Retrieval Practice and Learning

What is the most effective way to learn a subject? Many students focus exclusively on the *encoding* process---that is, how to get the knowledge into memory in the first place. For example, taking notes is an activity for encoding knowledge.

Retrieval, on the other hand, is the process of reconstructing that knowledge from memory. Karpicke and Blunt (2011) demonstrated that *retrieval* is more effective for learning than activites designed to promote effective encoding. They conducted an experiment in which subjects had to learn about sea otters by reading a passage. Subjects were randomly assigned to one of two conditions: some were instructed to create a concept map as they read the passage, while others were instructed to practice retrieval (i.e., read the passage, recall as much as they could, read the text again, and recall again). The two main measurements they recorded were:

1. each subject's score on a follow-up learning test one week later
2. each subject's *prediction* of how well they would do on that test

In this lab, you will analyze data from a *replication* of Karpicke and Blunt's experiment, conducted by Buttrick *et al*.

- The data file is : data.csv.
- The codebook (explaining what the variables mean) is : codebook.csv.

In [1]:
```
# READ IN THE DATA SET HERE
%matplotlib inline
import pandas as pd
import matplotlib.pyplot as plt

data_df = pd.read_csv("data.csv")
data_df
```

Out[1]:

	ID	Age	Gender	Date.P1	Date.P2	Condition	IC.1	IC.2	Comp.1	Comp.2	...	Scorer.
0	KB1	18	Female	11/21/16	11/28/16	Concept	1	1	1	1	...	N
1	KB2	18	Male	11/21/16	11/28/16	Concept	1	1	1	1	...	N
2	KB3	18	Male	11/21/16	11/28/16	Concept	1	1	1	1	...	N
3	KB4	19	Female	11/21/16	11/28/16	Concept	1	1	1	1	...	N
4	KB5	19	Female	11/22/16	11/29/16	Concept	1	1	1	1	...	N
5	KB6	19	Male	11/22/16	11/29/16	Concept	1	1	1	1	...	N

6	KB7	18	Male	11/22/16	12/6/16	Concept	1	1	1	1	...	N
7	KB8	20	Male	11/22/16	11/29/16	Concept	1	1	1	1	...	N
8	KB9	20	Male	11/22/16	11/28/16	Concept	1	1	1	1	...	N
9	KB10	20	Female	11/29/16	12/6/16	Concept	1	1	1	1	...	N
10	KB11	21	Female	11/21/16	11/28/16	Retrieval	1	1	1	1	...	
11	KB12	18	Female	11/21/16	11/29/16	Retrieval	1	1	1	1	...	
12	KB13	20	Female	11/21/16	11/28/16	Retrieval	1	1	1	1	...	
13	KB14	19	Female	11/21/16	11/28/16	Retrieval	1	1	1	1	...	
14	KB15	18	Female	11/22/16	11/29/16	Retrieval	1	1	1	1	...	
15	KB16	19	Male	11/22/16	11/29/16	Retrieval	1	1	1	1	...	
16	KB18	20	Male	11/22/16	11/29/16	Retrieval	1	1	1	1	...	
17	KB19	21	Female	11/29/16	12/6/16	Retrieval	1	1	1	1	...	
18	KB20	17	Male	11/29/16	12/6/16	Retrieval	1	1	1	1	...	
19	KB21	20	Male	11/29/16	12/6/16	Concept	1	1	1	1	...	N
20	KB22	18	Male	11/29/16	12/6/16	Concept	1	1	1	1	...	N
21	KB23	21	Male	11/29/16	12/6/16	Concept	1	1	1	1	...	N
22	KB24	18	Male	11/29/16	12/6/16	Concept	1	1	1	1	...	N
23	KB25	19	Male	11/29/16	12/6/16	Concept	1	1	1	1	...	N
24	KB26	18	Female	11/29/16	12/6/16	Concept	1	1	1	1	...	N
25	KB27	18	Male	11/29/16	12/6/16	Concept	1	1	1	1	...	N
26	KB28	18	Male	11/29/16	12/2/16	Concept	1	1	1	1	...	N
27	KB29	19	Male	1/23/17	1/31/17	Concept	1	1	1	1	...	N
28	KB30	18	Female	1/23/17	1/31/17	Concept	1	1	1	1	...	N
29	KB31	19	Female	1/23/17	2/1/17	Concept	1	1	1	1	...	N
30	KB32	18	Male	1/23/17	1/31/17	Concept	1	1	1	1	...	N
31	KB33	21	Male	1/24/17	1/31/17	Concept	1	1	1	1	...	N
32	KB34	22	Female	1/24/17	1/31/17	Retrieval	1	1	1	1	...	
33	KB35	19	Male	1/24/17	2/2/17	Retrieval	1	1	1	1	...	
34	KB37	20	Male	1/24/17	1/31/17	Retrieval	1	1	1	1	...	
35	KB38	19	Female	1/24/17	1/31/17	Concept	1	1	1	1	...	N
36	KB39	19	Female	1/25/17	2/1/17	Concept	1	1	1	1	...	N

37	KB40	20	Female	1/25/17	2/2/17	Retrieval	1	1	1	1	...	
38	KB41	19	Female	1/25/17	2/1/17	Retrieval	1	1	1	1	...	
39	KB42	19	Female	1/25/17	2/1/17	Retrieval	1	1	1	1	...	
40	KB43	18	Female	1/25/17	2/1/17	Retrieval	1	1	1	1	...	
41	KB44	20	Male	1/25/17	2/1/17	Concept	1	1	1	1	...	N
42	KB45	19	Female	1/26/17	2/2/17	Retrieval	1	1	1	1	...	

43 rows × 35 columns

Question 1

Which group felt like they learned more: the subjects who made concept maps or the ones who practiced retrieval? (Or are they about the same?) Make an appropriate visualization and explain what you see.

Hint: Use the variable `PR.2`, which contains the participants' predictions of how well they would do on a test one week later.

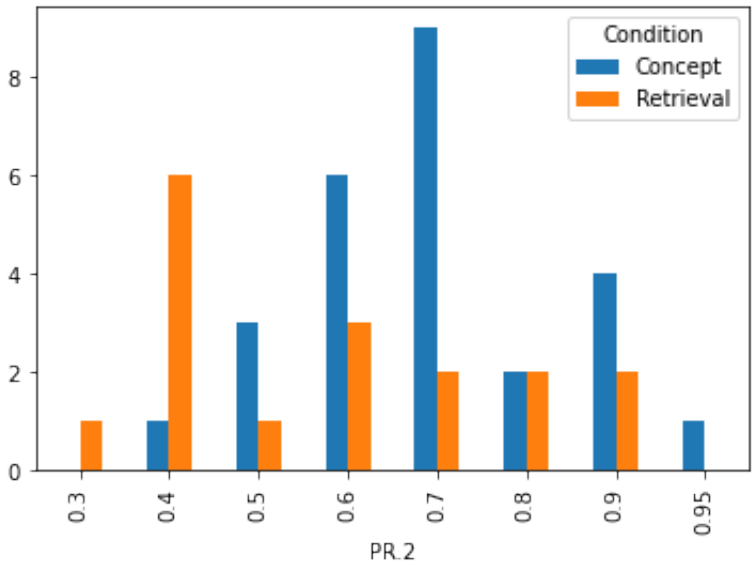
In [2]:
```
# YOUR CODE HERE
Predicted_Scores = pd.crosstab(data_df["PR.2"], data_df.Condition)
Predicted_Scores
```

Out[2]:

Condition	Concept	Retrieval
PR.2		
0.30	0	1
0.40	1	6
0.50	3	1
0.60	6	3
0.70	9	2
0.80	2	2
0.90	4	2
0.95	1	0

In [3]:
```
Predicted_Scores.plot.bar()
```

Out[3]: <AxesSubplot:xlabel='PR.2'>



YOUR EXPLANATION HERE

The people who made concept maps felt like they learned more because their predicted test scores were higher than those who praticed retrieval

Question 2

Which group actually did better on the follow-up learning test one week later? Make an appropriate visualization and explain what you see.

Hint: Don't ask which variable you should use. That is for you to figure out. Read the codebook carefully (consulting the original paper, if necessary), make an informed decision, and explain your choice.

In [4]:
```
# YOUR CODE HERE
Test_Scores = pd.crosstab(data_df["TS.avg"], data_df.Condition)
Test_Scores
```

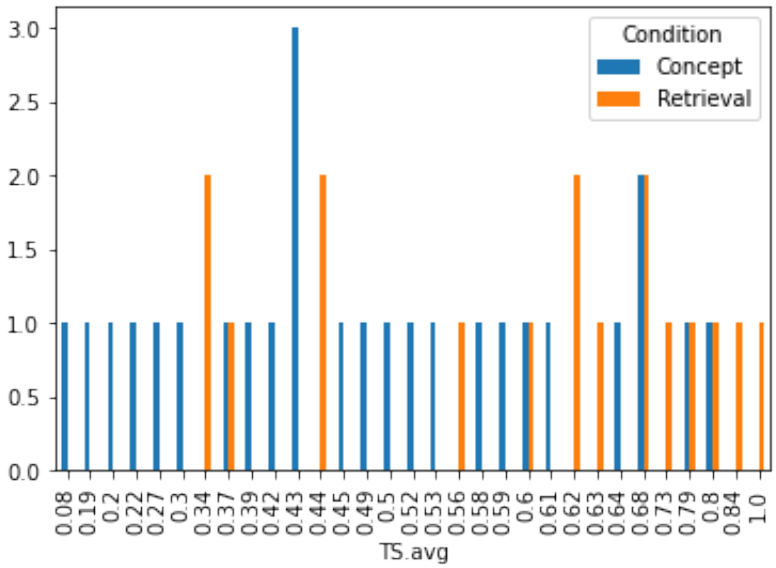
Out[4]:

Condition	Concept	Retrieval
TS.avg		
0.08	1	0
0.19	1	0
0.20	1	0
0.22	1	0
0.27	1	0

0.30	1	0
0.34	0	2
0.37	1	1
0.39	1	0
0.42	1	0
0.43	3	0
0.44	0	2
0.45	1	0
0.49	1	0
0.50	1	0
0.52	1	0
0.53	1	0
0.56	0	1
0.58	1	0
0.59	1	0
0.60	1	1
0.61	1	0
0.62	0	2
0.63	0	1
0.64	1	0
0.68	2	2
0.73	0	1
0.79	1	1
0.80	1	1
0.84	0	1
1.00	0	1

In [5]:
```
Test_Scores.plot.bar()
```

Out[5]: <AxesSubplot:xlabel='TS.avg'>



YOUR EXPLANATION HERE

Here we can see the the data graph, the Retrieval group actually getting higher scores than the Concept map group. We used the TS.avg because it is the test score average.

Question 3

How good were subjects at predicting how well they would do on the follow-up learning test? Calculate a measure of how well subjects predicted their performance and interpret the value in context. (Optionally, you may want to include a visualization as well.)

In [6]:
```
# YOUR CODE HERE
difference_df = Test_Scores
difference_df = abs(difference_df - Predicted_Scores)
difference_df
numOfWrong = difference_df["Concept"].sum()
numOfWrong
totalPrediciton = Predicted_Scores["Concept"].sum()
totalPrediciton
numOfWrong/totalPrediciton
print("The percentage of people with the concept condition that predicted the
numOfWrong = difference_df["Retrieval"].sum()
numOfWrong
totalPrediciton = Predicted_Scores["Retrieval"].sum()
totalPrediciton
numOfWrong/totalPrediciton
print("The percentage of people with the Retrieval condition that predicted t
```

```
The percentage of people with the concept condition that predicted their test
scores incorrectly is:  34.61538461538461
The percentage of people with the Retrieval condition that predicted their tes
t scores incorrectly is:  29.411764705882355
```

YOUR EXPLANATION HERE

We calculated the difference between the predicted scores and the actual scores then divided by the total number of people that gave a prediciton which gave us the percent error of people that got their prediciton wrong. What this showed is that the Retrieval subjects had a lower percent error which means they got more of their predicitons correct than the Concept subjects

Question 4

This was a completely randomized experiment. This means that the condition that each subject was assigned to should be independent of their gender, age, and any other subject characteristics. Does that seem to be true in this case? Calculate a summary measure and/or make a visualization, and explain what you see.

In [7]:
```
# YOUR CODE HERE
condition_counts = data_df.groupby("Condition")["ID"].count()
condition_counts/condition_counts.sum()
```

Out[7]:
```
Condition
Concept      0.604651
Retrieval    0.395349
Name: ID, dtype: float64
```

In [8]:
```
pd.crosstab(data_df["Condition"], data_df["Age"],
            normalize=True, margins=True)
```

Out[8]:

Age	17	18	19	20	21	22	All
Condition							
Concept	0.000000	0.255814	0.186047	0.116279	0.046512	0.000000	0.604651
Retrieval	0.023256	0.069767	0.139535	0.093023	0.046512	0.023256	0.395349
All	0.023256	0.325581	0.325581	0.209302	0.093023	0.023256	1.000000

In [9]:
```
pd.crosstab(data_df["Condition"], data_df["Gender"],
            normalize=True, margins=True)
```

Out[9]:

Gender	Female	Male	All
Condition			
Concept	0.209302	0.395349	0.604651
Retrieval	0.279070	0.116279	0.395349
All	0.488372	0.511628	1.000000

YOUR EXPLANATION HERE

Looking at the charts we made above, we first took the marginal distribution of "Condition" independent of any other subject characteristics and it comes out to be 60% Concept maps and 39% Retrieval. When we make a marginal distribution chart based on "Condtion" and "Age", then "Condition" and "Gender" we see the marginal distribution of the "Conditions" is the same as it was when condition was independant of any other charateristics. It is possible that it was random, but since in the ages of the concept subjects there were two ages that were not picked and in the retrieval subjects those ages were picked, this doesn't seem random. For the gender characteristic, the concept group has more males than females and retrieval is the opposite so that does not seem random also because they are opposite of that and not even. If it was gender and age was even, then they would be properly represented.

Submission Instructions

Once you are finished, follow these steps:

1. Restart the kernel and re-run this notebook from beginning to end by going to `Kernel > Restart Kernel and Run All Cells`.
2. If this process stops halfway through, that means there was an error. Correct the error and repeat Step 1 until the notebook runs from beginning to end.
3. Double check that there is a number next to each code cell and that these numbers are in order.

Then, submit your lab as follows:

1. Go to `File > Export Notebook As > PDF`.
2. Double check that the entire notebook, from beginning to end, is in this PDF file. (If the notebook is cut off, try first exporting the notebook to HTML and printing to PDF.)
3. Upload the PDF to Gradescope and Notebook (ipynb) to iLearn.