Challenge 4

The American Identity

1. (10 points) Build a shallow autoencoder with a single hidden layer consisting of 2 nodes on the full question space, but not including the dichotomous American identity feature. Then, extract the two "deep" features from the hidden layer and store these.

```
amer_h2o <- issues[-16] %>%
  as.h2o()
```

```
##   |                                                                      |
```

```
shallow_autoencoder_amer <- h2o.deeplearning(x = predictors,
                                training_frame = amer_h2o,
                                autoencoder = TRUE,
                                hidden = c(2),
                                epochs = 100,
                                activation = "Tanh")
```

```
##   |                                                                      |
```

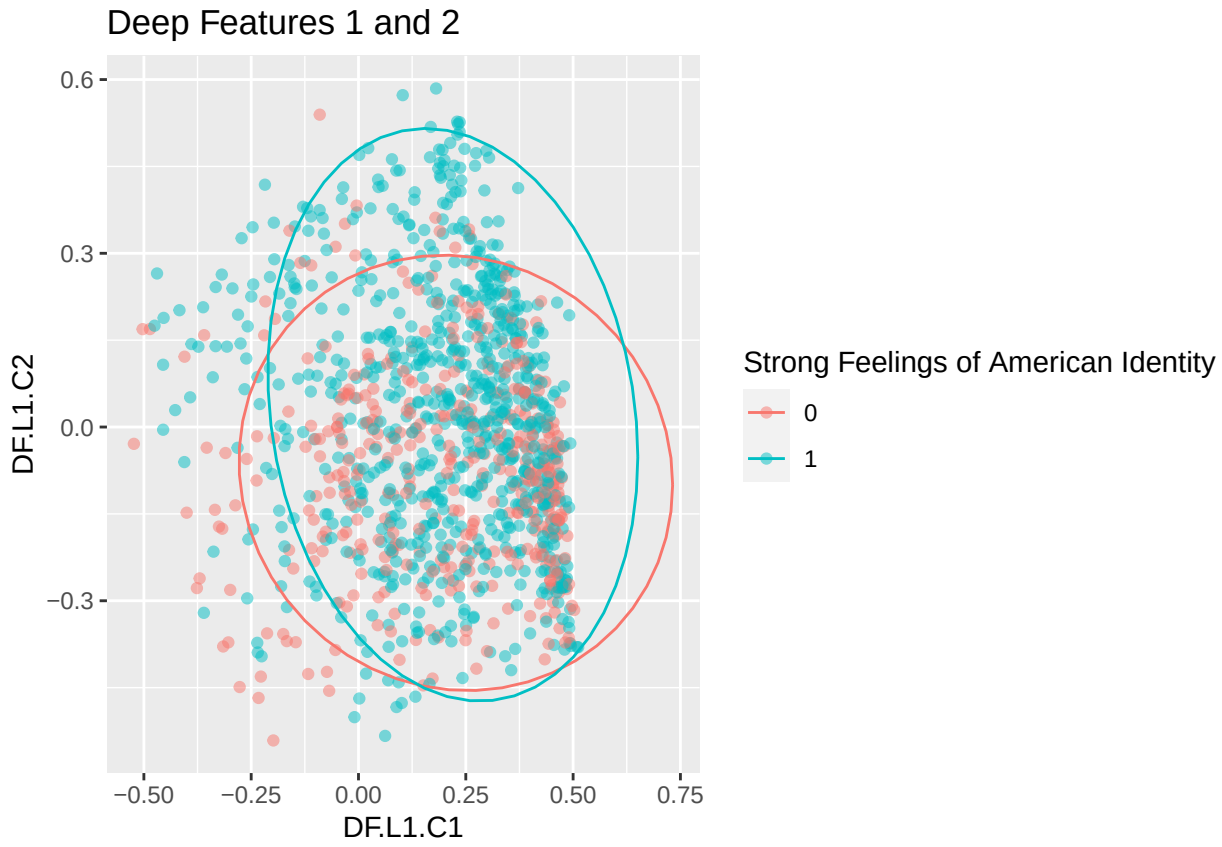
```
shallow_features_amer <- h2o.deepfeatures(shallow_autoencoder_amer,
                            data = amer_h2o,
                            layer = 1)%>%
  as.data.frame()%>%
  mutate(strong_amer_ident = as.vector(amer_h2o[,15]))
```

```
##   |                                                                      |
```

2. (10 points) Plot the two deep features against each other, with color conditioned by weak or strong American identity. Discuss the output in a few sentences. For example, do we see separation in the projection (question) space along senses of American identity or not? Why or why not do you think?

The AE did uncover some interesting structure in the data; there is a thick band of observations running across the projection space, although it's not exactly clear how to interpret that clustering. In terms of American identity, there is some spatial sorting; for instance it seems that negative values of feature 2 (along the y-axis) is associated strong American identity. Following the thick band I described before, it seems like the bottom of the band is associated with strong feelings of American identity and the top is associated with weak American identity. But by no means is this a clear distinction. There is no true separation to speak of. This could indicate that processing the survey responses with two neurons in one layer doesn't enable the model to detect strong/weak senses of American identity. It could also be because of a weak underlying relationship between the survey variables and sense of American identity.

```
ggplot(shallow_features_amer, aes(x=DF.L1.C1,
                          y = DF.L1.C2,
                          color = factor(strong_amer_ident)))+
  geom_point(alpha = 0.5) +
  stat_ellipse() +
  labs(title = "Deep Features 1 and 2",
       color = "Strong Feelings of American Identity")
```



3. (10 points) Build a deep autoencoder with 3 hidden layers consisting of 2 nodes in each on the full question space, but again not including the dichotomous American identity feature. Then, extract the two deep features from the third hidden layer and store these.

```
deep_autoencoder_amer <- h2o.deeplearning(x = predictors,
                                  training_frame = amer_h2o,
                                  autoencoder = TRUE,
                                  hidden = c(2, 2, 2),
                                  epochs = 100,
                                  activation = "Tanh")
```

```
##   |                                                                      |
```

```
deep_features_amer <- h2o.deepfeatures(deep_autoencoder_amer,
                               data = amer_h2o,
                               layer = 3)%>%
```

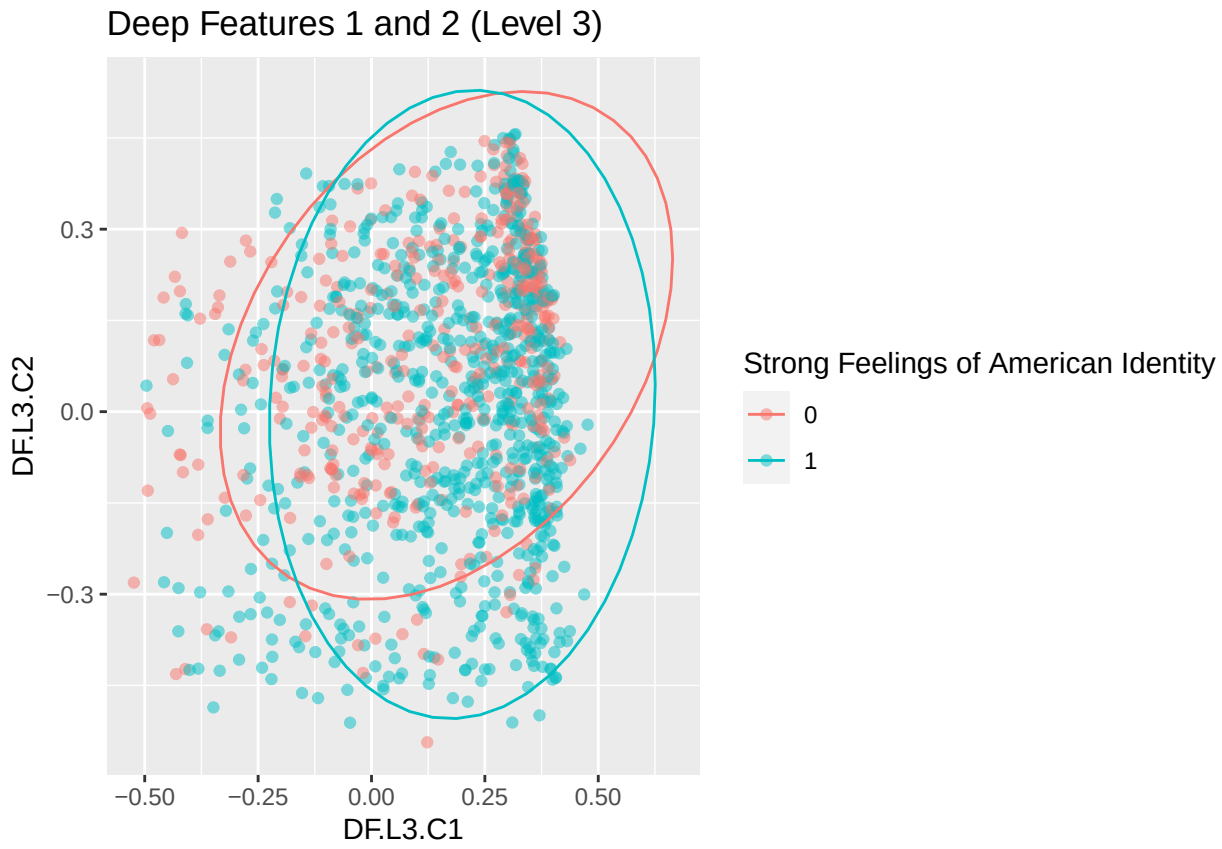
```
  as.data.frame()%>%
  mutate(strong_amer_ident = as.vector(amer_h2o[,15]))
```

```
##   |                                                                      |
```

4. (10 points) Plot the two deep features from the 3rd hidden layer against each other, with color conditioned by weak or strong American identity. Discuss the output in a few sentences. For example, does deepening the network help to recover different patterns and/or clearer separation in the question space along this identity? Why or why not do you think? What do we gain and what do we lose by deepening the network?

The additional neuron layers did not noticeably increase separation. To my eyes, it's hard to say that this graph produces better results than the previous one. Again, the AE does seem to be finding a kind of structure with a thick band at one side of a cloud of observations. As the ovals show, it does seem that strong and weak feelings of American Identity are distributed differently, but there is no separation. This could indicate that in this case the additional neuron layers do not detect deeper levels of structure in the data.

```
ggplot(deep_features_amer, aes(x=DF.L3.C1,
                               y = DF.L3.C2,
                               color = factor(strong_amer_ident)))+
  geom_point(alpha = 0.5) +
  stat_ellipse() +
  labs(title = "Deep Features 1 and 2 (Level 3)",
       color = "Strong Feelings of American Identity")
```



The Racial Identity

5. (10 points) Build a shallow autoencoder with a single hidden layer consisting of 2 nodes on the full question space, but not including the dichotomous race identity feature. Then, extract the two "deep" features from the hidden layer and store these.

```
race_h2o <- issues[-15] %>%
  as.h2o()
```

```
##   |                                                                      |
```

```
shallow_autoencoder_race <- h2o.deeplearning(x = predictors,
                                     training_frame = race_h2o,
                                     autoencoder = TRUE,
                                     hidden = c(2),
                                     epochs = 100,
                                     activation = "Tanh")
```

```
##   |                                                                      |
```

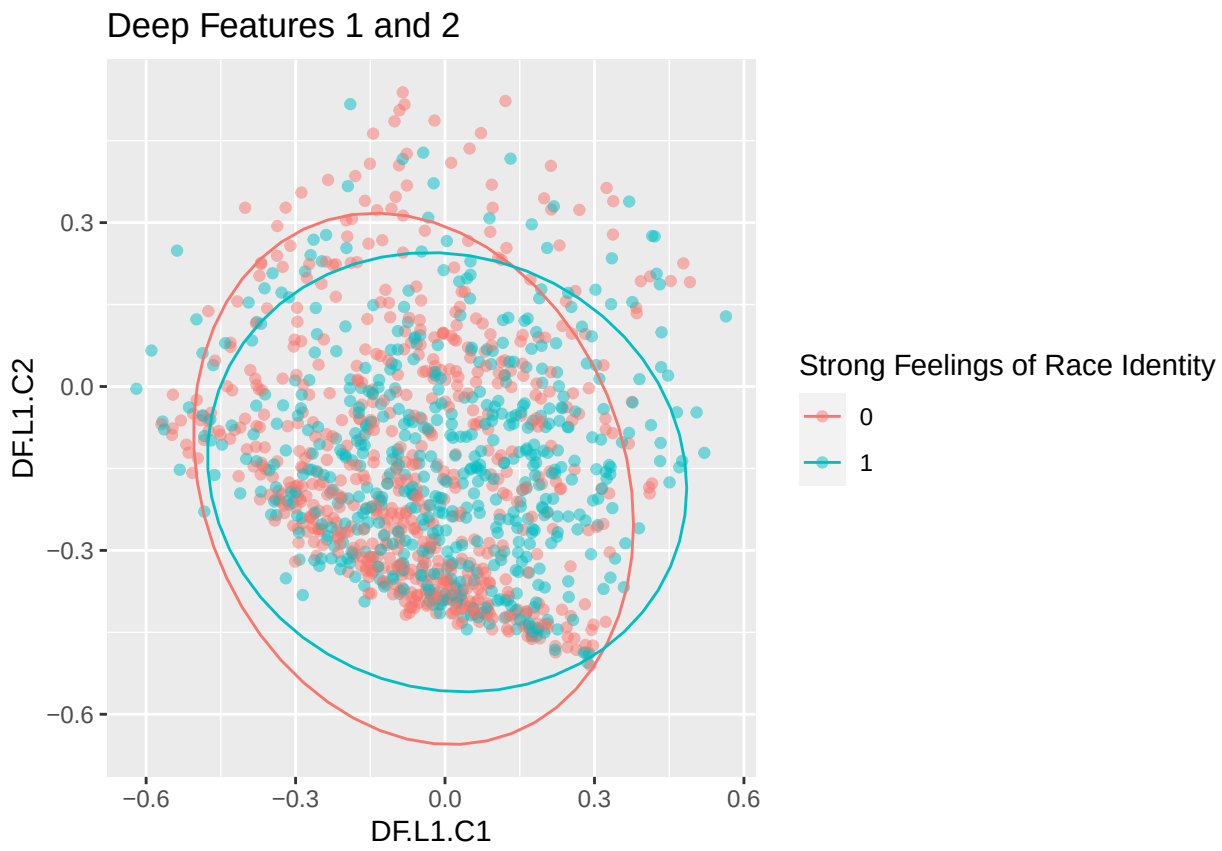
```
shallow_features_race <- h2o.deepfeatures(shallow_autoencoder_race,
                               data = race_h2o,
                               layer = 1)%>%
  as.data.frame()%>%
  mutate(strong_race_ident = as.vector(race_h2o[,15]))
```

```
##   |                                                                      |
```

6. (10 points) Plot the two deep features against each other, with color conditioned by weak or strong racial identity. Discuss the output in a few sentences. For example, do we see separation in the projection (question) space along senses of racial-identity or not? Why or why not do you think?

As with American identity, there is some sorting, but no actual separation on racial identity. It seems that strong feelings of race identity are farther to the left, while weak feelings are concentrated more to the right. As in the previous example, this could indicate either a lack of power in our 2 neuron AE, or it could indicate that racial identity does not have a strong correspondence with the survey variables.

```
ggplot(shallow_features_race, aes(x=DF.L1.C1,
                          y = DF.L1.C2,
                          color = factor(strong_race_ident)))+
  geom_point(alpha = 0.5) +
  stat_ellipse() +
  labs(title = "Deep Features 1 and 2",
       color = "Strong Feelings of Race Identity")
```



7. (10 points) Build a deep autoencoder with 3 hidden layers consisting of 2 nodes in each on the full question space, but again not including the dichotomous racial identity feature. Then, extract the two deep features from the third hidden layer and store these.

```
deep_autoencoder_race <- h2o.deeplearning(x = predictors,
                                  training_frame = race_h2o,
                                  autoencoder = TRUE,
                                  hidden = c(2, 2, 2),
                                  epochs = 100,
                                  activation = "Tanh")
```

```
##   |                                                                      |
```

```
deep_features_race <- h2o.deepfeatures(deep_autoencoder_race,
                               data = race_h2o,
                               layer = 3)%>%
  as.data.frame()%>%
  mutate(strong_race_ident = as.vector(race_h2o[,15]))
```

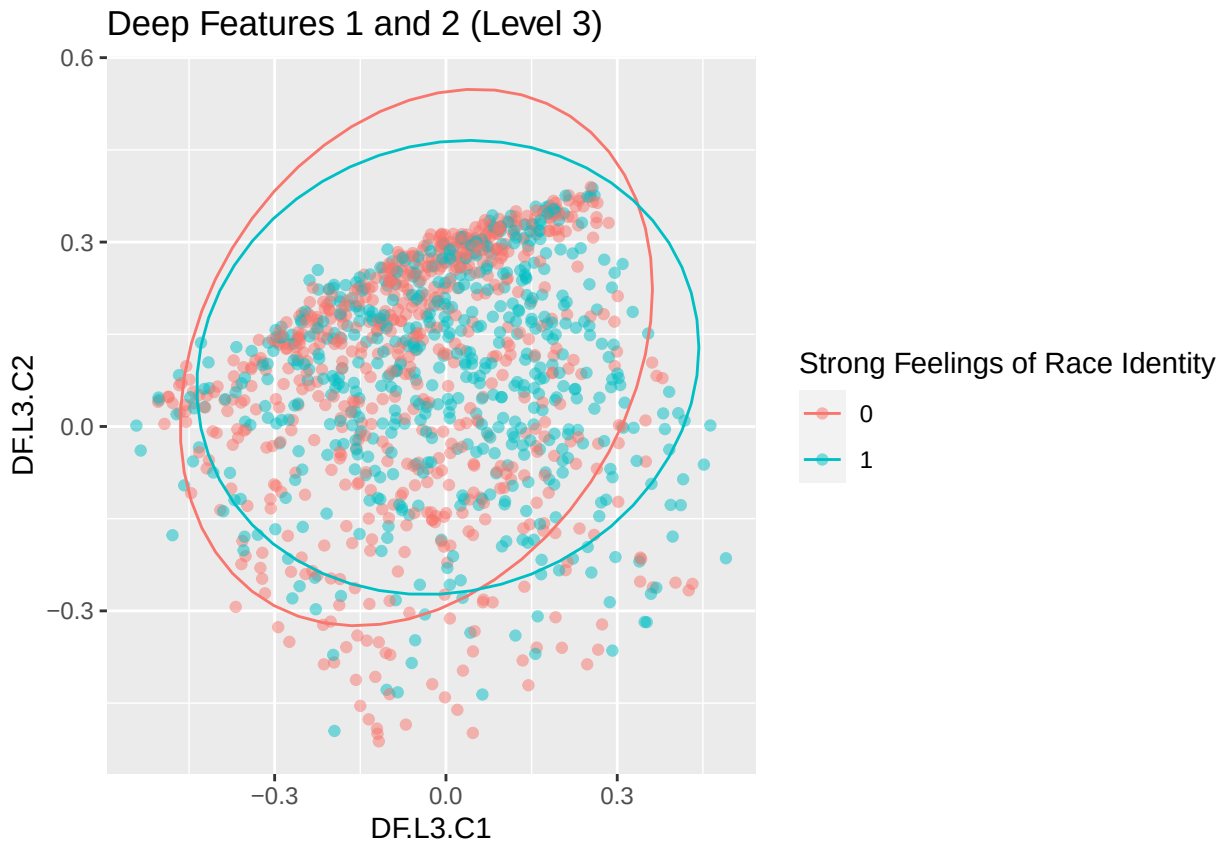
```
##   |                                                                      |
```

8. (10 points) Plot the two deep features from the 3rd hidden layer against each other, with color conditioned by weak or strong racial identity. Discuss the output in a few sentences. For example, does deepening the network help to recover different patterns and/or clearer separation in the question

space along this identity? Why or why not do you think? What do we gain and what do we lose by deepening the network?

There is no clear separation, but there is some kind of structure emerging that corresponds to feelings of racial identity. There is a thick line of weak feelings running along one edge of the data. Adjacent to that, there is a cluster of strong racial identity. The fact that this structure is more apparent when we add layers might indicate that there is some nonlinearity to the structure we are picking up here.

```
ggplot(deep_features_race, aes(x=DF.L3.C1,
                               y = DF.L3.C2,
                               color = factor(strong_race_ident)))+
  geom_point(alpha = 0.5) +
  stat_ellipse() +
  labs(title = "Deep Features 1 and 2 (Level 3)",
       color = "Strong Feelings of Race Identity")
```



Self-Organizing Maps vs. Autoencoders

9. (20 points) Compare the patterns across these two identities - American and racial - to the patterns found from last week's challenge using self-organizing maps. Are the patterns similar or different across these techniques (SOM vs. AE)? Why do you think? What might the benefit be of picking one of these neural network-based approaches to dimension reduction over the other? What do we gain with such a choice and what do we lose? And so on. 7-10 well-constructed sentences should suffice.

In last week's challenge, I found some amount of structure in the American identity mapping, but much weaker for the racial identity metrics. Again, I did not find amazing separation with AE. But I was able to make some progress, particularly in the case of the 3-level AE map which does seem to provide some interesting evidence of sorting and structure (though, again, not separation).

With regards to the types of relationships I searched for in these last two assignments, AE seems to be more helpful in certain contexts than others. AE has an advantage over PCA when it comes to nonlinear spaces; so it may be that in the case of race, where AE seems promising, there is a nonlinearity to the underlying structure. But it really didn't seem to improve my understanding of the American Identity variable.

One downside of AE is that I feel much less intuitive understanding of how the AE views the data. With PCA, I was able to produce heat maps of each input variable, which gave me a visual understanding of how the variables were related. But the AE approach seems like more of a "black box," where the computer is building an understanding of the structure that is obscured from human comprehension.