                                    JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                       POSS NEW
 CAR BREAK-DOWN
  105: JOHN *POSS                                                    JOHN LEG
  107: *MARY POSS *BOX *MARY *TOY1                                   JOHN POS
S FRIEND HAVE CANDY
  108: *LOVE *JOHN                                                   WOMAN AR
RIVE
  113: *SHOULD CAR *IX *JOHN *BOX                                    IX CAR B
LUE SUE BUY
  119: SUE *BUY1 IX *JOHN *GO                                        SUE BUY 
 IX CAR BLUE
  122: JOHN *GIVE1 BOOK                                              JOHN REA
D BOOK
  139: JOHN *BUY1 *CAR *JOHN BOOK                                    JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                  JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                 LOVE JOH
N WHO
  167: JOHN IX *SAY-1P LOVE *IX                                      JOHN IX 
 SAY LOVE MARY
  171: *MARY *JOHN BLAME                                             JOHN MAR
Y BLAME
  174: *CAR *GIVE1 GIVE1 *YESTERDAY *CAR                             PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN *BOX                                                     JOHN ARR
IVE
  184: *IX BOY *GIVE1 TEACHER APPLE                                  ALL BOY 
 GIVE TEACHER APPLE
  189: *MARY *MARY *YESTERDAY BOX                                    JOHN GIV
E GIRL BOX
  193: *LEAVE *YESTERDAY *YESTERDAY BOX                              JOHN GIV
E GIRL BOX
  199: *JOHN *ARRIVE *JOHN                                           LIKE CHO
COLATE WHO
  201: JOHN *GIVE1 *IX *WOMAN *ARRIVE HOUSE                          JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['norm-rx', 'norm-ry', 'norm-lx', 'norm-ly'] <class 'my_model_se
lectors.SelectorCV'>

**** WER = 0.6797752808988764
Total correct: 57 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: JOHN WRITE HOMEWORK                                           JOHN WRI
TE HOMEWORK
    7: JOHN *NEW *MARY *ARRIVE                                       JOHN CAN
 GO CAN
   12: *WHAT *WHAT *GO1 CAN                                          JOHN CAN
 GO CAN
   21: *LIKE FISH *HAVE *IX-1P *VISIT *BLAME *FUTURE *HAVE           JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: *ANN LIKE *ANN *LIKE *ANN                                     JOHN LIK
E IX IX IX
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   28: *ANN *ANN *ANN *ANN *ANN                                                  JOHN LIK
E IX IX IX
   30: *IX-1P LIKE *SHOOT *LIKE *SHOOT                                           JOHN LIK
E IX IX IX
   36: *SHOOT *NOT *YESTERDAY *SHOOT *LEAVE *LIKE                                MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN *VISIT *SELF *NOT LOVE                                               JOHN IX
 THINK MARY LOVE
   43: JOHN *JOHN BUY HOUSE                                                      JOHN MUS
T BUY HOUSE
   50: *POSS *FRANK *HAVE *HAVE *SOMETHING-ONE                                   FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *JOHN *PREFER *WRITE HOUSE                                           JOHN SHO
ULD NOT BUY HOUSE
   57: *SHOOT *WHO *MARY *SHOOT                                                  JOHN DEC
IDE VISIT MARY
   67: *LIKE FUTURE *JOHN *LAST-WEEK HOUSE                                       JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *PREFER *BLAME MARY                                                  JOHN WIL
L VISIT MARY
   74: JOHN *BILL VISIT *LOVE                                                    JOHN NOT
 VISIT MARY
   77: ANN *MARY *LOVE                                                           ANN BLAM
E MARY
   84: *JOHN *HOMEWORK *POSS *WRITE                                              IX-1P FI
ND SOMETHING-ONE BOOK
   89: *WHO *THROW *GO *MARY IX NEW COAT                                         JOHN IX
 GIVE MAN IX NEW COAT
   90: *SELF *GIVE1 IX *FUTURE WOMAN *LOVE                                       JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *GIVE1 IX *IX WOMAN BOOK                                             JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW *HOUSE BREAK-DOWN                                                POSS NEW
 CAR BREAK-DOWN
  105: JOHN *POSS                                                                JOHN LEG
  107: *TELL *IX *BOX *LIKE *TOY1                                                JOHN POS
S FRIEND HAVE CANDY
  108: *LOVE *HOMEWORK                                                           WOMAN AR
RIVE
  113: *HIT CAR *IX *JOHN *BOX                                                   IX CAR B
LUE SUE BUY
  119: *NOT *BUY1 *SOMETHING-ONE *PEOPLE *SUE                                    SUE BUY
 IX CAR BLUE
  122: JOHN *HOUSE BOOK                                                          JOHN REA
D BOOK
  139: JOHN *BUY1 *VIDEOTAPE YESTERDAY *LOVE                                     JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN *ARRIVE *CHICAGO WHAT *COAT                                          JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE *MARY *CORN                                                          LOVE JOH
N WHO
  167: *TELL *GIVE2 *VISIT LOVE MARY                                             JOHN IX
 SAY LOVE MARY
  171: *JANA *JOHN BLAME                                                         JOHN MAR
Y BLAME
  174: *NEW GROUP GIVE1 *TELL TOY                                                PEOPLE G
ROUP GIVE1 JANA TOY
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  181: *VISIT *BOX                                                  JOHN ARR
IVE
  184: *IX BOY *GIVE1 TEACHER APPLE                                 ALL BOY
 GIVE TEACHER APPLE
  189: *TOY1 *GIVE1 *NOT *ARRIVE                                    JOHN GIV
E GIRL BOX
  193: JOHN *SEE *WHO BOX                                           JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE *JOHN                                        LIKE CHO
COLATE WHO
  201: JOHN *GIVE1 *WOMAN *WOMAN *WRITE HOUSE                       JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['polar-rr', 'polar-rtheta', 'polar-lr', 'polar-ltheta'] <class
 'my_model_selectors.SelectorConstant'>

**** WER = 0.6179775280898876
Total correct: 68 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: *GO WRITE HOMEWORK                                           JOHN WRI
TE HOMEWORK
    7: JOHN *WHAT *MARY *WHAT                                       JOHN CAN
 GO CAN
   12: JOHN *WHAT *GO1 CAN                                          JOHN CAN
 GO CAN
   21: *IX *HOMEWORK WONT *FUTURE *CAR *CAR *GO *TOMORROW           JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: *FRANK LIKE IX *WHO IX                                       JOHN LIK
E IX IX IX
   28: *IX *WHO *FUTURE *FUTURE IX                                  JOHN LIK
E IX IX IX
   30: *SHOULD LIKE *GO *MARY *GO                                   JOHN LIK
E IX IX IX
   36: *SOMETHING-ONE VEGETABLE *GIRL *GIVE *MARY *MARY             MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: *SUE *GIVE *DECIDE MARY *GO                                  JOHN IX
 THINK MARY LOVE
   43: *IX *GO BUY HOUSE                                            JOHN MUS
T BUY HOUSE
   50: *POSS *SEE BUY CAR *ARRIVE                                   FUTURE J
OHN BUY CAR SHOULD
   54: JOHN SHOULD *WHO BUY HOUSE                                   JOHN SHO
ULD NOT BUY HOUSE
   57: *MARY *PREFER *MARY MARY                                     JOHN DEC
IDE VISIT MARY
   67: *LIKE *MOTHER NOT BUY HOUSE                                  JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FINISH *GIVE1 MARY                                     JOHN WIL
L VISIT MARY
   74: *GO *WHO *GO *GO                                             JOHN NOT
 VISIT MARY
   77: *IX BLAME *LOVE                                              ANN BLAM
E MARY
   84: *HOMEWORK *GIVE1 *POSS BOOK                                  IX-1P FI
ND SOMETHING-ONE BOOK
   89: *MAN *GIVE *WOMAN *IX IX *BUY *BOOK                          JOHN IX
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 GIVE MAN IX NEW COAT
   90: JOHN *GIVE1 IX *GIVE3 *GIVE1 *COAT                           JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *WOMAN *WOMAN *WOMAN WOMAN BOOK                         JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                      POSS NEW
 CAR BREAK-DOWN
  105: *FRANK *VEGETABLE                                            JOHN LEG
  107: *LIKE *SOMETHING-ONE *HAVE *GO *WHO                          JOHN POS
S FRIEND HAVE CANDY
  108: *IX ARRIVE                                                   WOMAN AR
RIVE
  113: IX CAR *SUE *SOMETHING-ONE *ARRIVE                           IX CAR B
LUE SUE BUY
  119: *PREFER *BUY1 IX CAR *SOMETHING-ONE                          SUE BUY
 IX CAR BLUE
  122: JOHN *GIVE1 BOOK                                             JOHN REA
D BOOK
  139: *SHOULD *BUY1 *CAR YESTERDAY BOOK                            JOHN BUY
 WHAT YESTERDAY BOOK
  142: *FRANK BUY YESTERDAY WHAT BOOK                               JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE *MARY WHO                                               LOVE JOH
N WHO
  167: *MARY *SOMETHING-ONE *MARY LOVE *LOVE                        JOHN IX
 SAY LOVE MARY
  171: *SOMETHING-ONE *SOMETHING-ONE BLAME                          JOHN MAR
Y BLAME
  174: *CAN *GIVE3 GIVE1 *GO *WHAT                                  PEOPLE G
ROUP GIVE1 JANA TOY
  181: *SUE ARRIVE                                                  JOHN ARR
IVE
  184: *IX BOY *GIVE1 TEACHER APPLE                                 ALL BOY
 GIVE TEACHER APPLE
  189: *SUE *SOMETHING-ONE *YESTERDAY *ARRIVE                       JOHN GIV
E GIRL BOX
  193: JOHN *SOMETHING-ONE *YESTERDAY BOX                           JOHN GIV
E GIRL BOX
  199: *HOMEWORK CHOCOLATE WHO                                      LIKE CHO
COLATE WHO
  201: JOHN *MAN *MAN *JOHN BUY HOUSE                               JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['polar-rr', 'polar-rtheta', 'polar-lr', 'polar-ltheta'] <class
 'my_model_selectors.SelectorBIC'>

**** WER = 0.5449438202247191
Total correct: 81 out of 178
Video  Recognized                                                   Correct
=============================================================================
========================
    2: *GO WRITE *NEW                                               JOHN WRI
TE HOMEWORK
    7: JOHN *PEOPLE GO *ARRIVE                                      JOHN CAN
 GO CAN
   12: JOHN *WHAT *GO1 CAN                                          JOHN CAN
 GO CAN
   21: JOHN *NEW WONT *NOT *GIVE1 *TEACHER *FUTURE *WHO             JOHN FIS
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H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN LIKE *LOVE *WHO IX                                          JOHN LIK
E IX IX IX
   28: JOHN *WHO *FUTURE *WHO IX                                        JOHN LIK
E IX IX IX
   30: JOHN LIKE *MARY *MARY *MARY                                      JOHN LIK
E IX IX IX
   36: *VISIT VEGETABLE *GIRL *GIVE *MARY *MARY                         MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN *VISIT *FUTURE1 *JOHN *MARY                                 JOHN IX
 THINK MARY LOVE
   43: JOHN *FUTURE BUY HOUSE                                           JOHN MUS
T BUY HOUSE
   50: *JOHN *SEE *STUDENT CAR *JOHN                                    FUTURE J
OHN BUY CAR SHOULD
   54: JOHN SHOULD *WHO BUY HOUSE                                       JOHN SHO
ULD NOT BUY HOUSE
   57: *MARY *VISIT VISIT MARY                                          JOHN DEC
IDE VISIT MARY
   67: *SHOULD FUTURE *MARY BUY HOUSE                                   JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FINISH *GIVE1 MARY                                         JOHN WIL
L VISIT MARY
   74: *IX *VISIT *GIVE MARY                                            JOHN NOT
 VISIT MARY
   77: *JOHN BLAME *LOVE                                                ANN BLAM
E MARY
   84: *HOMEWORK *GIVE1 *GIVE1 BOOK                                     IX-1P FI
ND SOMETHING-ONE BOOK
   89: *GIVE *GIVE *WOMAN *WOMAN IX *ARRIVE *BREAK-DOWN                 JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN *HAVE IX SOMETHING-ONE *VISIT *BREAK-DOWN                   JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *WOMAN IX *WOMAN WOMAN BOOK                                 JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                          POSS NEW
 CAR BREAK-DOWN
  105: JOHN *VEGETABLE                                                  JOHN LEG
  107: JOHN *IX *HAVE *GO *JANA                                         JOHN POS
S FRIEND HAVE CANDY
  108: *JOHN *HOMEWORK                                                  WOMAN AR
RIVE
  113: IX CAR *IX *IX *BUY1                                             IX CAR B
LUE SUE BUY
  119: *PREFER *BUY1 *CAR CAR *GO                                       SUE BUY
 IX CAR BLUE
  122: JOHN *GIVE1 BOOK                                                 JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT *BLAME *CHOCOLATE                                JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                     JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                    LOVE JOH
N WHO
  167: JOHN IX *VISIT LOVE MARY                                         JOHN IX
 SAY LOVE MARY
  171: JOHN *IX BLAME                                                   JOHN MAR
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Y BLAME
  174: *JOHN *GIVE3 GIVE1 *YESTERDAY *JOHN                          PEOPLE G
ROUP GIVE1 JANA TOY
  181: *EAT ARRIVE                                                  JOHN ARR
IVE
  184: ALL BOY *GIVE1 TEACHER APPLE                                 ALL BOY
 GIVE TEACHER APPLE
  189: *MARY *VISIT *VISIT BOX                                      JOHN GIV
E GIRL BOX
  193: JOHN *POSS *VISIT BOX                                        JOHN GIV
E GIRL BOX
  199: *HOMEWORK *VIDEOTAPE *JOHN                                   LIKE CHO
COLATE WHO
  201: JOHN *MAN *MAN *LIKE BUY HOUSE                               JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['polar-rr', 'polar-rtheta', 'polar-lr', 'polar-ltheta'] <class
 'my_model_selectors.SelectorDIC'>

**** WER = 0.5449438202247191
Total correct: 81 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: JOHN *NEW *GIVE1                                             JOHN WRI
TE HOMEWORK
    7: JOHN CAN GO CAN                                              JOHN CAN
 GO CAN
   12: JOHN *WHAT *JOHN CAN                                         JOHN CAN
 GO CAN
   21: JOHN *NEW *JOHN *PREFER *GIVE1 *WHAT *FUTURE *WHO            JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX IX *WHO IX                                          JOHN LIK
E IX IX IX
   28: JOHN *FUTURE IX *FUTURE *LOVE                                JOHN LIK
E IX IX IX
   30: JOHN LIKE *MARY *MARY *MARY                                  JOHN LIK
E IX IX IX
   36: *IX *VISIT *GIVE *GIVE *MARY *MARY                           MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN *GO *GIVE *JOHN *MARY                                   JOHN IX
 THINK MARY LOVE
   43: JOHN *IX BUY HOUSE                                           JOHN MUS
T BUY HOUSE
   50: *JOHN *SEE BUY CAR *JOHN                                     FUTURE J
OHN BUY CAR SHOULD
   54: JOHN SHOULD NOT BUY HOUSE                                    JOHN SHO
ULD NOT BUY HOUSE
   57: *MARY *GO *GO MARY                                           JOHN DEC
IDE VISIT MARY
   67: *SHOULD FUTURE *MARY BUY HOUSE                               JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FUTURE *GIVE1 MARY                                     JOHN WIL
L VISIT MARY
   74: *IX *GO *GO *VISIT                                           JOHN NOT
 VISIT MARY
   77: *JOHN *GIVE1 MARY                                            ANN BLAM
E MARY
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   84: *HOMEWORK *GIVE1 *GIVE1 *COAT                                     IX-1P FI
ND SOMETHING-ONE BOOK
   89: *GIVE *GIVE *WOMAN *WOMAN IX *ARRIVE *BOOK                        JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN GIVE IX SOMETHING-ONE WOMAN *ARRIVE                          JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *WOMAN IX *WOMAN WOMAN BOOK                                  JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                           POSS NEW
 CAR BREAK-DOWN
  105: JOHN *SEE                                                         JOHN LEG
  107: JOHN POSS *HAVE HAVE *MARY                                        JOHN POS
S FRIEND HAVE CANDY
  108: *LOVE *LOVE                                                       WOMAN AR
RIVE
  113: IX CAR *IX *MARY *JOHN                                            IX CAR B
LUE SUE BUY
  119: *MARY *BUY1 IX *BLAME *IX                                         SUE BUY
 IX CAR BLUE
  122: JOHN *GIVE1 BOOK                                                  JOHN REA
D BOOK
  139: JOHN *ARRIVE WHAT *MARY *ARRIVE                                   JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                      JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                     LOVE JOH
N WHO
  167: JOHN *MARY *VISIT LOVE MARY                                       JOHN IX
 SAY LOVE MARY
  171: *IX MARY BLAME                                                    JOHN MAR
Y BLAME
  174: *JOHN *JOHN GIVE1 *YESTERDAY *JOHN                                PEOPLE G
ROUP GIVE1 JANA TOY
  181: *EAT ARRIVE                                                       JOHN ARR
IVE
  184: *GO BOY *GIVE1 TEACHER *YESTERDAY                                 ALL BOY
 GIVE TEACHER APPLE
  189: *MARY *GO *YESTERDAY BOX                                          JOHN GIV
E GIRL BOX
  193: JOHN *GO *YESTERDAY BOX                                           JOHN GIV
E GIRL BOX
  199: *JOHN *STUDENT *GO                                                LIKE CHO
COLATE WHO
  201: JOHN *MAN *LOVE *JOHN BUY HOUSE                                   JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['polar-rr', 'polar-rtheta', 'polar-lr', 'polar-ltheta'] <class
 'my_model_selectors.SelectorCV'>

**** WER = 0.601123595505618
Total correct: 71 out of 178
Video  Recognized                                                    Correct
=============================================================================
=======================
    2: *POSS WRITE HOMEWORK                                          JOHN WRI
TE HOMEWORK
    7: JOHN *HAVE GO *WHAT                                           JOHN CAN
 GO CAN
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   12: *IX *MANY *WHAT CAN                                              JOHN CAN
 GO CAN
   21: JOHN *NEW *HOMEWORK *JOHN *CAR *CAR *CHICAGO *TOMORROW        JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN LIKE *LOVE *JOHN IX                                      JOHN LIK
E IX IX IX
   28: JOHN *JOHN *MARY *JOHN IX                                     JOHN LIK
E IX IX IX
   30: JOHN LIKE IX *LIKE *SHOOT                                     JOHN LIK
E IX IX IX
   36: MARY VEGETABLE *GIRL *GIVE2 *MARY *MARY                       MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN *GIVE *CORN *SAY-1P *SHOOT                               JOHN IX
 THINK MARY LOVE
   43: JOHN *HIT BUY HOUSE                                           JOHN MUS
T BUY HOUSE
   50: *FRANK *SEE BUY *MANY *WHAT                                   FUTURE J
OHN BUY CAR SHOULD
   54: JOHN SHOULD *WHO BUY HOUSE                                    JOHN SHO
ULD NOT BUY HOUSE
   57: *IX *SEE *GIVE *IX                                            JOHN DEC
IDE VISIT MARY
   67: JOHN *JOHN NOT BUY HOUSE                                      JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FINISH *GO *BLAME                                       JOHN WIL
L VISIT MARY
   74: *IX *IX *MARY *GO                                             JOHN NOT
 VISIT MARY
   77: *JOHN BLAME *SOMETHING-ONE                                    ANN BLAM
E MARY
   84: *FRANK *ARRIVE *HOMEWORK BOOK                                 IX-1P FI
ND SOMETHING-ONE BOOK
   89: *GIVE IX *WOMAN *IX IX *ARRIVE *BOOK                          JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN *GIVE1 *WOMAN *WOMAN WOMAN *CHOCOLATE                    JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *WOMAN IX *WOMAN *SOMETHING-ONE BOOK                     JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                       POSS NEW
 CAR BREAK-DOWN
  105: JOHN *FRANK                                                   JOHN LEG
  107: JOHN *GIVE *HAVE *GO CANDY                                    JOHN POS
S FRIEND HAVE CANDY
  108: *MARY *LOVE                                                   WOMAN AR
RIVE
  113: *GO *HAVE *GO *MARY *BUY1                                     IX CAR B
LUE SUE BUY
  119: *VEGETABLE *BUY1 *GO *HAVE *GIVE                              SUE BUY
 IX CAR BLUE
  122: JOHN *HOUSE BOOK                                              JOHN REA
D BOOK
  139: JOHN *BUY1 *TOY YESTERDAY *LAST-WEEK                          JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN *NEW YESTERDAY *MANY BOOK                                JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                 LOVE JOH
N WHO
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  167: JOHN *MARY *SAY-1P *WOMAN *GO                                    JOHN IX
 SAY LOVE MARY
  171: JOHN MARY BLAME                                                  JOHN MAR
Y BLAME
  174: *CAN GROUP GIVE1 *GIRL *WHAT                                     PEOPLE G
ROUP GIVE1 JANA TOY
  181: *VISIT *BOX                                                      JOHN ARR
IVE
  184: *WOMAN *YESTERDAY *BLAME TEACHER *GIRL                           ALL BOY
 GIVE TEACHER APPLE
  189: JOHN GIVE *YESTERDAY *CAN                                        JOHN GIV
E GIRL BOX
  193: JOHN *GIVE1 *YESTERDAY BOX                                       JOHN GIV
E GIRL BOX
  199: *FRANK CHOCOLATE *FRANK                                          LIKE CHO
COLATE WHO
  201: JOHN *SHOULD *WOMAN *LOVE BUY HOUSE                              JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['delta-rx', 'delta-ry', 'delta-lx', 'delta-ly'] <class 'my_mode
l_selectors.SelectorConstant'>

**** WER = 0.6404494382022472
Total correct: 64 out of 178
Video  Recognized                                                    Correct
==============================================================================
========================
    2: JOHN *JOHN HOMEWORK                                          JOHN WRI
TE HOMEWORK
    7: JOHN *HAVE *GIVE1 *TEACHER                                   JOHN CAN
 GO CAN
   12: JOHN CAN *GO1 CAN                                            JOHN CAN
 GO CAN
   21: *MARY *MARY *JOHN *MARY *CAR *GO *FUTURE *MARY               JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *MARY *JOHN IX *MARY                                    JOHN LIK
E IX IX IX
   28: JOHN *MARY *MARY IX IX                                       JOHN LIK
E IX IX IX
   30: JOHN *MARY *JOHN *JOHN IX                                    JOHN LIK
E IX IX IX
   36: MARY *JOHN *JOHN IX *MARY *MARY                              MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: *MARY IX *MARY MARY *MARY                                    JOHN IX
 THINK MARY LOVE
   43: JOHN *JOHN *FINISH HOUSE                                     JOHN MUS
T BUY HOUSE
   50: *JOHN JOHN BUY CAR *MARY                                     FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *MARY *MARY BUY HOUSE                                   JOHN SHO
ULD NOT BUY HOUSE
   57: JOHN *JOHN *IX *JOHN                                         JOHN DEC
IDE VISIT MARY
   67: JOHN *JOHN *JOHN BUY HOUSE                                   JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *JOHN VISIT MARY                                        JOHN WIL
L VISIT MARY
   74: JOHN *JOHN *MARY MARY                                        JOHN NOT
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 VISIT MARY
   77: *JOHN BLAME MARY                                                   ANN BLAM
E MARY
   84: *JOHN *GO *IX *WHAT                                                IX-1P FI
ND SOMETHING-ONE BOOK
   89: *GIVE1 *JOHN *IX *JOHN IX *WHAT *HOUSE                             JOHN IX
 GIVE MAN IX NEW COAT
   90: *MARY *JOHN *JOHN *IX *IX *MARY                                    JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *MARY *JOHN *JOHN WOMAN *ARRIVE                               JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: *JOHN NEW *WHAT BREAK-DOWN                                         POSS NEW
 CAR BREAK-DOWN
  105: JOHN *MARY                                                         JOHN LEG
  107: JOHN POSS FRIEND *LOVE *MARY                                       JOHN POS
S FRIEND HAVE CANDY
  108: *JOHN ARRIVE                                                       WOMAN AR
RIVE
  113: *JOHN CAR *MARY *MARY *GIVE1                                       IX CAR B
LUE SUE BUY
  119: *JOHN *BUY1 IX CAR *IX                                             SUE BUY
 IX CAR BLUE
  122: JOHN *VISIT *YESTERDAY                                             JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT *MARY *ARRIVE                                      JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY *MARY *MARY *YESTERDAY                                    JOHN BUY
 YESTERDAY WHAT BOOK
  158: *BOY *WHO *MARY                                                    LOVE JOH
N WHO
  167: *MARY *MARY *IX *ARRIVE *WHAT                                      JOHN IX
 SAY LOVE MARY
  171: JOHN *JOHN BLAME                                                   JOHN MAR
Y BLAME
  174: *GIVE1 *MARY GIVE1 *MARY *FINISH                                   PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN *GIVE1                                                        JOHN ARR
IVE
  184: *IX *WHO *GIVE1 *HAVE *MARY                                        ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *IX *MARY *VISIT                                              JOHN GIV
E GIRL BOX
  193: JOHN *IX *IX BOX                                                   JOHN GIV
E GIRL BOX
  199: *JOHN *ARRIVE *MARY                                                LIKE CHO
COLATE WHO
  201: JOHN *MARY MARY *LIKE *VISIT HOUSE                                 JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['delta-rx', 'delta-ry', 'delta-lx', 'delta-ly'] <class 'my_mode
l_selectors.SelectorBIC'>

**** WER = 0.6179775280898876
Total correct: 68 out of 178
Video  Recognized                                                         Correct
=============================================================================
========================
    2: JOHN *LOVE HOMEWORK                                                JOHN WRI
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TE HOMEWORK
    7: JOHN *STUDENT *GIVE1 *STUDENT                                  JOHN CAN
 GO CAN
   12: JOHN CAN *GO1 CAN                                              JOHN CAN
 GO CAN
   21: *MARY *MARY WONT *MARY *CAR *TOMORROW *FUTURE *MARY           JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX *MARY IX IX                                           JOHN LIK
E IX IX IX
   28: JOHN *MARY *JOHN IX *SHOULD                                    JOHN LIK
E IX IX IX
   30: JOHN *IX IX *JOHN IX                                           JOHN LIK
E IX IX IX
   36: *JOHN *JOHN *JOHN IX *MARY *MARY                               MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: *MARY IX *JOHN MARY *MARY                                      JOHN IX
 THINK MARY LOVE
   43: JOHN *IX *FINISH HOUSE                                         JOHN MUS
T BUY HOUSE
   50: *JOHN JOHN BUY CAR *MARY                                       FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *JOHN *JOHN BUY HOUSE                                     JOHN SHO
ULD NOT BUY HOUSE
   57: *MARY *JOHN *IX *IX                                            JOHN DEC
IDE VISIT MARY
   67: JOHN *JOHN *MARY BUY HOUSE                                     JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *MARY VISIT MARY                                          JOHN WIL
L VISIT MARY
   74: JOHN *JOHN *IX MARY                                            JOHN NOT
 VISIT MARY
   77: *JOHN *CAR MARY                                                ANN BLAM
E MARY
   84: *JOHN *GIVE1 *IX BOOK                                          IX-1P FI
ND SOMETHING-ONE BOOK
   89: *MARY *JOHN *IX *IX *JOHN *WHAT *CAN                           JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN *JOHN *JOHN *IX *IX *JOHN                                 JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *IX *JOHN *IX *IX BOOK                                    JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: *JOHN NEW CAR BREAK-DOWN                                       POSS NEW
 CAR BREAK-DOWN
  105: JOHN *JOHN                                                     JOHN LEG
  107: JOHN *JOHN FRIEND *JOHN *MARY                                  JOHN POS
S FRIEND HAVE CANDY
  108: *JOHN *MOVIE                                                   WOMAN AR
RIVE
  113: *JOHN CAR *MARY *MARY *GIVE1                                   IX CAR B
LUE SUE BUY
  119: *JOHN *BUY1 IX CAR *MARY                                       SUE BUY
 IX CAR BLUE
  122: JOHN *ARRIVE *WHAT                                             JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT *JOHN *MARY                                    JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY *FUTURE WHAT *MARY                                    JOHN BUY
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 YESTERDAY WHAT BOOK
  158: *ARRIVE JOHN *JOHN                                            LOVE JOH
N WHO
  167: JOHN IX *IX *CAR *WHAT                                        JOHN IX
 SAY LOVE MARY
  171: JOHN *JOHN BLAME                                              JOHN MAR
Y BLAME
  174: *GIVE1 *MARY GIVE1 *MARY *FINISH                              PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN *GIVE1                                                   JOHN ARR
IVE
  184: *IX *JOHN *GIVE1 *WHO *MARY                                   ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *JOHN *JOHN *ARRIVE                                      JOHN GIV
E GIRL BOX
  193: JOHN *IX *WOMAN BOX                                           JOHN GIV
E GIRL BOX
  199: *JOHN *WHAT *MARY                                             LIKE CHO
COLATE WHO
  201: JOHN *IX MARY *IX BUY HOUSE                                   JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['delta-rx', 'delta-ry', 'delta-lx', 'delta-ly'] <class 'my_mode
l_selectors.SelectorDIC'>

**** WER = 0.6292134831460674
Total correct: 66 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: JOHN *GIVE1 *ARRIVE                                           JOHN WRI
TE HOMEWORK
    7: JOHN *GIVE1 *GIVE1 *ARRIVE                                    JOHN CAN
 GO CAN
   12: JOHN *BOX *JOHN CAN                                           JOHN CAN
 GO CAN
   21: JOHN *MARY *LOVE *MARY *HOUSE *FUTURE *FUTURE *MARY           JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX *JOHN IX IX                                          JOHN LIK
E IX IX IX
   28: JOHN *MARY *JOHN IX *SHOULD                                   JOHN LIK
E IX IX IX
   30: JOHN *IX *SHOULD *JOHN IX                                     JOHN LIK
E IX IX IX
   36: *JOHN *JOHN *JOHN IX *MARY *MARY                              MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: *MARY IX *JOHN MARY *MARY                                     JOHN IX
 THINK MARY LOVE
   43: JOHN *IX BUY HOUSE                                            JOHN MUS
T BUY HOUSE
   50: *JOHN JOHN BUY CAR *MARY                                      FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *JOHN *JOHN BUY HOUSE                                    JOHN SHO
ULD NOT BUY HOUSE
   57: *MARY *JOHN *IX *IX                                           JOHN DEC
IDE VISIT MARY
   67: JOHN *JOHN *MARY BUY HOUSE                                    JOHN FUT
URE NOT BUY HOUSE
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   71: JOHN *MARY VISIT MARY                                     JOHN WIL
L VISIT MARY
   74: JOHN *JOHN *IX MARY                                       JOHN NOT
 VISIT MARY
   77: *JOHN *ARRIVE MARY                                        ANN BLAM
E MARY
   84: *GO *CAR *IX *LOVE                                        IX-1P FI
ND SOMETHING-ONE BOOK
   89: *MARY *JOHN *IX *IX *JOHN *WHAT *CAN                      JOHN IX 
 GIVE MAN IX NEW COAT
   90: JOHN *JOHN *JOHN *IX *IX *MARY                            JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *IX *JOHN *IX WOMAN *MARY                            JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: *JOHN *ARRIVE CAR *HOUSE                                  POSS NEW
 CAR BREAK-DOWN
  105: JOHN *JOHN                                                JOHN LEG
  107: JOHN POSS *ARRIVE *MARY *JOHN                             JOHN POS
S FRIEND HAVE CANDY
  108: *JOHN *LOVE                                               WOMAN AR
RIVE
  113: *JOHN CAR *MARY *IX *GIVE1                                IX CAR B
LUE SUE BUY
  119: *JOHN *GIVE1 IX CAR *MARY                                 SUE BUY 
 IX CAR BLUE
  122: JOHN *GIVE1 *WHAT                                         JOHN REA
D BOOK
  139: JOHN *GIVE1 WHAT *JOHN *WHAT                              JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY *FUTURE WHAT *WHAT                               JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE JOHN *JOHN                                           LOVE JOH
N WHO
  167: JOHN IX *IX *WHAT MARY                                    JOHN IX 
 SAY LOVE MARY
  171: JOHN *JOHN BLAME                                          JOHN MAR
Y BLAME
  174: *GIVE1 *LOVE GIVE1 *JOHN *CAR                             PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN ARRIVE                                               JOHN ARR
IVE
  184: *IX *JOHN *GIVE1 TEACHER *MARY                            ALL BOY 
 GIVE TEACHER APPLE
  189: JOHN *JOHN *JOHN *ARRIVE                                  JOHN GIV
E GIRL BOX
  193: JOHN *IX *WOMAN BOX                                       JOHN GIV
E GIRL BOX
  199: *JOHN *WHAT *MARY                                         LIKE CHO
COLATE WHO
  201: JOHN *IX *IX *JOHN BUY HOUSE                              JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['delta-rx', 'delta-ry', 'delta-lx', 'delta-ly'] <class 'my_mode
l_selectors.SelectorCV'>

**** WER = 0.6235955056179775
Total correct: 67 out of 178
Video  Recognized                                                    Correct
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    2: JOHN *LOVE HOMEWORK                                               JOHN WRI
TE HOMEWORK
    7: JOHN *TOY GO *TEACHER                                             JOHN CAN
 GO CAN
   12: JOHN CAN *GROUP CAN                                               JOHN CAN
 GO CAN
   21: *MARY *MARY *LOVE *MARY *BUY *GO *YESTERDAY *MARY                 JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX *MARY IX IX                                              JOHN LIK
E IX IX IX
   28: JOHN *IX IX IX IX                                                 JOHN LIK
E IX IX IX
   30: JOHN *IX *WHO *JOHN IX                                            JOHN LIK
E IX IX IX
   36: *IX *IX *IX *GIVE *MARY *IX                                       MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: *MARY IX *JOHN *IX *IX                                            JOHN IX 
 THINK MARY LOVE
   43: JOHN *IX BUY HOUSE                                                JOHN MUS
T BUY HOUSE
   50: *JOHN *NOT BUY CAR *MARY                                          FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *JOHN *JOHN BUY HOUSE                                        JOHN SHO
ULD NOT BUY HOUSE
   57: *WOMAN *JOHN *IX *IX                                              JOHN DEC
IDE VISIT MARY
   67: JOHN *WHO *IX BUY *LOVE                                           JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *JOHN VISIT MARY                                             JOHN WIL
L VISIT MARY
   74: JOHN *WHO *IX MARY                                                JOHN NOT
 VISIT MARY
   77: *JOHN BLAME MARY                                                  ANN BLAM
E MARY
   84: *JOHN *GO *IX *MARY                                               IX-1P FI
ND SOMETHING-ONE BOOK
   89: *MARY IX GIVE *IX IX *CAR COAT                                    JOHN IX 
 GIVE MAN IX NEW COAT
   90: *IX *IX *JOHN *IX *LIKE *MARY                                     JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *IX IX *IX *POSS *GROUP                                      JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: *JOHN *GO CAR BREAK-DOWN                                          POSS NEW
 CAR BREAK-DOWN
  105: JOHN *IX                                                          JOHN LEG
  107: JOHN POSS *TOY *MARY *MARY                                        JOHN POS
S FRIEND HAVE CANDY
  108: *JOHN *POTATO                                                     WOMAN AR
RIVE
  113: *JOHN CAR *MARY *JOHN *BUY1                                       IX CAR B
LUE SUE BUY
  119: *JOHN *BUY1 *GO CAR *MARY                                         SUE BUY 
 IX CAR BLUE
  122: JOHN *BOX BOOK                                                    JOHN REA
D BOOK
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  139: JOHN *BUY1 WHAT *IX *MARY                                      JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT *MARY                                  JOHN BUY
 YESTERDAY WHAT BOOK
  158: *GIVE1 *MARY *MARY                                             LOVE JOH
N WHO
  167: JOHN IX *IX *ARRIVE *WHAT                                      JOHN IX 
 SAY LOVE MARY
  171: *IX *JOHN BLAME                                                JOHN MAR
Y BLAME
  174: *GO *MARY GIVE1 *MARY *PEOPLE                                  PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN *GIVE1                                                    JOHN ARR
IVE
  184: *GIVE *JOHN *GIVE1 TEACHER *MARY                               ALL BOY 
 GIVE TEACHER APPLE
  189: JOHN *IX *JOHN *WHAT                                           JOHN GIV
E GIRL BOX
  193: JOHN *IX *LIKE BOX                                             JOHN GIV
E GIRL BOX
  199: *JOHN *BOOK *MARY                                              LIKE CHO
COLATE WHO
  201: JOHN *IX *IX *LIKE BUY HOUSE                                   JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['dist-norm-left-right', 'delta-dist-norm-left-right'] <class 'm
y_model_selectors.SelectorConstant'>

**** WER = 0.8651685393258427
Total correct: 24 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: *FUTURE *ARRIVE *CHOCOLATE                                     JOHN WRI
TE HOMEWORK
    7: JOHN *BUY1 *BLUE *FRIEND                                       JOHN CAN
 GO CAN
   12: *WRITE *STOLEN *GIVE *WHAT                                     JOHN CAN
 GO CAN
   21: *MARY *TOY1 WONT *PREFER *BLAME *CAR *SHOULD *JOHN             JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: *ALL *FUTURE1 *GO1 *MAN *WHAT                                  JOHN LIK
E IX IX IX
   28: *MAN *GIVE3 *GO1 *ANN *WANT                                    JOHN LIK
E IX IX IX
   30: *WONT *MOTHER *KNOW *CHICAGO *TELL                             JOHN LIK
E IX IX IX
   36: *SAY-1P *FIND *TELL *OLD *CANDY *LIKE                          MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: *TOY1 *LOVE *CORN1 *BROCCOLI *SELF                             JOHN IX 
 THINK MARY LOVE
   43: *ARRIVE *GIRL BUY *CAN                                         JOHN MUS
T BUY HOUSE
   50: *PAST *BREAK-DOWN *WRITE CAR *MARY                             FUTURE J
OHN BUY CAR SHOULD
   54: *TOY1 *KNOW *GIRL BUY HOUSE                                    JOHN SHO
ULD NOT BUY HOUSE
   57: *JANA *PREFER *POSS *BREAK-DOWN                                JOHN DEC
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IDE VISIT MARY
   67: *WONT FUTURE NOT BUY *CAN                                          JOHN FUT
URE NOT BUY HOUSE
   71: *BUY WILL *JOHN *VISIT                                             JOHN WIL
L VISIT MARY
   74: *TOY1 *CANDY *NOT *PREFER                                          JOHN NOT
 VISIT MARY
   77: ANN *STUDENT *BUT                                                  ANN BLAM
E MARY
   84: *BROTHER *BUY1 *ARRIVE *SAY                                        IX-1P FI
ND SOMETHING-ONE BOOK
   89: *YESTERDAY *PUTASIDE *GO1 *SOMETHING-ONE *HOUSE *SHOOT *BOOK  JOHN IX
 GIVE MAN IX NEW COAT
   90: *VEGETABLE *FUTURE *GO1 *ALL *HAVE BOOK                            JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: *SHOOT *YESTERDAY *WHAT *TEACHER *TEACHER *NEXT-WEEK               JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: *LOVE NEW *STOLEN BREAK-DOWN                                       POSS NEW
 CAR BREAK-DOWN
  105: *SEE *GIRL                                                         JOHN LEG
  107: *LIKE *NEW *ARRIVE *WONT *SAY-1P                                   JOHN POS
S FRIEND HAVE CANDY
  108: *NEXT-WEEK *SOMETHING-ONE                                          WOMAN AR
RIVE
  113: *SHOOT *BOX *VEGETABLE *NOT *BUY1                                  IX CAR B
LUE SUE BUY
  119: *JANA *BUY1 *LOVE *HOMEWORK *FRIEND                                SUE BUY
 IX CAR BLUE
  122: *BUY *ARRIVE *APPLE                                                JOHN REA
D BOOK
  139: *WONT *BUY1 *LOVE *GO1 BOOK                                        JOHN BUY
 WHAT YESTERDAY BOOK
  142: *BREAK-DOWN *FRIEND *CHICAGO WHAT *CORN                            JOHN BUY
 YESTERDAY WHAT BOOK
  158: *BLAME *BOY *PREFER                                                LOVE JOH
N WHO
  167: *WONT *BUY *SAY-1P LOVE *BOY                                       JOHN IX
 SAY LOVE MARY
  171: *LIKE *MOTHER BLAME                                                JOHN MAR
Y BLAME
  174: *ARRIVE *YESTERDAY *CAR *CORN1 *LOVE                               PEOPLE G
ROUP GIVE1 JANA TOY
  181: *TEACHER ARRIVE                                                    JOHN ARR
IVE
  184: *GIVE1 *FRIEND *GIVE1 TEACHER *PREFER                              ALL BOY
 GIVE TEACHER APPLE
  189: *WHO *VEGETABLE *PREFER BOX                                        JOHN GIV
E GIRL BOX
  193: *SUE *HERE GIRL *CAR                                               JOHN GIV
E GIRL BOX
  199: *OLD *WONT *SEE                                                    LIKE CHO
COLATE WHO
  201: JOHN *THINK *COAT *NOT BUY *GIVE                                   JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['dist-norm-left-right', 'delta-dist-norm-left-right'] <class 'm
y_model_selectors.SelectorBIC'>
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**** WER = 0.8089887640449438
Total correct: 34 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: *FUTURE *ARRIVE *CHOCOLATE                                   JOHN WRI
TE HOMEWORK
    7: *JANA *BUY1 *BLUE *FRIEND                                    JOHN CAN
 GO CAN
   12: *BUY *BUT *WHAT *WHAT                                        JOHN CAN
 GO CAN
   21: JOHN *TOY1 *WHO *JOHN *BLAME *BLAME *JOHN *JOHN              JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: *TEACHER *VIDEOTAPE *CAN *NEW *PUTASIDE                      JOHN LIK
E IX IX IX
   28: *BREAK-DOWN *GIVE *GO1 *MAN *WANT                            JOHN LIK
E IX IX IX
   30: *WHO *MOTHER *PAST *SHOULD *TELL                             JOHN LIK
E IX IX IX
   36: *JOHN *FIND KNOW *PREFER *CANDY *JOHN                        MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: *TOY1 *SOMETHING-ONE *CORN1 *BROCCOLI *JOHN                  JOHN IX
 THINK MARY LOVE
   43: JOHN *GIRL BUY *CAN                                          JOHN MUS
T BUY HOUSE
   50: *PAST *BREAK-DOWN *BUY1 CAR *MARY                            FUTURE J
OHN BUY CAR SHOULD
   54: *MOVIE *SELF *GIRL BUY HOUSE                                 JOHN SHO
ULD NOT BUY HOUSE
   57: JOHN *PREFER *IX *BREAK-DOWN                                 JOHN DEC
IDE VISIT MARY
   67: JOHN *IX *CHICKEN BUY *CAN                                   JOHN FUT
URE NOT BUY HOUSE
   71: *BUY *SHOULD *JOHN *VISIT                                    JOHN WIL
L VISIT MARY
   74: *MOVIE *SUE *JOHN *NEW-YORK                                  JOHN NOT
 VISIT MARY
   77: *SUE *STUDENT *CAN                                           ANN BLAM
E MARY
   84: *BROTHER *BUY1 *WRITE *SAY                                   IX-1P FI
ND SOMETHING-ONE BOOK
   89: *YESTERDAY *YESTERDAY *GO1 *SOMETHING-ONE *HOUSE *CHICAGO *BOOK  JOHN
 IX GIVE MAN IX NEW COAT
   90: *VEGETABLE *FUTURE *GO1 SOMETHING-ONE *JOHN BOOK             JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *YESTERDAY *WHAT *WHAT *TEACHER BOOK                    JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: *IX NEW *STOLEN BREAK-DOWN                                   POSS NEW
 CAR BREAK-DOWN
  105: JOHN *GIRL                                                   JOHN LEG
  107: JOHN *BLAME *ARRIVE *JOHN *JOHN                              JOHN POS
S FRIEND HAVE CANDY
  108: *FRIEND *JOHN                                                WOMAN AR
RIVE
  113: *JOHN *BOX *GIVE *SHOULD *BUY1                               IX CAR B
LUE SUE BUY
  119: *JANA *BUY1 *TOY *HOMEWORK *POSS                             SUE BUY
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 IX CAR BLUE
  122: JOHN *IX *APPLE                                                  JOHN REA
D BOOK
  139: JOHN *BUY1 *LOVE *WHAT BOOK                                      JOHN BUY
 WHAT YESTERDAY BOOK
  142: *EAT *FRIEND YESTERDAY WHAT *CORN                                JOHN BUY
 YESTERDAY WHAT BOOK
  158: *WHAT *PEOPLE *FRANK                                             LOVE JOH
N WHO
  167: JOHN *JOHN *IX-1P LOVE *MAN                                      JOHN IX
 SAY LOVE MARY
  171: *LIKE *JOHN BLAME                                                JOHN MAR
Y BLAME
  174: *TOY *KNOW *CAR *CORN1 *LOVE                                     PEOPLE G
ROUP GIVE1 JANA TOY
  181: *TEACHER ARRIVE                                                  JOHN ARR
IVE
  184: *GIVE1 *WHO *GIVE1 *TOY *PREFER                                  ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *JOHN *PREFER BOX                                           JOHN GIV
E GIRL BOX
  193: JOHN *JOHN GIRL *CAR                                             JOHN GIV
E GIRL BOX
  199: *OLD CHOCOLATE *SEE                                              LIKE CHO
COLATE WHO
  201: JOHN *THINK *KNOW *MARY BUY *GIVE                                JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['dist-norm-left-right', 'delta-dist-norm-left-right'] <class 'm
y_model_selectors.SelectorDIC'>

**** WER = 0.8370786516853933
Total correct: 29 out of 178
Video  Recognized                                                    Correct
==============================================================================
========================
    2: JOHN *STUDENT *IX                                                JOHN WRI
TE HOMEWORK
    7: *MARY *BUY1 *MARY CAN                                            JOHN CAN
 GO CAN
   12: JOHN *ALL *BROTHER *HOUSE                                        JOHN CAN
 GO CAN
   21: *MARY *TOY1 *SHOULD *SUE *CAR *BLAME *FUTURE *WHO                JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: *CAN *FUTURE1 *HOUSE *BOX IX                                     JOHN LIK
E IX IX IX
   28: *ANN *GIVE3 *PEOPLE *NEW IX                                      JOHN LIK
E IX IX IX
   30: *SHOULD *MOTHER *PAST *SHOULD *NAME                              JOHN LIK
E IX IX IX
   36: *SUE *NOT *YESTERDAY *BREAK-DOWN *CANDY *CHOCOLATE               MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: *TOY1 *POSS *WHO *SAY *WHO                                       JOHN IX
 THINK MARY LOVE
   43: *GO *NOT *FRIEND HOUSE                                           JOHN MUS
T BUY HOUSE
   50: *SEE *APPLE *ARRIVE CAR *MARY                                    FUTURE J
OHN BUY CAR SHOULD
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   54: *CHOCOLATE *KNOW *SHOULD *STUDENT *GO                         JOHN SHO
ULD NOT BUY HOUSE
   57: JOHN *LEAVE *IX *BREAK-DOWN                                   JOHN DEC
IDE VISIT MARY
   67: JOHN FUTURE *GIRL *SHOOT *CAN                                 JOHN FUT
URE NOT BUY HOUSE
   71: *LOVE *SHOULD *ARRIVE *FUTURE                                 JOHN WIL
L VISIT MARY
   74: *TOY1 *CANDY *SHOULD *WRITE                                   JOHN NOT
 VISIT MARY
   77: *SOMETHING-ONE *LOVE MARY                                     ANN BLAM
E MARY
   84: *BROTHER *IX *WRITE *PAST                                     IX-1P FI
ND SOMETHING-ONE BOOK
   89: *YESTERDAY *YESTERDAY *PEOPLE *BREAK-DOWN *HOUSE *POSS *APPLE  JOHN IX
 GIVE MAN IX NEW COAT
   90: *VEGETABLE *POSS *LOVE *TEACHER WOMAN BOOK                    JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *POSS IX *HOUSE *CAN BOOK                                JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: *IX NEW CAR *WOMAN                                            POSS NEW
 CAR BREAK-DOWN
  105: *YESTERDAY *APPLE                                             JOHN LEG
  107: JOHN *IX *ARRIVE *JOHN *SUE                                   JOHN POS
S FRIEND HAVE CANDY
  108: *SOMETHING-ONE *HOMEWORK                                      WOMAN AR
RIVE
  113: *JOHN *POSS *MARY *MAN *BUY1                                  IX CAR B
LUE SUE BUY
  119: *JANA *ARRIVE *CAR *POSS *BOX                                 SUE BUY
 IX CAR BLUE
  122: JOHN *ARRIVE *APPLE                                           JOHN REA
D BOOK
  139: *TOMORROW *ARRIVE *LOVE *GIVE1 *DECIDE                        JOHN BUY
 WHAT YESTERDAY BOOK
  142: *WOMAN *LOVE *CAR WHAT *CORN                                  JOHN BUY
 YESTERDAY WHAT BOOK
  158: *BLAME JOHN WHO                                               LOVE JOH
N WHO
  167: *CHOCOLATE *JOHN *SAY-1P *GO *JOHN                            JOHN IX
 SAY LOVE MARY
  171: *MARY *MOTHER *WHAT                                           JOHN MAR
Y BLAME
  174: *CAN *KNOW *BLAME *WHO *LOVE                                  PEOPLE G
ROUP GIVE1 JANA TOY
  181: *HOUSE ARRIVE                                                 JOHN ARR
IVE
  184: *GIVE1 *WHO *GIVE1 *BROTHER *WRITE                            ALL BOY
 GIVE TEACHER APPLE
  189: *SUE *GO *NOT BOX                                             JOHN GIV
E GIRL BOX
  193: JOHN *KNOW *PAST *CAR                                         JOHN GIV
E GIRL BOX
  199: *CHICKEN CHOCOLATE *SEE                                       LIKE CHO
COLATE WHO
  201: JOHN *THINK *YESTERDAY *LIKE BUY *GIVE                        JOHN TEL
L MARY IX-1P BUY HOUSE
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----running: ['dist-norm-left-right', 'delta-dist-norm-left-right'] <class 'm
y_model_selectors.SelectorCV'>

**** WER = 0.8089887640449438
Total correct: 34 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: JOHN *ARRIVE *CHOCOLATE                                       JOHN WRI
TE HOMEWORK
    7: JOHN *BUY *MARY CAN                                           JOHN CAN
 GO CAN
   12: JOHN *BUT *THROW *HOUSE                                       JOHN CAN
 GO CAN
   21: JOHN *TOY1 *WHO *JANA *WHAT *BLAME *SHOULD *JOHN              JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: *GIVE1 *NEXT-WEEK *HOUSE *GIVE1 *WHAT                         JOHN LIK
E IX IX IX
   28: *MAN *GIRL *HOUSE *GIVE1 *HOUSE                               JOHN LIK
E IX IX IX
   30: *WHO *MOTHER *JOHN *SHOULD *TELL                              JOHN LIK
E IX IX IX
   36: *JOHN *JOHN *GIRL *LOVE *CANDY *JOHN                          MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: *TOY1 *NEW *CORN *NEW-YORK *MARY                              JOHN IX
 THINK MARY LOVE
   43: *YESTERDAY *GIRL BUY HOUSE                                    JOHN MUS
T BUY HOUSE
   50: *PREFER *PREFER *BUY1 *WHAT *JOHN                             FUTURE J
OHN BUY CAR SHOULD
   54: *MOTHER *SELF *CORN *JOHN HOUSE                               JOHN SHO
ULD NOT BUY HOUSE
   57: *NOT *SELF *IX *BREAK-DOWN                                    JOHN DEC
IDE VISIT MARY
   67: JOHN *YESTERDAY *VISIT BUY *CAN                               JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *THINK *BUY1 *FUTURE                                     JOHN WIL
L VISIT MARY
   74: *MOTHER *CANDY *MARY *PREFER                                  JOHN NOT
 VISIT MARY
   77: ANN *LOVE *GO1                                                ANN BLAM
E MARY
   84: *BOY *BUY1 SOMETHING-ONE *GIRL                                IX-1P FI
ND SOMETHING-ONE BOOK
   89: *BOOK *YESTERDAY *CAN *SOMETHING-ONE *HOUSE *IX *BOOK         JOHN IX
 GIVE MAN IX NEW COAT
   90: *VEGETABLE *GIVE1 *GO1 *MAN WOMAN *CAN                        JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *YESTERDAY *WHAT *WHAT *VIDEOTAPE BOOK                   JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: *LOVE *VIDEOTAPE *WHAT BREAK-DOWN                             POSS NEW
 CAR BREAK-DOWN
  105: *WHO *GIRL                                                    JOHN LEG
  107: JOHN *BLAME *BUY1 *JOHN *MARY                                 JOHN POS
S FRIEND HAVE CANDY
  108: *BOOK *JOHN                                                   WOMAN AR
RIVE
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  113: *JOHN *NEW *MARY *NOT *BUY1                                    IX CAR B
LUE SUE BUY
  119: *JANA *BUY1 *LOVE *FINISH *CHICAGO                             SUE BUY
 IX CAR BLUE
  122: JOHN *LOVE *CHINA                                              JOHN REA
D BOOK
  139: JOHN *ARRIVE *GIVE1 *THROW *DECIDE                             JOHN BUY
 WHAT YESTERDAY BOOK
  142: *VISIT *LOVE YESTERDAY WHAT *CORN                              JOHN BUY
 YESTERDAY WHAT BOOK
  158: *BLAME *ARRIVE *NEW-YORK                                       LOVE JOH
N WHO
  167: JOHN *BUY1 *CANDY *CAN MARY                                    JOHN IX
 SAY LOVE MARY
  171: *LIKE *JOHN BLAME                                              JOHN MAR
Y BLAME
  174: *BOX *THINK *BLAME *NEW-YORK *GO                               PEOPLE G
ROUP GIVE1 JANA TOY
  181: *HOUSE *LOVE                                                   JOHN ARR
IVE
  184: *GIVE1 BOY *GIVE1 TEACHER *PREFER                              ALL BOY
 GIVE TEACHER APPLE
  189: *JANA *MARY *IX BOX                                            JOHN GIV
E GIRL BOX
  193: JOHN *YESTERDAY GIRL *GIVE1                                    JOHN GIV
E GIRL BOX
  199: *VISIT CHOCOLATE *BLUE                                         LIKE CHO
COLATE WHO
  201: JOHN *MOTHER *THINK *CHICKEN BUY HOUSE                         JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['delta-norm-rx', 'delta-norm-ry', 'delta-norm-lx', 'delta-norm-
ly'] <class 'my_model_selectors.SelectorConstant'>

**** WER = 0.5449438202247191
Total correct: 81 out of 178
Video  Recognized                                                    Correct
==============================================================================
========================
    2: JOHN *JOHN HOMEWORK                                            JOHN WRI
TE HOMEWORK
    7: JOHN *VISIT *GIVE1 *TEACHER                                    JOHN CAN
 GO CAN
   12: JOHN CAN *GO1 CAN                                              JOHN CAN
 GO CAN
   21: JOHN FISH *HOMEWORK *APPLE *NEW *GO *MARY *BOOK                JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX *JOHN IX IX                                           JOHN LIK
E IX IX IX
   28: JOHN *MARY IX IX IX                                            JOHN LIK
E IX IX IX
   30: JOHN *IX *MARY *JOHN IX                                        JOHN LIK
E IX IX IX
   36: MARY *JOHN *JOHN IX *JOHN *JOHN                                MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN IX *VEGETABLE MARY *MARY                                  JOHN IX
 THINK MARY LOVE
   43: JOHN *JOHN BUY HOUSE                                           JOHN MUS
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T BUY HOUSE
    50: *JOHN *WHO BUY CAR *MARY   FUTURE J
OHN BUY CAR SHOULD
    54: JOHN *JOHN *WHO BUY HOUSE   JOHN SHO
ULD NOT BUY HOUSE
    57: JOHN *JOHN *IX *JOHN   JOHN DEC
IDE VISIT MARY
    67: JOHN *JOHN *JOHN BUY HOUSE   JOHN FUT
URE NOT BUY HOUSE
    71: JOHN *JOHN VISIT MARY   JOHN WIL
L VISIT MARY
    74: JOHN *MARY *IX *JOHN   JOHN NOT
 VISIT MARY
    77: *JOHN BLAME *JOHN   ANN BLAM
E MARY
    84: *JOHN *NEW *IX *NEW   IX-1P FI
ND SOMETHING-ONE BOOK
    89: JOHN *JOHN *IX *JOHN IX NEW *HOUSE   JOHN IX
 GIVE MAN IX NEW COAT
    90: *WHO *JOHN *JOHN *IX *IX BOOK   JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
    92: JOHN *IX IX *JOHN WOMAN *ARRIVE   JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   100: *JOHN NEW CAR BREAK-DOWN   POSS NEW
 CAR BREAK-DOWN
   105: JOHN *JOHN   JOHN LEG
   107: JOHN *IX FRIEND HAVE *JOHN   JOHN POS
S FRIEND HAVE CANDY
   108: *JOHN ARRIVE   WOMAN AR
RIVE
   113: *JOHN CAR *MARY *MARY *BUY1   IX CAR B
LUE SUE BUY
   119: *JOHN *BUY1 IX CAR *MARY   SUE BUY
 IX CAR BLUE
   122: JOHN READ *YESTERDAY   JOHN REA
D BOOK
   139: JOHN *BUY1 WHAT *JOHN *STOLEN   JOHN BUY
 WHAT YESTERDAY BOOK
   142: JOHN BUY YESTERDAY WHAT *YESTERDAY   JOHN BUY
 YESTERDAY WHAT BOOK
   158: LOVE *IX WHO   LOVE JOH
N WHO
   167: JOHN IX *LIKE LOVE *HERE   JOHN IX
 SAY LOVE MARY
   171: JOHN *JOHN BLAME   JOHN MAR
Y BLAME
   174: *CAR *LOVE GIVE1 *WHAT *FINISH   PEOPLE G
ROUP GIVE1 JANA TOY
   181: JOHN *GIVE1   JOHN ARR
IVE
   184: *IX *WHO *GIVE1 TEACHER *MARY   ALL BOY
 GIVE TEACHER APPLE
   189: JOHN *IX *WHAT *WHAT   JOHN GIV
E GIRL BOX
   193: JOHN *IX *IX BOX   JOHN GIV
E GIRL BOX
   199: *JOHN *ARRIVE *BROCCOLI   LIKE CHO

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COLATE WHO
  201: JOHN *IX MARY *IX *VISIT HOUSE                               JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['delta-norm-rx', 'delta-norm-ry', 'delta-norm-lx', 'delta-norm-
ly'] <class 'my_model_selectors.SelectorBIC'>

**** WER = 0.5449438202247191
Total correct: 81 out of 178
Video  Recognized                                                    Correct
=============================================================================
=======================
    2: JOHN *IX HOMEWORK                                            JOHN WRI
TE HOMEWORK
    7: JOHN *PEOPLE GO *TEACHER                                     JOHN CAN
 GO CAN
   12: JOHN *BOX *GO1 CAN                                           JOHN CAN
 GO CAN
   21: JOHN *NAME *HOMEWORK *MARY *BUY *GO *YESTERDAY *MARY         JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX IX IX IX                                            JOHN LIK
E IX IX IX
   28: JOHN *MARY IX IX IX                                          JOHN LIK
E IX IX IX
   30: JOHN *IX IX *JOHN IX                                         JOHN LIK
E IX IX IX
   36: *JOHN *SEE *IX IX *JOHN *MARY                                MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN IX *JOHN MARY *MARY                                     JOHN IX 
 THINK MARY LOVE
   43: JOHN *IX *FINISH HOUSE                                       JOHN MUS
T BUY HOUSE
   50: *JOHN *IX BUY CAR *MARY                                      FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *JOHN *WHO BUY HOUSE                                    JOHN SHO
ULD NOT BUY HOUSE
   57: JOHN *JOHN *IX *IX                                           JOHN DEC
IDE VISIT MARY
   67: JOHN *IX *WOMAN BUY HOUSE                                    JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *JOHN VISIT *CAR                                        JOHN WIL
L VISIT MARY
   74: JOHN *IX *IX MARY                                            JOHN NOT
 VISIT MARY
   77: *JOHN BLAME MARY                                             ANN BLAM
E MARY
   84: *JOHN *NEW *IX *BUY1                                         IX-1P FI
ND SOMETHING-ONE BOOK
   89: JOHN IX *IX *IX IX NEW COAT                                  JOHN IX 
 GIVE MAN IX NEW COAT
   90: JOHN *IX IX *IX *IX *MARY                                    JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *IX IX *IX WOMAN *FINISH                                JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: *JOHN NEW CAR *MANY                                          POSS NEW
 CAR BREAK-DOWN
  105: JOHN *JOHN                                                   JOHN LEG
  107: JOHN *JOHN FRIEND *YESTERDAY *JOHN                           JOHN POS
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S FRIEND HAVE CANDY
  108: *IX ARRIVE                                                WOMAN AR
RIVE
  113: *JOHN CAR *MARY *IX *BUY1                                 IX CAR B
LUE SUE BUY
  119: *JOHN *BUY1 *HERE CAR *HAVE                               SUE BUY
 IX CAR BLUE
  122: JOHN READ *HERE                                           JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT *JOHN *MARY                               JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                              JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE JOHN *JOHN                                           LOVE JOH
N WHO
  167: JOHN *JOHN *LIKE LOVE *HERE                               JOHN IX
 SAY LOVE MARY
  171: *IX *JOHN BLAME                                           JOHN MAR
Y BLAME
  174: *VISIT *YESTERDAY GIVE1 *MARY *WANT                       PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN *BUY1                                                JOHN ARR
IVE
  184: *IX *JOHN *GIVE1 TEACHER *MARY                            ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *IX *JOHN *ARRIVE                                    JOHN GIV
E GIRL BOX
  193: JOHN *IX *IX BOX                                          JOHN GIV
E GIRL BOX
  199: *JOHN *JOHN *MARY                                         LIKE CHO
COLATE WHO
  201: JOHN *MARY MARY *SOMETHING-ONE BUY HOUSE                  JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['delta-norm-rx', 'delta-norm-ry', 'delta-norm-lx', 'delta-norm-
ly'] <class 'my_model_selectors.SelectorDIC'>

**** WER = 0.5955056179775281
Total correct: 72 out of 178
Video  Recognized                                                Correct
=============================================================================
========================
    2: JOHN WRITE HOMEWORK                                       JOHN WRI
TE HOMEWORK
    7: JOHN *HAVE *CAR *VISIT                                    JOHN CAN
 GO CAN
   12: JOHN *BOX *GO1 CAN                                        JOHN CAN
 GO CAN
   21: JOHN FISH *GIVE1 *MARY BUT *BLAME *MARY *MARY             JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *WHAT *JOHN IX *CORN                                 JOHN LIK
E IX IX IX
   28: JOHN *MARY *JOHN *JOHN IX                                 JOHN LIK
E IX IX IX
   30: JOHN *MARY *PUTASIDE *JOHN IX                             JOHN LIK
E IX IX IX
   36: *JOHN *JOHN *JOHN *GIVE *JOHN *JOHN                       MARY VEG
ETABLE KNOW IX LIKE CORN1
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   40: JOHN IX *JOHN MARY *MARY                                                      JOHN IX
 THINK MARY LOVE
   43: JOHN *WOMAN *GO HOUSE                                                          JOHN MUS
T BUY HOUSE
   50: *JOHN *VISIT BUY CAR *MARY                                                     FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *JOHN *WHO BUY HOUSE                                                      JOHN SHO
ULD NOT BUY HOUSE
   57: JOHN *JOHN *SOMETHING-ONE *JOHN                                                JOHN DEC
IDE VISIT MARY
   67: JOHN *JOHN *WOMAN *NEW HOUSE                                                   JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *JOHN VISIT *CAR                                                          JOHN WIL
L VISIT MARY
   74: JOHN *JOHN *MARY MARY                                                          JOHN NOT
 VISIT MARY
   77: *JOHN BLAME *JOHN                                                              ANN BLAM
E MARY
   84: *JOHN *CAR *JOHN BOOK                                                          IX-1P FI
ND SOMETHING-ONE BOOK
   89: JOHN *JOHN GIVE *IX *JOHN *WHAT *CAN                                           JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN *JOHN *JOHN *GIVE WOMAN BOOK                                              JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *IX *JOHN *JOHN WOMAN *JOHN                                               JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: *JOHN NEW CAR *BOOK                                                            POSS NEW
 CAR BREAK-DOWN
  105: JOHN *JOHN                                                                     JOHN LEG
  107: JOHN *JOHN FRIEND *JOHN *JOHN                                                  JOHN POS
S FRIEND HAVE CANDY
  108: *JOHN ARRIVE                                                                   WOMAN AR
RIVE
  113: *JOHN CAR *MARY *JOHN *BUY1                                                    IX CAR B
LUE SUE BUY
  119: *JOHN *BUY1 IX CAR *MARY                                                       SUE BUY
 IX CAR BLUE
  122: JOHN *CAR BOOK                                                                 JOHN REA
D BOOK
  139: JOHN *BUY1 *CAR *JOHN *MARY                                                    JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY *JOHN WHAT *CAR                                                       JOHN BUY
 YESTERDAY WHAT BOOK
  158: *JOHN JOHN *JOHN                                                               LOVE JOH
N WHO
  167: JOHN IX *OLD *GIVE1 MARY                                                       JOHN IX
 SAY LOVE MARY
  171: JOHN *JOHN BLAME                                                               JOHN MAR
Y BLAME
  174: *CAR *JOHN GIVE1 *JOHN *CAR                                                    PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN ARRIVE                                                                    JOHN ARR
IVE
  184: *GIVE *JOHN *GIVE1 TEACHER *MARY                                               ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *JOHN *JOHN *ARRIVE                                                       JOHN GIV
E GIRL BOX
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  193: JOHN *JOHN *WOMAN BOX                                        JOHN GIV
E GIRL BOX
  199: *JOHN *JOHN *MARY                                            LIKE CHO
COLATE WHO
  201: JOHN *MARY *JOHN *WOMAN BUY HOUSE                            JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['delta-norm-rx', 'delta-norm-ry', 'delta-norm-lx', 'delta-norm-
ly'] <class 'my_model_selectors.SelectorCV'>

**** WER = 0.5730337078651685
Total correct: 76 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: JOHN *LOVE HOMEWORK                                          JOHN WRI
TE HOMEWORK
    7: JOHN *TOY GO *TEACHER                                        JOHN CAN
 GO CAN
   12: JOHN *BOX *GO1 CAN                                           JOHN CAN
 GO CAN
   21: JOHN *JOHN *TOMORROW *MARY *BUY *GO *FUTURE *MARY            JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX *YESTERDAY IX IX                                    JOHN LIK
E IX IX IX
   28: JOHN *IX IX IX IX                                            JOHN LIK
E IX IX IX
   30: JOHN *IX *LOVE *JOHN IX                                      JOHN LIK
E IX IX IX
   36: *IX *JOHN *JOHN IX *WHAT *IX                                 MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN IX *JOHN *IX *IX                                        JOHN IX 
 THINK MARY LOVE
   43: JOHN *WOMAN BUY HOUSE                                        JOHN MUS
T BUY HOUSE
   50: *JOHN JOHN BUY CAR *FUTURE                                   FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *IX *IX BUY HOUSE                                       JOHN SHO
ULD NOT BUY HOUSE
   57: JOHN *JOHN *IX *IX                                           JOHN DEC
IDE VISIT MARY
   67: JOHN *JOHN *IX BUY HOUSE                                     JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *JOHN VISIT MARY                                        JOHN WIL
L VISIT MARY
   74: JOHN *IX *IX MARY                                            JOHN NOT
 VISIT MARY
   77: *JOHN BLAME MARY                                             ANN BLAM
E MARY
   84: *ANN *NEW *LOVE BOOK                                         IX-1P FI
ND SOMETHING-ONE BOOK
   89: JOHN IX GIVE *IX *MARY *WHAT COAT                            JOHN IX 
 GIVE MAN IX NEW COAT
   90: *MARY *JOHN *JOHN *IX WOMAN BOOK                             JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *IX IX *IX *POSS *NEW                                   JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: *JOHN NEW CAR BREAK-DOWN                                     POSS NEW
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 CAR BREAK-DOWN
  105: JOHN *IX                                                         JOHN LEG
  107: JOHN POSS *ARRIVE *YESTERDAY *JOHN                               JOHN POS
S FRIEND HAVE CANDY
  108: *JOHN *HOMEWORK                                                  WOMAN AR
RIVE
  113: *JOHN *PEOPLE *MARY *JOHN *BUY1                                  IX CAR B
LUE SUE BUY
  119: *JOHN *BUY1 *WHAT CAR *FUTURE                                    SUE BUY
 IX CAR BLUE
  122: JOHN *PEOPLE *YESTERDAY                                          JOHN REA
D BOOK
  139: JOHN *NEW WHAT *JOHN *ARRIVE                                     JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                     JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE *WHAT *MARY                                                 LOVE JOH
N WHO
  167: JOHN IX *LOVE *FRIEND *HERE                                      JOHN IX
 SAY LOVE MARY
  171: *IX *JOHN BLAME                                                  JOHN MAR
Y BLAME
  174: *LOVE *JOHN GIVE1 *MARY *PEOPLE                                  PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN *BOOK                                                       JOHN ARR
IVE
  184: *GIVE *JOHN *GIVE1 TEACHER *YESTERDAY                            ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *IX *JOHN *ARRIVE                                           JOHN GIV
E GIRL BOX
  193: JOHN *IX *VISIT BOX                                              JOHN GIV
E GIRL BOX
  199: *JOHN *JOHN *MARY                                                LIKE CHO
COLATE WHO
  201: JOHN *IX *WHO *IX BUY HOUSE                                      JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['norm-polar-rr', 'norm-rtheta', 'norm-polar-lr', 'norm-polar-lt
heta', 'delta-norm-polar-rr', 'delta-norm-rtheta', 'delta-norm-polar-lr', 'de
lta-norm-polar-ltheta'] <class 'my_model_selectors.SelectorConstant'>

**** WER = 0.4606741573033708
Total correct: 96 out of 178
Video  Recognized                                                       Correct
=============================================================================
========================
    2: *POSS WRITE HOMEWORK                                             JOHN WRI
TE HOMEWORK
    7: JOHN *HAVE GO *TOY                                               JOHN CAN
 GO CAN
   12: JOHN *WHAT *GO1 *WHAT                                            JOHN CAN
 GO CAN
   21: JOHN FISH WONT *WHO BUT *CAR *CHICKEN CHICKEN                    JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *TELL *LOVE *WHO IX                                         JOHN LIK
E IX IX IX
   28: JOHN *WHO *WHO *WHO IX                                           JOHN LIK
E IX IX IX
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   30: *LIKE *MARY *MARY *MARY *MARY                                         JOHN LIK
E IX IX IX
   36: MARY *WHO *GIRL *GIVE *MARY *MARY                                     MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN *BILL *CORN MARY *MARY                                           JOHN IX
 THINK MARY LOVE
   43: JOHN *POSS BUY HOUSE                                                  JOHN MUS
T BUY HOUSE
   50: *FRANK *SEE BUY CAR *ARRIVE                                           FUTURE J
OHN BUY CAR SHOULD
   54: JOHN SHOULD *FUTURE BUY HOUSE                                         JOHN SHO
ULD NOT BUY HOUSE
   57: JOHN *PREFER VISIT MARY                                               JOHN DEC
IDE VISIT MARY
   67: JOHN FUTURE NOT BUY HOUSE                                             JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FUTURE VISIT MARY                                               JOHN WIL
L VISIT MARY
   74: JOHN *WHO *GIVE MARY                                                  JOHN NOT
 VISIT MARY
   77: *JOHN BLAME MARY                                                      ANN BLAM
E MARY
   84: *LOVE *NEW *HOMEWORK BOOK                                             IX-1P FI
ND SOMETHING-ONE BOOK
   89: *WILL IX *WOMAN *WILL *WILL NEW *BOOK                                 JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN *GIVE1 IX *ALL WOMAN BOOK                                        JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *WOMAN IX *WOMAN WOMAN BOOK                                      JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                               POSS NEW
 CAR BREAK-DOWN
  105: JOHN *VEGETABLE                                                       JOHN LEG
  107: JOHN POSS FRIEND *GO *WHO                                             JOHN POS
S FRIEND HAVE CANDY
  108: *THINK *BOOK                                                          WOMAN AR
RIVE
  113: IX CAR BLUE *MARY *IX-1P                                              IX CAR B
LUE SUE BUY
  119: *PREFER *BUY1 *BLUE *TOY *SELF                                        SUE BUY
 IX CAR BLUE
  122: JOHN READ BOOK                                                        JOHN REA
D BOOK
  139: *SHOULD *BUY1 WHAT YESTERDAY BOOK                                     JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                          JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE *MARY WHO                                                        LOVE JOH
N WHO
  167: JOHN *TOY1 *MARY *WOMAN MARY                                          JOHN IX
 SAY LOVE MARY
  171: JOHN *JOHN BLAME                                                      JOHN MAR
Y BLAME
  174: PEOPLE GROUP GIVE1 *CORN TOY                                          PEOPLE G
ROUP GIVE1 JANA TOY
  181: *SUE ARRIVE                                                           JOHN ARR
IVE
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  184: ALL BOY *GIVE1 TEACHER *CORN                                  ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *SELF *CORN *BUY1                                        JOHN GIV
E GIRL BOX
  193: JOHN *SELF *GIVE1 BOX                                         JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE WHO                                           LIKE CHO
COLATE WHO
  201: JOHN *SHOULD *WOMAN *LOVE BUY HOUSE                           JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['norm-polar-rr', 'norm-rtheta', 'norm-polar-lr', 'norm-polar-lt
heta', 'delta-norm-polar-rr', 'delta-norm-rtheta', 'delta-norm-polar-lr', 'de
lta-norm-polar-ltheta'] <class 'my_model_selectors.SelectorBIC'>

**** WER = 0.42696629213483145
Total correct: 102 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: JOHN WRITE HOMEWORK                                           JOHN WRI
TE HOMEWORK
    7: JOHN *HAVE *IX *TOY                                           JOHN CAN
 GO CAN
   12: JOHN CAN *GO1 CAN                                             JOHN CAN
 GO CAN
   21: JOHN *HOMEWORK WONT *WHO BUT *CAR *CHICKEN CHICKEN            JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN LIKE IX *WHO IX                                          JOHN LIK
E IX IX IX
   28: JOHN *WHO IX IX IX                                            JOHN LIK
E IX IX IX
   30: JOHN *MARY *MARY *MARY *MARY                                  JOHN LIK
E IX IX IX
   36: MARY *WHO *GIRL *GIVE *MARY *MARY                             MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN *BILL *CORN MARY *MARY                                   JOHN IX
 THINK MARY LOVE
   43: JOHN *POSS BUY HOUSE                                          JOHN MUS
T BUY HOUSE
   50: *JOHN *SEE BUY CAR *VIDEOTAPE                                 FUTURE J
OHN BUY CAR SHOULD
   54: JOHN SHOULD *MARY BUY HOUSE                                   JOHN SHO
ULD NOT BUY HOUSE
   57: JOHN *PREFER VISIT MARY                                       JOHN DEC
IDE VISIT MARY
   67: JOHN *YESTERDAY NOT BUY HOUSE                                 JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FUTURE VISIT MARY                                       JOHN WIL
L VISIT MARY
   74: JOHN *WHO *MARY MARY                                          JOHN NOT
 VISIT MARY
   77: *JOHN BLAME MARY                                              ANN BLAM
E MARY
   84: *MARY *NEW *HOMEWORK BOOK                                     IX-1P FI
ND SOMETHING-ONE BOOK
   89: JOHN *GIVE *WOMAN *OLD IX *BUY *BOOK                          JOHN IX
 GIVE MAN IX NEW COAT
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   90: JOHN *GIVE1 IX *IX WOMAN BOOK                                 JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *WOMAN IX *WOMAN WOMAN BOOK                              JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                       POSS NEW
 CAR BREAK-DOWN
  105: JOHN *VEGETABLE                                               JOHN LEG
  107: JOHN POSS FRIEND *MARY *WHO                                   JOHN POS
S FRIEND HAVE CANDY
  108: *MAN *BOOK                                                    WOMAN AR
RIVE
  113: IX CAR BLUE *JOHN *IX-1P                                      IX CAR B
LUE SUE BUY
  119: *JOHN *BUY1 *BLUE *TOY *JANA                                  SUE BUY
 IX CAR BLUE
  122: JOHN READ BOOK                                                JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT YESTERDAY BOOK                                JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                  JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE *MARY WHO                                                LOVE JOH
N WHO
  167: JOHN *TOY1 *MARY LOVE MARY                                    JOHN IX
 SAY LOVE MARY
  171: JOHN *JOHN BLAME                                              JOHN MAR
Y BLAME
  174: PEOPLE GROUP GIVE1 *CORN TOY                                  PEOPLE G
ROUP GIVE1 JANA TOY
  181: *SUE ARRIVE                                                   JOHN ARR
IVE
  184: *GIVE3 BOY *GIVE1 TEACHER *GIRL                               ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *SELF *CORN *BUY1                                        JOHN GIV
E GIRL BOX
  193: JOHN *SOMETHING-ONE *GIVE1 BOX                                JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE WHO                                           LIKE CHO
COLATE WHO
  201: JOHN *MARY *WOMAN *WOMAN BUY HOUSE                            JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['norm-polar-rr', 'norm-rtheta', 'norm-polar-lr', 'norm-polar-lt
heta', 'delta-norm-polar-rr', 'delta-norm-rtheta', 'delta-norm-polar-lr', 'de
lta-norm-polar-ltheta'] <class 'my_model_selectors.SelectorDIC'>

**** WER = 0.4044943820224719
Total correct: 106 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: JOHN WRITE HOMEWORK                                           JOHN WRI
TE HOMEWORK
    7: JOHN CAN GO *TOY                                              JOHN CAN
 GO CAN
   12: JOHN *WHAT *GO1 CAN                                           JOHN CAN
 GO CAN
   21: JOHN FISH WONT *WHO BUT CAN *FUTURE CHICKEN                   JOHN FIS
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H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN LIKE IX *WHO IX                                          JOHN LIK
E IX IX IX
   28: JOHN *WHO IX *WHO IX                                          JOHN LIK
E IX IX IX
   30: JOHN *MARY *MARY *MARY *MARY                                  JOHN LIK
E IX IX IX
   36: MARY VEGETABLE *GIRL *GIVE *MARY *MARY                        MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN *BILL *CORN MARY *MARY                                   JOHN IX
 THINK MARY LOVE
   43: JOHN *POSS BUY HOUSE                                          JOHN MUS
T BUY HOUSE
   50: *JOHN *SEE BUY CAR *JOHN                                      FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *JOHN *MARY BUY HOUSE                                    JOHN SHO
ULD NOT BUY HOUSE
   57: JOHN *PREFER VISIT MARY                                       JOHN DEC
IDE VISIT MARY
   67: JOHN *YESTERDAY NOT BUY HOUSE                                 JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FUTURE VISIT MARY                                       JOHN WIL
L VISIT MARY
   74: *IX *MARY *MARY MARY                                          JOHN NOT
 VISIT MARY
   77: *JOHN BLAME MARY                                              ANN BLAM
E MARY
   84: *MARY *NEW *HOMEWORK BOOK                                     IX-1P FI
ND SOMETHING-ONE BOOK
   89: *SAY *GIVE *MAN *OLD IX NEW COAT                              JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN *GIVE1 IX *IX WOMAN *ARRIVE                              JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *MAN IX SOMETHING-ONE WOMAN BOOK                         JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                       POSS NEW
 CAR BREAK-DOWN
  105: JOHN *VEGETABLE                                               JOHN LEG
  107: JOHN *IX FRIEND *MARY *JOHN                                   JOHN POS
S FRIEND HAVE CANDY
  108: *MAN *BOOK                                                    WOMAN AR
RIVE
  113: IX CAR BLUE *MARY *BUY1                                       IX CAR B
LUE SUE BUY
  119: *MARY *BUY1 *BLUE CAR *MARY                                   SUE BUY
 IX CAR BLUE
  122: JOHN READ BOOK                                                JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT YESTERDAY BOOK                                JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                  JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                 LOVE JOH
N WHO
  167: JOHN *TOY1 *MARY LOVE MARY                                    JOHN IX
 SAY LOVE MARY
  171: JOHN *JOHN BLAME                                              JOHN MAR
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Y BLAME
  174: PEOPLE GROUP GIVE1 *CORN TOY                                        PEOPLE G
ROUP GIVE1 JANA TOY
  181: *SUE ARRIVE                                                         JOHN ARR
IVE
  184: ALL BOY *GIVE1 TEACHER *GIRL                                        ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *SELF *CORN *BUY1                                              JOHN GIV
E GIRL BOX
  193: JOHN *GIVE1 *GIVE BOX                                               JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE WHO                                                 LIKE CHO
COLATE WHO
  201: JOHN *MARY *WOMAN *JOHN BUY HOUSE                                   JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['norm-polar-rr', 'norm-rtheta', 'norm-polar-lr', 'norm-polar-lt
heta', 'delta-norm-polar-rr', 'delta-norm-rtheta', 'delta-norm-polar-lr', 'de
lta-norm-polar-ltheta'] <class 'my_model_selectors.SelectorCV'>

**** WER = 0.449438202247191
Total correct: 98 out of 178
Video  Recognized                                                          Correct
=============================================================================
========================
    2: JOHN WRITE HOMEWORK                                                 JOHN WRI
TE HOMEWORK
    7: JOHN CAN GO *TOY                                                    JOHN CAN
 GO CAN
   12: JOHN CAN *GO1 CAN                                                   JOHN CAN
 GO CAN
   21: JOHN FISH *HOMEWORK *WHO BUT *MANY EAT CHICKEN                      JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN LIKE *MARY *WHO IX                                             JOHN LIK
E IX IX IX
   28: JOHN *WHO *MARY *WHO IX                                             JOHN LIK
E IX IX IX
   30: JOHN *MARY *MARY *MARY *SHOOT                                       JOHN LIK
E IX IX IX
   36: MARY *WHO *GIRL *GIVE2 *MARY *MARY                                  MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN *VISIT *CORN *JOHN *MARY                                       JOHN IX
 THINK MARY LOVE
   43: JOHN *PAST BUY HOUSE                                                JOHN MUS
T BUY HOUSE
   50: *JOHN JOHN BUY CAR SHOULD                                           FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *JOHN NOT BUY HOUSE                                            JOHN SHO
ULD NOT BUY HOUSE
   57: JOHN *VEGETABLE VISIT MARY                                          JOHN DEC
IDE VISIT MARY
   67: JOHN *JOHN NOT BUY HOUSE                                            JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *GIVE1 *GO MARY                                                JOHN WIL
L VISIT MARY
   74: JOHN *WHO *MARY *SHOOT                                              JOHN NOT
 VISIT MARY
   77: *JOHN BLAME MARY                                                    ANN BLAM
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E MARY
   84: *LOVE *NEW *HOMEWORK BOOK                                    IX-1P FI
ND SOMETHING-ONE BOOK
   89: JOHN IX GIVE *MOTHER *GIVE NEW COAT                          JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN *GIVE1 *GIVE1 SOMETHING-ONE WOMAN BOOK                  JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN GIVE *SOMETHING-ONE SOMETHING-ONE WOMAN BOOK            JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                      POSS NEW
 CAR BREAK-DOWN
  105: JOHN *VEGETABLE                                              JOHN LEG
  107: JOHN *SUE FRIEND *GO *WHO                                    JOHN POS
S FRIEND HAVE CANDY
  108: WOMAN *BOOK                                                  WOMAN AR
RIVE
  113: *JOHN CAR BLUE *JOHN *BUY1                                   IX CAR B
LUE SUE BUY
  119: *JOHN *BUY1 *SUE *TOY *JANA                                  SUE BUY
 IX CAR BLUE
  122: JOHN *HOUSE BOOK                                             JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT YESTERDAY BOOK                               JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY *MANY BOOK                                JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE *SOMETHING-ONE WHO                                      LOVE JOH
N WHO
  167: JOHN *TOY1 *MARY LOVE *LOVE                                  JOHN IX
 SAY LOVE MARY
  171: *MARY *JOHN BLAME                                            JOHN MAR
Y BLAME
  174: *GIVE1 GROUP GIVE1 *CORN TOY                                 PEOPLE G
ROUP GIVE1 JANA TOY
  181: *SUE *BOX                                                    JOHN ARR
IVE
  184: ALL BOY *SELL TEACHER *CORN                                  ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *JANA *CORN *BUY1                                       JOHN GIV
E GIRL BOX
  193: JOHN *GIVE1 *CORN BOX                                        JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE *FRANK                                       LIKE CHO
COLATE WHO
  201: JOHN *SHOULD *WOMAN *LIKE BUY HOUSE                          JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['dist-norm-left-right', 'delta-dist-norm-left-right', 'delta-no
rm-rx', 'delta-norm-ry', 'delta-norm-lx', 'delta-norm-ly', 'norm-polar-rr',
 'norm-rtheta', 'norm-polar-lr', 'norm-polar-ltheta', 'delta-norm-polar-rr',
 'delta-norm-rtheta', 'delta-norm-polar-lr', 'delta-norm-polar-ltheta'] <clas
s 'my_model_selectors.SelectorConstant'>

**** WER = 0.46629213483146065
Total correct: 95 out of 178
Video  Recognized                                                    Correct
=============================================================================
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    2: JOHN WRITE HOMEWORK                                          JOHN WRI
TE HOMEWORK
    7: JOHN *CAR *BLUE *CAR                                         JOHN CAN
 GO CAN
   12: JOHN CAN *GO1 CAN                                            JOHN CAN
 GO CAN
   21: JOHN *JOHN WONT *TELL *CAR *CAR *FUTURE *JOHN                JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *WHO *THROW IX *THROW                                   JOHN LIK
E IX IX IX
   28: JOHN *TELL *BILL IX IX                                       JOHN LIK
E IX IX IX
   30: JOHN *MARY *MARY *JOHN IX                                    JOHN LIK
E IX IX IX
   36: MARY *WHO *IX *GIVE *MARY *MARY                              MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN IX *JOHN MARY *MARY                                     JOHN IX 
 THINK MARY LOVE
   43: JOHN *POSS BUY HOUSE                                         JOHN MUS
T BUY HOUSE
   50: *JOHN *SEE BUY CAR *JOHN                                     FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *JOHN *MARY BUY HOUSE                                   JOHN SHO
ULD NOT BUY HOUSE
   57: *MARY *MARY *IX *IX                                          JOHN DEC
IDE VISIT MARY
   67: JOHN FUTURE NOT BUY HOUSE                                    JOHN FUT
URE NOT BUY HOUSE
   71: JOHN WILL *GO MARY                                           JOHN WIL
L VISIT MARY
   74: JOHN *MARY *MARY MARY                                        JOHN NOT
 VISIT MARY
   77: *JOHN BLAME MARY                                             ANN BLAM
E MARY
   84: *JOHN *NEW *YESTERDAY *NEW                                   IX-1P FI
ND SOMETHING-ONE BOOK
   89: *WHO IX *IX *THROW IX NEW COAT                               JOHN IX 
 GIVE MAN IX NEW COAT
   90: JOHN *IX IX *IX *IX BOOK                                     JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *IX IX *IX WOMAN *HOUSE                                 JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                      POSS NEW
 CAR BREAK-DOWN
  105: JOHN *WHO                                                    JOHN LEG
  107: *MARY *IX FRIEND HAVE *JOHN                                  JOHN POS
S FRIEND HAVE CANDY
  108: *IX ARRIVE                                                   WOMAN AR
RIVE
  113: *JOHN CAR *JOHN *MARY *BUY1                                  IX CAR B
LUE SUE BUY
  119: *MARY *BUY1 IX CAR *APPLE                                    SUE BUY 
 IX CAR BLUE
  122: JOHN READ *COAT                                              JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT *WHAT BOOK                                   JOHN BUY
 WHAT YESTERDAY BOOK
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  142: JOHN BUY YESTERDAY WHAT BOOK                                  JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                 LOVE JOH
N WHO
  167: JOHN *JOHN *MARY LOVE MARY                                    JOHN IX 
 SAY LOVE MARY
  171: *MARY *JOHN BLAME                                             JOHN MAR
Y BLAME
  174: PEOPLE GROUP GIVE1 *JOHN *WHAT                                PEOPLE G
ROUP GIVE1 JANA TOY
  181: *SUE ARRIVE                                                   JOHN ARR
IVE
  184: ALL BOY *GIVE1 TEACHER APPLE                                  ALL BOY 
 GIVE TEACHER APPLE
  189: *MARY *IX *CORN BOX                                           JOHN GIV
E GIRL BOX
  193: JOHN *IX GIRL BOX                                             JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE WHO                                           LIKE CHO
COLATE WHO
  201: JOHN *JOHN *LOVE *JOHN BUY HOUSE                              JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['dist-norm-left-right', 'delta-dist-norm-left-right', 'delta-no
rm-rx', 'delta-norm-ry', 'delta-norm-lx', 'delta-norm-ly', 'norm-polar-rr',
 'norm-rtheta', 'norm-polar-lr', 'norm-polar-ltheta', 'delta-norm-polar-rr',
 'delta-norm-rtheta', 'delta-norm-polar-lr', 'delta-norm-polar-ltheta'] <clas
s 'my_model_selectors.SelectorBIC'>

**** WER = 0.42696629213483145
Total correct: 102 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: JOHN WRITE HOMEWORK                                           JOHN WRI
TE HOMEWORK
    7: JOHN *CAR *HAVE *CAR                                          JOHN CAN
 GO CAN
   12: JOHN CAN *GO1 CAN                                             JOHN CAN
 GO CAN
   21: JOHN *JOHN WONT *WHO BUT *CAR *MARY *MARY                     JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: *ANN *LOVE *LOVE IX *LOVE                                     JOHN LIK
E IX IX IX
   28: JOHN *WHO *LOVE IX *LOVE                                      JOHN LIK
E IX IX IX
   30: JOHN *MARY *MARY *MARY IX                                     JOHN LIK
E IX IX IX
   36: MARY *JOHN *GIRL *GIVE *MARY *MARY                            MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN IX *JOHN MARY *MARY                                      JOHN IX 
 THINK MARY LOVE
   43: JOHN *POSS BUY HOUSE                                          JOHN MUS
T BUY HOUSE
   50: *JOHN *PREFER BUY CAR *JOHN                                   FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *JOHN *MARY BUY HOUSE                                    JOHN SHO
ULD NOT BUY HOUSE
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   57: JOHN *JOHN *IX *GIVE                                         JOHN DEC
IDE VISIT MARY
   67: JOHN FUTURE NOT BUY HOUSE                                    JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FUTURE VISIT MARY                                      JOHN WIL
L VISIT MARY
   74: JOHN *MARY *MARY MARY                                        JOHN NOT
 VISIT MARY
   77: *JOHN BLAME MARY                                             ANN BLAM
E MARY
   84: *JOHN *NEW *YESTERDAY *NEW                                   IX-1P FI
ND SOMETHING-ONE BOOK
   89: JOHN IX GIVE *THROW IX NEW COAT                              JOHN IX 
 GIVE MAN IX NEW COAT
   90: JOHN *IX IX *IX WOMAN BOOK                                   JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *WOMAN IX *IX WOMAN BOOK                                JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                      POSS NEW
 CAR BREAK-DOWN
  105: JOHN *VEGETABLE                                              JOHN LEG
  107: JOHN *IX FRIEND *MARY *JOHN                                  JOHN POS
S FRIEND HAVE CANDY
  108: WOMAN ARRIVE                                                 WOMAN AR
RIVE
  113: *JOHN CAR *JOHN *JOHN *BUY1                                  IX CAR B
LUE SUE BUY
  119: *JOHN *BUY1 IX CAR *JANA                                     SUE BUY 
 IX CAR BLUE
  122: JOHN READ *COAT                                              JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT YESTERDAY BOOK                               JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                 JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                LOVE JOH
N WHO
  167: JOHN *JOHN *JOHN LOVE MARY                                   JOHN IX 
 SAY LOVE MARY
  171: *MARY *JOHN BLAME                                            JOHN MAR
Y BLAME
  174: PEOPLE GROUP GIVE1 *JOHN *WHAT                               PEOPLE G
ROUP GIVE1 JANA TOY
  181: *SUE ARRIVE                                                  JOHN ARR
IVE
  184: ALL BOY *GIVE1 TEACHER APPLE                                 ALL BOY 
 GIVE TEACHER APPLE
  189: JOHN *JOHN *JOHN BOX                                         JOHN GIV
E GIRL BOX
  193: JOHN *IX *CORN BOX                                           JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE WHO                                          LIKE CHO
COLATE WHO
  201: JOHN *JOHN MARY *JOHN BUY HOUSE                              JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['dist-norm-left-right', 'delta-dist-norm-left-right', 'delta-no
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 'delta-norm-rtheta', 'delta-norm-polar-lr', 'delta-norm-polar-ltheta'] <clas
s 'my_model_selectors.SelectorDIC'>

**** WER = 0.46629213483146065
Total correct: 95 out of 178
Video  Recognized                                                    Correct
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    2: JOHN WRITE *ARRIVE                                            JOHN WRI
TE HOMEWORK
    7: JOHN *CAR GO CAN                                              JOHN CAN
 GO CAN
   12: JOHN CAN *GO1 CAN                                             JOHN CAN
 GO CAN
   21: JOHN *JOHN WONT *WHO *CAR *CAR *FUTURE *MARY                  JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: *ANN *IX *MARY IX *THROW                                      JOHN LIK
E IX IX IX
   28: JOHN *WHO *BILL IX IX                                         JOHN LIK
E IX IX IX
   30: JOHN *MARY *MARY *MARY IX                                     JOHN LIK
E IX IX IX
   36: MARY *JOHN *YESTERDAY *GIVE *MARY *MARY                       MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN *GIVE *JOHN MARY *MARY                                   JOHN IX
 THINK MARY LOVE
   43: JOHN *VISIT BUY HOUSE                                         JOHN MUS
T BUY HOUSE
   50: *JOHN *SEE BUY CAR *JOHN                                      FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *JOHN *MARY BUY HOUSE                                    JOHN SHO
ULD NOT BUY HOUSE
   57: JOHN *JOHN *IX *GIVE                                          JOHN DEC
IDE VISIT MARY
   67: JOHN *IX NOT BUY HOUSE                                        JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FUTURE VISIT MARY                                       JOHN WIL
L VISIT MARY
   74: JOHN *MARY *MARY MARY                                         JOHN NOT
 VISIT MARY
   77: *JOHN BLAME MARY                                              ANN BLAM
E MARY
   84: *JOHN *JOHN *YESTERDAY BOOK                                   IX-1P FI
ND SOMETHING-ONE BOOK
   89: JOHN IX GIVE *THROW IX *BUY COAT                              JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN *IX IX *GIVE WOMAN BOOK                                  JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *WOMAN IX *IX WOMAN BOOK                                 JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                       POSS NEW
 CAR BREAK-DOWN
  105: JOHN *VEGETABLE                                               JOHN LEG
  107: JOHN *IX *ARRIVE *MARY *JOHN                                  JOHN POS
S FRIEND HAVE CANDY
  108: WOMAN *BOOK                                                   WOMAN AR
```

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RIVE
  113: *JOHN CAR *JOHN *JOHN *BUY1                                  IX CAR B
LUE SUE BUY
  119: *JOHN *BUY1 IX CAR *IX                                       SUE BUY
 IX CAR BLUE
  122: JOHN *CAR BOOK                                               JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT *WHAT BOOK                                   JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                 JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                LOVE JOH
N WHO
  167: JOHN *JOHN *JOHN LOVE MARY                                   JOHN IX
 SAY LOVE MARY
  171: *MARY *JOHN BLAME                                            JOHN MAR
Y BLAME
  174: *CAR GROUP GIVE1 *JOHN *WHAT                                 PEOPLE G
ROUP GIVE1 JANA TOY
  181: *SUE ARRIVE                                                  JOHN ARR
IVE
  184: ALL BOY *GIVE1 TEACHER APPLE                                 ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *JOHN *JOHN *WHAT                                       JOHN GIV
E GIRL BOX
  193: JOHN *POSS *CORN BOX                                         JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE *MARY                                        LIKE CHO
COLATE WHO
  201: JOHN *JOHN MARY *JOHN BUY HOUSE                              JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['dist-norm-left-right', 'delta-dist-norm-left-right', 'delta-no
rm-rx', 'delta-norm-ry', 'delta-norm-lx', 'delta-norm-ly', 'norm-polar-rr',
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 'delta-norm-rtheta', 'delta-norm-polar-lr', 'delta-norm-polar-ltheta'] <clas
s 'my_model_selectors.SelectorCV'>

**** WER = 0.46629213483146065
Total correct: 95 out of 178
Video  Recognized                                                    Correct
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    2: JOHN WRITE HOMEWORK                                          JOHN WRI
TE HOMEWORK
    7: JOHN *TOY *HAVE CAN                                          JOHN CAN
 GO CAN
   12: JOHN *CAR *GO1 CAN                                           JOHN CAN
 GO CAN
   21: JOHN *JOHN WONT *MARY *CAR *CAR *FUTURE *MARY                JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX IX IX IX                                            JOHN LIK
E IX IX IX
   28: JOHN *WHO IX IX IX                                           JOHN LIK
E IX IX IX
   30: JOHN *MARY *MARY *MARY *SHOOT                                JOHN LIK
E IX IX IX
   36: MARY *JOHN *WOMAN *GIVE2 *MARY *MARY                         MARY VEG
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ETABLE KNOW IX LIKE CORN1
   40: JOHN IX *JOHN MARY *MARY                                          JOHN IX
 THINK MARY LOVE
   43: JOHN *POSS BUY HOUSE                                              JOHN MUS
T BUY HOUSE
   50: *JOHN *SEE BUY CAR *MARY                                          FUTURE J
OHN BUY CAR SHOULD
   54: JOHN SHOULD *MARY BUY HOUSE                                       JOHN SHO
ULD NOT BUY HOUSE
   57: JOHN *JOHN VISIT *WOMAN                                           JOHN DEC
IDE VISIT MARY
   67: JOHN *POSS NOT BUY HOUSE                                          JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *JOHN VISIT MARY                                             JOHN WIL
L VISIT MARY
   74: JOHN *MARY *MARY MARY                                             JOHN NOT
 VISIT MARY
   77: *JOHN *ARRIVE MARY                                                ANN BLAM
E MARY
   84: *JOHN *NEW *YESTERDAY BOOK                                        IX-1P FI
ND SOMETHING-ONE BOOK
   89: JOHN IX *IX *THINK IX NEW *BOOK                                   JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN *WOMAN *GIVE *WOMAN WOMAN *LOVE                              JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *IX IX *IX WOMAN BOOK                                        JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                           POSS NEW
 CAR BREAK-DOWN
  105: JOHN *VEGETABLE                                                   JOHN LEG
  107: JOHN *JOHN FRIEND HAVE *MARY                                      JOHN POS
S FRIEND HAVE CANDY
  108: *MARY ARRIVE                                                      WOMAN AR
RIVE
  113: *JOHN *TOY *JOHN *MARY *BUY1                                      IX CAR B
LUE SUE BUY
  119: *JOHN *BUY1 *HAVE *HAVE *VISIT                                    SUE BUY
 IX CAR BLUE
  122: JOHN *GO BOOK                                                     JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT *SOMETHING-ONE *ARRIVE                            JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                      JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                     LOVE JOH
N WHO
  167: JOHN *JOHN *SAY-1P LOVE MARY                                      JOHN IX
 SAY LOVE MARY
  171: *MARY *JOHN BLAME                                                 JOHN MAR
Y BLAME
  174: *CAN GROUP GIVE1 *JOHN TOY                                        PEOPLE G
ROUP GIVE1 JANA TOY
  181: *SUE ARRIVE                                                       JOHN ARR
IVE
  184: *GIVE BOY *CAR TEACHER APPLE                                      ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *MARY *JOHN BOX                                              JOHN GIV
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E GIRL BOX
  193: JOHN *GIVE1 GIRL BOX                                    JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE *MARY                                   LIKE CHO
COLATE WHO
  201: JOHN *SHOULD *LOVE *LIKE BUY HOUSE                      JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['norm-rx', 'norm-ry', 'norm-lx', 'norm-ly', 'dist-norm-left-rig
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orm-polar-ltheta', 'delta-norm-polar-rr', 'delta-norm-rtheta', 'delta-norm-po
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nt'>

**** WER = 0.4550561797752809
Total correct: 97 out of 178
Video  Recognized                                                    Correct
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    2: JOHN WRITE HOMEWORK                                     JOHN WRI
TE HOMEWORK
    7: JOHN *CAR *HAVE *CAR                                    JOHN CAN
 GO CAN
   12: JOHN CAN *GO1 CAN                                       JOHN CAN
 GO CAN
   21: JOHN *NEW *VISIT *MARY *CAR *CAR *FUTURE *JOHN          JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: *IX *IX IX *LIKE IX                                     JOHN LIK
E IX IX IX
   28: *ANN *MARY IX IX IX                                     JOHN LIK
E IX IX IX
   30: JOHN LIKE *MARY *LIKE IX                                JOHN LIK
E IX IX IX
   36: MARY *JOHN *GIRL *GIVE *MARY *MARY                      MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN IX *CORN MARY *MARY                                JOHN IX
 THINK MARY LOVE
   43: JOHN *IX BUY HOUSE                                      JOHN MUS
T BUY HOUSE
   50: *POSS *SEE BUY CAR *IX                                  FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *JOHN NOT BUY HOUSE                                JOHN SHO
ULD NOT BUY HOUSE
   57: JOHN *JOHN *IX *IX                                      JOHN DEC
IDE VISIT MARY
   67: JOHN FUTURE NOT BUY HOUSE                               JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FUTURE VISIT MARY                                 JOHN WIL
L VISIT MARY
   74: JOHN *MARY *MARY MARY                                   JOHN NOT
 VISIT MARY
   77: *IX BLAME MARY                                          ANN BLAM
E MARY
   84: *IX *ARRIVE *VISIT BOOK                                 IX-1P FI
ND SOMETHING-ONE BOOK
   89: JOHN IX *IX *GO IX NEW COAT                             JOHN IX
 GIVE MAN IX NEW COAT
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   90: *MARY *GIVE1 IX *IX WOMAN BOOK                              JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *WOMAN IX *IX WOMAN BOOK                               JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                     POSS NEW
 CAR BREAK-DOWN
  105: JOHN *SEE                                                   JOHN LEG
  107: JOHN *IX *CAR HAVE *JOHN                                    JOHN POS
S FRIEND HAVE CANDY
  108: *LOVE *BOOK                                                 WOMAN AR
RIVE
  113: *JOHN CAR *JOHN *JOHN *BUY1                                 IX CAR B
LUE SUE BUY
  119: *WHO *BUY1 IX CAR *JOHN                                     SUE BUY
 IX CAR BLUE
  122: JOHN *GIVE1 BOOK                                            JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT YESTERDAY BOOK                              JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE *MARY WHO                                              LOVE JOH
N WHO
  167: JOHN IX *LEAVE LOVE MARY                                    JOHN IX
 SAY LOVE MARY
  171: *MARY *JOHN BLAME                                           JOHN MAR
Y BLAME
  174: *CAR *GIVE1 GIVE1 *WHO *CAN                                 PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN *BOX                                                   JOHN ARR
IVE
  184: *IX BOY *GIVE1 TEACHER APPLE                                ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *SEE GIRL *CAR                                         JOHN GIV
E GIRL BOX
  193: JOHN *SEE GIRL BOX                                          JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE *MARY                                       LIKE CHO
COLATE WHO
  201: JOHN *THINK *WOMAN *LIKE BUY HOUSE                          JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['norm-rx', 'norm-ry', 'norm-lx', 'norm-ly', 'dist-norm-left-rig
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orm-polar-ltheta', 'delta-norm-polar-rr', 'delta-norm-rtheta', 'delta-norm-po
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**** WER = 0.449438202247191
Total correct: 98 out of 178
Video  Recognized                                                  Correct
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    2: JOHN WRITE HOMEWORK                                         JOHN WRI
TE HOMEWORK
    7: JOHN *CAR GO CAN                                            JOHN CAN
 GO CAN
   12: JOHN CAN *GO1 CAN                                           JOHN CAN
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 GO CAN
   21: JOHN *NEW *VISIT *JOHN *CAR *CAR *FUTURE *FUTURE                  JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX *LOVE *MARY IX                                           JOHN LIK
E IX IX IX
   28: *ANN LIKE *ANN IX IX                                              JOHN LIK
E IX IX IX
   30: *IX *MARY *MARY IX IX                                             JOHN LIK
E IX IX IX
   36: MARY *JOHN *GIRL *VISIT *JOHN *MARY                               MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN IX *JOHN *JOHN *MARY                                         JOHN IX 
 THINK MARY LOVE
   43: JOHN *JOHN BUY HOUSE                                              JOHN MUS
T BUY HOUSE
   50: *JOHN *SEE BUY CAR SHOULD                                         FUTURE J
OHN BUY CAR SHOULD
   54: JOHN SHOULD *FUTURE BUY HOUSE                                     JOHN SHO
ULD NOT BUY HOUSE
   57: *IX *JOHN *IX *IX                                                 JOHN DEC
IDE VISIT MARY
   67: JOHN FUTURE NOT BUY HOUSE                                         JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FUTURE VISIT MARY                                           JOHN WIL
L VISIT MARY
   74: *IX *MARY *MARY MARY                                              JOHN NOT
 VISIT MARY
   77: *JOHN BLAME MARY                                                  ANN BLAM
E MARY
   84: *JOHN *NEW *HOMEWORK BOOK                                         IX-1P FI
ND SOMETHING-ONE BOOK
   89: JOHN *POSS *MAN MAN IX NEW COAT                                   JOHN IX 
 GIVE MAN IX NEW COAT
   90: JOHN *GIVE1 IX *IX WOMAN BOOK                                     JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *MAN IX *IX WOMAN BOOK                                       JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                           POSS NEW
 CAR BREAK-DOWN
  105: JOHN *SEE                                                         JOHN LEG
  107: *MARY *IX FRIEND *IX *JOHN                                        JOHN POS
S FRIEND HAVE CANDY
  108: *MARY *HOMEWORK                                                   WOMAN AR
RIVE
  113: IX CAR *JOHN *JOHN *BUY1                                          IX CAR B
LUE SUE BUY
  119: *MARY *BUY1 IX CAR *IX                                            SUE BUY 
 IX CAR BLUE
  122: JOHN *GIVE1 BOOK                                                  JOHN REA
D BOOK
  139: *IX *BUY1 WHAT YESTERDAY BOOK                                     JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                      JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                     LOVE JOH
N WHO
  167: JOHN IX *VISIT LOVE MARY                                          JOHN IX
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 SAY LOVE MARY
  171: *MARY *JOHN BLAME                                                    JOHN MAR
Y BLAME
  174: *CAR GROUP GIVE1 *JOHN TOY                                           PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN *VIDEOTAPE                                                      JOHN ARR
IVE
  184: ALL BOY *GIVE1 TEACHER APPLE                                         ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *JOHN *PREFER *CAN                                              JOHN GIV
E GIRL BOX
  193: JOHN *IX *YESTERDAY BOX                                              JOHN GIV
E GIRL BOX
  199: *JOHN CHOCOLATE *JOHN                                                LIKE CHO
COLATE WHO
  201: JOHN *GIVE1 *WOMAN *WOMAN BUY HOUSE                                  JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['norm-rx', 'norm-ry', 'norm-lx', 'norm-ly', 'dist-norm-left-rig
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lar-lr', 'delta-norm-polar-ltheta'] <class 'my_model_selectors.SelectorDIC'>

**** WER = 0.4606741573033708
Total correct: 96 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: JOHN WRITE *ARRIVE                                               JOHN WRI
TE HOMEWORK
    7: JOHN *CAR GO CAN                                                 JOHN CAN
 GO CAN
   12: JOHN CAN *GO1 CAN                                                JOHN CAN
 GO CAN
   21: JOHN *JOHN *JOHN *JOHN *CAR *CAR *FUTURE *FUTURE                 JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX *LOVE IX IX                                             JOHN LIK
E IX IX IX
   28: *ANN *IX IX IX IX                                                JOHN LIK
E IX IX IX
   30: *IX *MARY IX IX IX                                               JOHN LIK
E IX IX IX
   36: MARY *JOHN *GIVE3 *VISIT *JOHN *MARY                             MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN IX *JOHN MARY *IX                                           JOHN IX
 THINK MARY LOVE
   43: JOHN *JOHN BUY HOUSE                                             JOHN MUS
T BUY HOUSE
   50: *JOHN *SEE BUY CAR *JOHN                                         FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *FUTURE *FUTURE BUY HOUSE                                   JOHN SHO
ULD NOT BUY HOUSE
   57: *IX *MARY VISIT *IX                                              JOHN DEC
IDE VISIT MARY
   67: JOHN FUTURE *MARY BUY HOUSE                                      JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FUTURE VISIT MARY                                          JOHN WIL
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L VISIT MARY
   74: *IX *MARY *MARY MARY                                          JOHN NOT
 VISIT MARY
   77: *JOHN BLAME MARY                                              ANN BLAM
E MARY
   84: *JOHN *ARRIVE *CAR BOOK                                       IX-1P FI
ND SOMETHING-ONE BOOK
   89: JOHN IX *IX *IX IX NEW COAT                                   JOHN IX
 GIVE MAN IX NEW COAT
   90: *MARY *GIVE1 IX *IX WOMAN BOOK                                JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *IX IX *IX WOMAN BOOK                                    JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                       POSS NEW
 CAR BREAK-DOWN
  105: JOHN *POSS                                                    JOHN LEG
  107: *MARY POSS *JOHN *IX *JOHN                                    JOHN POS
S FRIEND HAVE CANDY
  108: *MARY *LOVE                                                   WOMAN AR
RIVE
  113: IX CAR *JOHN *JOHN *BUY1                                      IX CAR B
LUE SUE BUY
  119: *MARY *BUY1 IX *JOHN *IX                                      SUE BUY
 IX CAR BLUE
  122: JOHN *HOUSE BOOK                                              JOHN REA
D BOOK
  139: *IX *BUY1 WHAT YESTERDAY BOOK                                 JOHN BUY
 WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                  JOHN BUY
 YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                 LOVE JOH
N WHO
  167: JOHN IX *MARY LOVE MARY                                       JOHN IX
 SAY LOVE MARY
  171: *MARY *JOHN BLAME                                             JOHN MAR
Y BLAME
  174: *JOHN *GIVE1 GIVE1 *JOHN TOY                                  PEOPLE G
ROUP GIVE1 JANA TOY
  181: JOHN ARRIVE                                                   JOHN ARR
IVE
  184: *IX BOY *GIVE1 TEACHER APPLE                                  ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *MARY *PREFER BOX                                        JOHN GIV
E GIRL BOX
  193: JOHN *POSS *VISIT BOX                                         JOHN GIV
E GIRL BOX
  199: *JOHN *ARRIVE WHO                                             LIKE CHO
COLATE WHO
  201: JOHN *GIVE1 *IX *LIKE BUY HOUSE                               JOHN TEL
L MARY IX-1P BUY HOUSE
----running: ['norm-rx', 'norm-ry', 'norm-lx', 'norm-ly', 'dist-norm-left-rig
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lar-lr', 'delta-norm-polar-ltheta'] <class 'my_model_selectors.SelectorCV'>

**** WER = 0.48314606741573035
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Total correct: 92 out of 178
Video  Recognized                                                    Correct
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    2: JOHN WRITE HOMEWORK                                           JOHN WRI
TE HOMEWORK
    7: JOHN *PEOPLE *HAVE CAN                                        JOHN CAN
 GO CAN
   12: JOHN *CAR *GO1 CAN                                            JOHN CAN
 GO CAN
   21: JOHN *HOMEWORK *HOMEWORK *MARY *CAR *CAR *FUTURE *MARY        JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: *ANN *ANN *ANN *LIKE *ANN                                     JOHN LIK
E IX IX IX
   28: JOHN LIKE *ANN *ANN IX                                        JOHN LIK
E IX IX IX
   30: JOHN *MARY *MARY *MARY *SHOOT                                 JOHN LIK
E IX IX IX
   36: MARY *JOHN *YESTERDAY *SHOOT LIKE *MARY                       MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN *MARY *JOHN MARY *MARY                                   JOHN IX
 THINK MARY LOVE
   43: JOHN *JOHN BUY HOUSE                                          JOHN MUS
T BUY HOUSE
   50: *JOHN JOHN BUY CAR *HOMEWORK                                  FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *JOHN NOT BUY HOUSE                                      JOHN SHO
ULD NOT BUY HOUSE
   57: JOHN *MARY VISIT MARY                                         JOHN DEC
IDE VISIT MARY
   67: JOHN *POSS NOT BUY HOUSE                                      JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *JOHN VISIT MARY                                         JOHN WIL
L VISIT MARY
   74: JOHN *MARY *MARY MARY                                         JOHN NOT
 VISIT MARY
   77: *JOHN BLAME MARY                                              ANN BLAM
E MARY
   84: *GO *ARRIVE *HOMEWORK BOOK                                    IX-1P FI
ND SOMETHING-ONE BOOK
   89: JOHN IX *IX *GO IX NEW COAT                                   JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN *GIVE1 IX *GIVE1 WOMAN *VIDEOTAPE                        JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN *WOMAN IX *IX WOMAN BOOK                                 JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                       POSS NEW
 CAR BREAK-DOWN
  105: JOHN *POSS                                                    JOHN LEG
  107: JOHN *JOHN *HAVE HAVE *MARY                                   JOHN POS
S FRIEND HAVE CANDY
  108: *LOVE ARRIVE                                                  WOMAN AR
RIVE
  113: *JOHN CAR *MARY *JOHN *BUY1                                   IX CAR B
LUE SUE BUY
  119: *WHO *BUY1 *GO CAR *VISIT                                     SUE BUY
 IX CAR BLUE
```

122: JOHN *BLAME BOOK JOHN REA
D BOOK
139: JOHN *BUY1 WHAT YESTERDAY *VIDEOTAPE JOHN BUY
WHAT YESTERDAY BOOK
142: JOHN BUY YESTERDAY WHAT BOOK JOHN BUY
YESTERDAY WHAT BOOK
158: LOVE *MARY *MARY LOVE JOH
N WHO
167: JOHN *JOHN *VISIT LOVE MARY JOHN IX
SAY LOVE MARY
171: *MARY *JOHN BLAME JOHN MAR
Y BLAME
174: *CAR GROUP GIVE1 *WHO TOY PEOPLE G
ROUP GIVE1 JANA TOY
181: *SOMETHING-ONE *BOX JOHN ARR
IVE
184: *IX BOY *GIVE1 TEACHER APPLE ALL BOY
GIVE TEACHER APPLE
189: JOHN *GIVE1 *JOHN BOX JOHN GIV
E GIRL BOX
193: JOHN *SEE *NOT BOX JOHN GIV
E GIRL BOX
199: *JOHN CHOCOLATE *MARY LIKE CHO
COLATE WHO
201: JOHN *WHO *WOMAN *WOMAN BUY HOUSE JOHN TEL
L MARY IX-1P BUY HOUSE

In [185]:

```
from IPython.display import display, Image
from matplotlib import pyplot as plt
%matplotlib inline

data = pd.read_csv('recognizer-collected_data-filter.csv', parse_dates=True)

print('best 5:')
display(data.sort_values(by='WER',ascending=True).head(5))

print('worst 5:')
display(data.sort_values(by='WER',ascending=False).head(5))

data.groupby('Selector')['Num correct of 178'].plot(  title='Num Correct by Se
lector-',legend=True,figsize= (16,6))
```

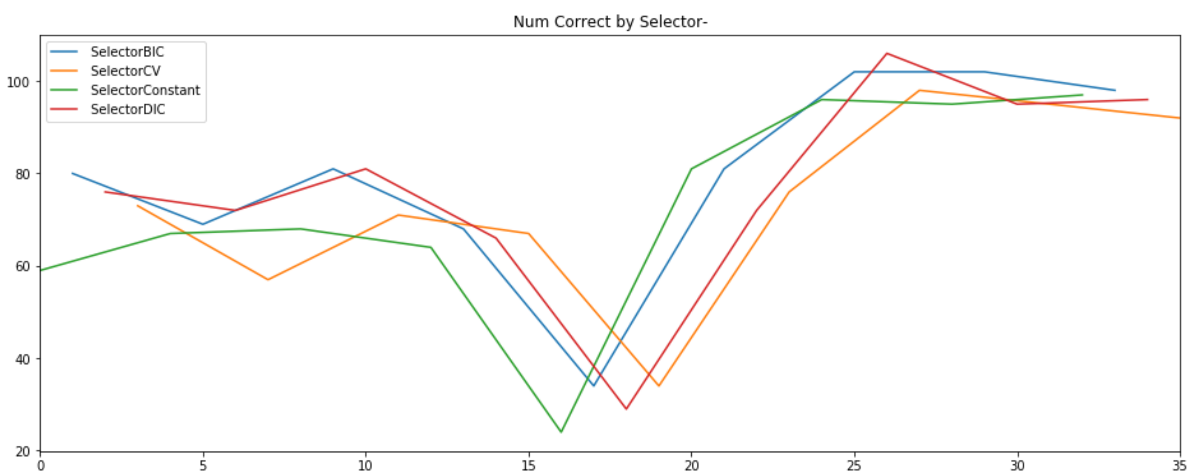
best 5:

	Features	Selector	WER	Num correct of 178
26	features_norm_polar_coords	SelectorDIC	0.404494	106
29	features_custom	SelectorBIC	0.426966	102
25	features_norm_polar_coords	SelectorBIC	0.426966	102
27	features_norm_polar_coords	SelectorCV	0.449438	98
33	features_best	SelectorBIC	0.449438	98

worst 5:

	Features	Selector	WER	Num correct of 178
16	features_hand_dist	SelectorConstant	0.865169	24
18	features_hand_dist	SelectorDIC	0.837079	29
19	features_hand_dist	SelectorCV	0.808989	34
17	features_hand_dist	SelectorBIC	0.808989	34
7	features_norm	SelectorCV	0.679775	57

```
Out[185]: Selector
 SelectorBIC          Axes(0.125,0.125;0.775x0.755)
 SelectorCV           Axes(0.125,0.125;0.775x0.755)
 SelectorConstant     Axes(0.125,0.125;0.775x0.755)
 SelectorDIC          Axes(0.125,0.125;0.775x0.755)
Name: Num correct of 178, dtype: object
```

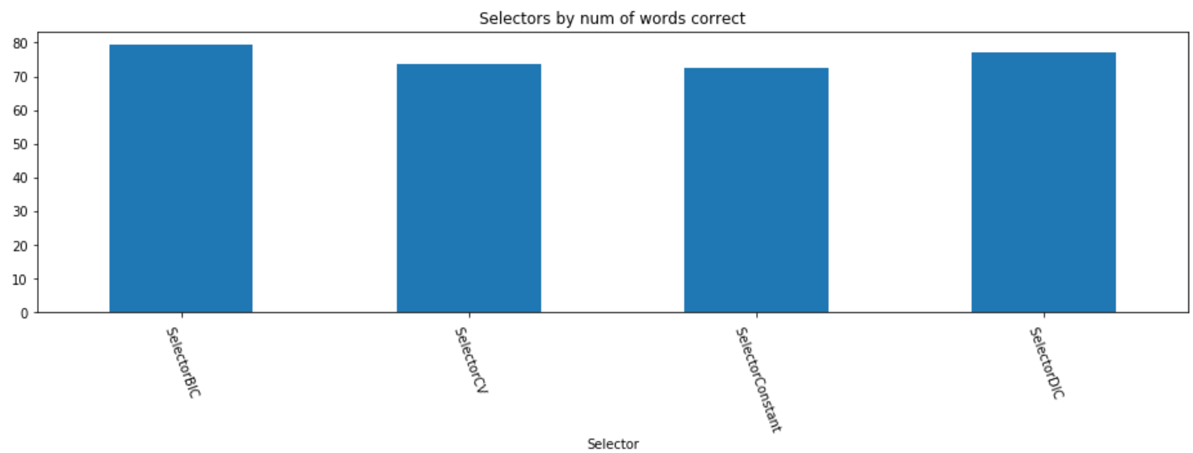


In [213]:
```
print('Selectors ordered by best')
display(data.groupby('Selector').WER.mean().sort_values())
data.groupby('Selector')['Num correct of 178'].mean().plot(rot=290,title="Sele
ctors by num of words correct", kind ='bar',figsize= (16,4))
```

```
Selectors ordered by best

Selector
 SelectorBIC         0.553683
 SelectorDIC         0.567416
 SelectorCV          0.586142
 SelectorConstant    0.593633
Name: WER, dtype: float64
```

Out[213]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1bff04cc208>
```

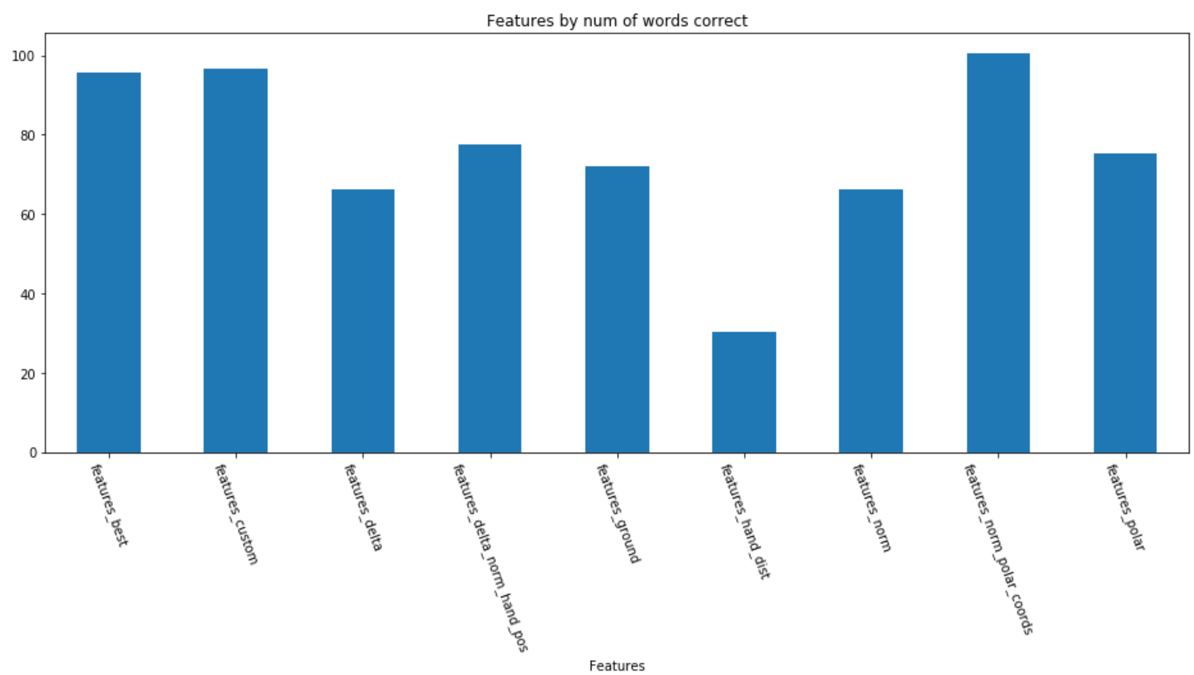


In [214]:
```
print('Features ordered by best')
display(data.groupby('Features').WER.mean().sort_values())
data.groupby('Features')['Num correct of 178'].mean().plot(rot=290, title="Fea
tures by num of words correct",kind ='bar',figsize= (16,6))
```

```
Features ordered by best

Features
features_norm_polar_coords      0.435393
features_custom                 0.456461
features_best                   0.462079
features_delta_norm_hand_pos    0.564607
features_polar                  0.577247
features_ground                 0.595506
features_delta                  0.627809
features_norm                   0.627809
features_hand_dist              0.830056
Name: WER, dtype: float64
```

Out[214]: <matplotlib.axes._subplots.AxesSubplot at 0x1bff08a8518>



In [215]:
```
# run a test for a specific combination of features/selectors
recognize_and_display_result(features_norm_polar_coords+features_delta_norm_ha
nd_pos, selector_sets[2] )
```

```
**** WER = 0.39325842696629215
Total correct: 108 out of 178
Video  Recognized                                                    Correct
=============================================================================
========================
    2: JOHN WRITE HOMEWORK                                           JOHN WRI
TE HOMEWORK
    7: JOHN *CAR GO *WHAT                                            JOHN CAN
GO CAN
   12: JOHN CAN *GO1 CAN                                             JOHN CAN
GO CAN
   21: JOHN *VIDEOTAPE WONT *WHO BUT *CAR *FUTURE *MARY              JOHN FIS
H WONT EAT BUT CAN EAT CHICKEN
   25: JOHN *IX *LOVE IX IX                                          JOHN LIK
E IX IX IX
   28: JOHN *WHO IX IX IX                                            JOHN LIK
E IX IX IX
   30: JOHN *MARY *MARY IX IX                                        JOHN LIK
E IX IX IX
   36: MARY *JOHN *GIRL *GIVE *MARY *MARY                            MARY VEG
ETABLE KNOW IX LIKE CORN1
   40: JOHN *GIVE *CORN MARY *MARY                                   JOHN IX
 THINK MARY LOVE
   43: JOHN *POSS BUY HOUSE                                          JOHN MUS
T BUY HOUSE
   50: *JOHN JOHN BUY CAR *MARY                                      FUTURE J
OHN BUY CAR SHOULD
   54: JOHN *FUTURE *FUTURE BUY HOUSE                                JOHN SHO
ULD NOT BUY HOUSE
   57: *MARY *JOHN VISIT MARY                                        JOHN DEC
IDE VISIT MARY
   67: JOHN FUTURE NOT BUY HOUSE                                     JOHN FUT
URE NOT BUY HOUSE
   71: JOHN *FUTURE VISIT MARY                                       JOHN WIL
L VISIT MARY
   74: JOHN *MARY *MARY MARY                                         JOHN NOT
VISIT MARY
   77: *JOHN BLAME MARY                                              ANN BLAM
E MARY
   84: *JOHN *BUY *HOMEWORK BOOK                                     IX-1P FI
ND SOMETHING-ONE BOOK
   89: JOHN *JOHN *WOMAN *THROW IX *BUY COAT                         JOHN IX
 GIVE MAN IX NEW COAT
   90: JOHN *IX IX *IX WOMAN BOOK                                    JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
   92: JOHN GIVE *WOMAN *WOMAN WOMAN BOOK                            JOHN GIV
E IX SOMETHING-ONE WOMAN BOOK
  100: POSS NEW CAR BREAK-DOWN                                       POSS NEW
CAR BREAK-DOWN
  105: JOHN *JOHN                                                    JOHN LEG
  107: JOHN *IX FRIEND *MARY *JOHN                                   JOHN POS
S FRIEND HAVE CANDY
  108: *JOHN *BOOK                                                   WOMAN AR
RIVE
  113: IX CAR *JOHN *JOHN *BUY1                                      IX CAR B
LUE SUE BUY
  119: *JOHN *BUY1 IX CAR *JANA                                      SUE BUY
```

```
 IX CAR BLUE
  122: JOHN *GIVE1 BOOK                                                  JOHN REA
D BOOK
  139: JOHN *BUY1 WHAT YESTERDAY BOOK                                    JOHN BUY
WHAT YESTERDAY BOOK
  142: JOHN BUY YESTERDAY WHAT BOOK                                      JOHN BUY
YESTERDAY WHAT BOOK
  158: LOVE JOHN WHO                                                     LOVE JOH
N WHO
  167: JOHN IX *IX LOVE MARY                                             JOHN IX
 SAY LOVE MARY
  171: JOHN *JOHN BLAME                                                  JOHN MAR
Y BLAME
  174: *GIVE1 GROUP GIVE1 *JOHN TOY                                      PEOPLE G
ROUP GIVE1 JANA TOY
  181: *SUE ARRIVE                                                       JOHN ARR
IVE
  184: ALL BOY *GIVE1 TEACHER APPLE                                      ALL BOY
 GIVE TEACHER APPLE
  189: JOHN *IX GIRL *CAR                                                JOHN GIV
E GIRL BOX
  193: JOHN *IX GIRL BOX                                                 JOHN GIV
E GIRL BOX
  199: *JOHN *ARRIVE WHO                                                 LIKE CHO
COLATE WHO
  201: JOHN *FUTURE MARY *JOHN BUY HOUSE                                 JOHN TEL
L MARY IX-1P BUY HOUSE
```

Question 3: Summarize the error results from three combinations of features and model selectors. What was the "best" combination and why? What additional information might we use to improve our WER? For more insight on improving WER, take a look at the introduction to Part 4.

Answer 3: The best combination from my original feature sets seems to have come from the combination of normalized polar coordinates with their deltas(features_delta_norm_hand_pos), and the DIC selector, with a WER = 0.0.404494, and Total correct: 106 out of 178. This can be attributed to several factors:

```
- The selector policy not overfitting the data, as opposed to what we anticipated w
ith the last question. This may change as more data is used.
- The normalized polar coordinates/w deltas seem to better indicate hand position c
orrectly.
```

The worst combination observed was using distance between hands, and the rate of change of that distance (features_hand_dist) with SelectorConstant, with a WER = 0.865169 and Total correct: 24 out of 178. The data set simply did not have enough features to be of use!

After observing the scores, I suspected that the hand distance should still be able to add value, so I combined the two data sets(features_delta_norm_hand_pos and features_hand_dist) and again used SelectorBIC to achieve the highest score observed in these tests: WER = 0.393258, and Total correct: 108 out of 178.

This validates the idea that normalized data/polar coordinates/hand-distance features are the most valuablefeatures, and the original data needs to be greatly transformed to be most useful.

From the data collected by running all the selectors and features, we can see that the BIC selector and the features_norm_polar_coords actually had the best overall scores.

We can anticipate two methods to improve the score:

```
- Add more features: one method, mentioned in [Speech Recognition Techniques for a
 Sign Language Recognition System, Philippe Dreuw et al](https://www-i6.informatik.
rwth-aachen.de/publications/download/154/Dreuw--2007.pdf), is to use PCA on each im
age frame, to assist in capturing more information about hand orientation. Other ta
ctics to be tried include using different combinations of the tested feature sets
- Improve our guess. This can be done in various ways, with the first and most obvi
ous being to use a words probability of appearing in the same phrase as a modifier
 on probability, and calculating the guess based in that information, as outlined b
elow!
- Improve our probabilities: First, we can optimize the hyperparameters of the mode
l using a gridsearch or similar. Also, we can use ensemble methods, such as stackin
g to combine multiple models, for an improved probability set. This would require a
 bit or rework of the base_model method, to convert everything over to a format tha
t works for scikit learn and build a proper pipeline that can be returned as a mode
l.
```

Recognizer Unit Tests

Run the following unit tests as a sanity check on the defined recognizer. The test simply looks for some valid values but is not exhaustive. However, the project should not be submitted if these tests don't pass.

In [87]:
```
from asl_test_recognizer import TestRecognize
suite = unittest.TestLoader().loadTestsFromModule(TestRecognize())
unittest.TextTestRunner().run(suite)
```

```
..
----------------------------------------------------------------------
Ran 2 tests in 23.933s

OK
```

Out[87]:
```
<unittest.runner.TextTestResult run=2 errors=0 failures=0>
```

PART 4: (OPTIONAL) Improve the WER with Language Models

We've squeezed just about as much as we can out of the model and still only get about 50% of the words right! Surely we can do better than that. Probability to the rescue again in the form of statistical language models (SLM) (https://en.wikipedia.org/wiki/Language_model). The basic idea is that each word has some probability of occurrence within the set, and some probability that it is adjacent to specific other words. We can use that additional information to make better choices.

Additional reading and resources

- Introduction to N-grams (Stanford Jurafsky slides) (https://web.stanford.edu/class/cs124/lec/languagemodeling.pdf)
- Speech Recognition Techniques for a Sign Language Recognition System, Philippe Dreuw et al (https://www-i6.informatik.rwth-aachen.de/publications/download/154/Dreuw--2007.pdf) see the improved results of applying LM on *this* data!
- SLM data for *this* ASL dataset (ftp://wasserstoff.informatik.rwth-aachen.de/pub/rwth-boston-104/lm/)

Optional challenge

The recognizer you implemented in Part 3 is equivalent to a "0-gram" SLM. Improve the WER with the SLM data provided with the data set in the link above using "1-gram", "2-gram", and/or "3-gram" statistics. The `probabilities` data you've already calculated will be useful and can be turned into a pandas DataFrame if desired (see next cell).
Good luck! Share your results with the class!

In [93]:
```
# create a DataFrame of log likelihoods for the test word items
df_probs = pd.DataFrame(data=probabilities)
df_probs.head()
```

Out[93]:

	ALL	ANN	APPLE	ARRIVE	BILL	BLAME	BL
0	-2067.010836	-767.519589	-1539.325400	-83.791391	-1045.751728	-337.658776	-22
1	-7456.930610	-4643.414672	-3527.246300	158.675871	-6698.850106	-139.137972	-39
2	-10634.334063	-5419.519485	-5415.645160	193.809785	-9780.359478	-330.496706	-54
3	-1266.006788	-2052.018577	-886.241616	-51.800291	-1655.268607	-351.466072	-80
4	-2259.790386	-2052.046270	-760.550551	31.038891	-3682.778663	-23.609359	-14

5 rows × 112 columns

EOF - Submited for review 7-13-2017