PSY 1406: Primate FaceNet Detection

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Research Questions

- How does FaceNet perform on **non-human face recognition tasks?**

- What role do **gender** and **age** play in FaceNet's detection capabilities?

- Can FaceNet help us gain insight into visual indicators of **evolutionary similarity?**

- Does FaceNet prove useful in **differentiating between species?**

Hypothesis

While FaceNet ***will*** be able to distinguish between **individual chimps** (by some statistically significant margin), it will **struggle** with more **advanced face recognition tasks** along the axes of gender, age, and interspecies identification.

To test this theory, we will pass input images from annotated datasets of **chimps**, **rhesus macaques,** and **Japanese Monkeys** into FaceNet and compute **statistical analysis** on the **euclidean distance scores**.

We will break this analysis into **4 questions** and carry out **independent** euclidean distance computations for each of them.

Question 1

Can FaceNet identify individual chimps?

Dataset and Wrangling

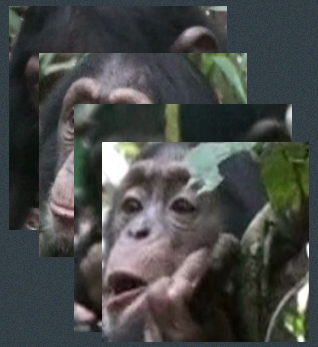
Name: Alexander Freytag and Erik Rodner and Marcel Simon and Alexander Loos and Hjalmar Kühl and Joachim Denzler: "Chimpanzee Faces in the Wild: Log-Euclidean CNNs for Predicting Identities and Attributes of Primates", German Conference on Pattern Recognition (GCPR), 2016.

Cleaned Data: 50 chimp images. Half of the images are of the same chimp named ‘Fredy’. The other half of the images depict different chimps.

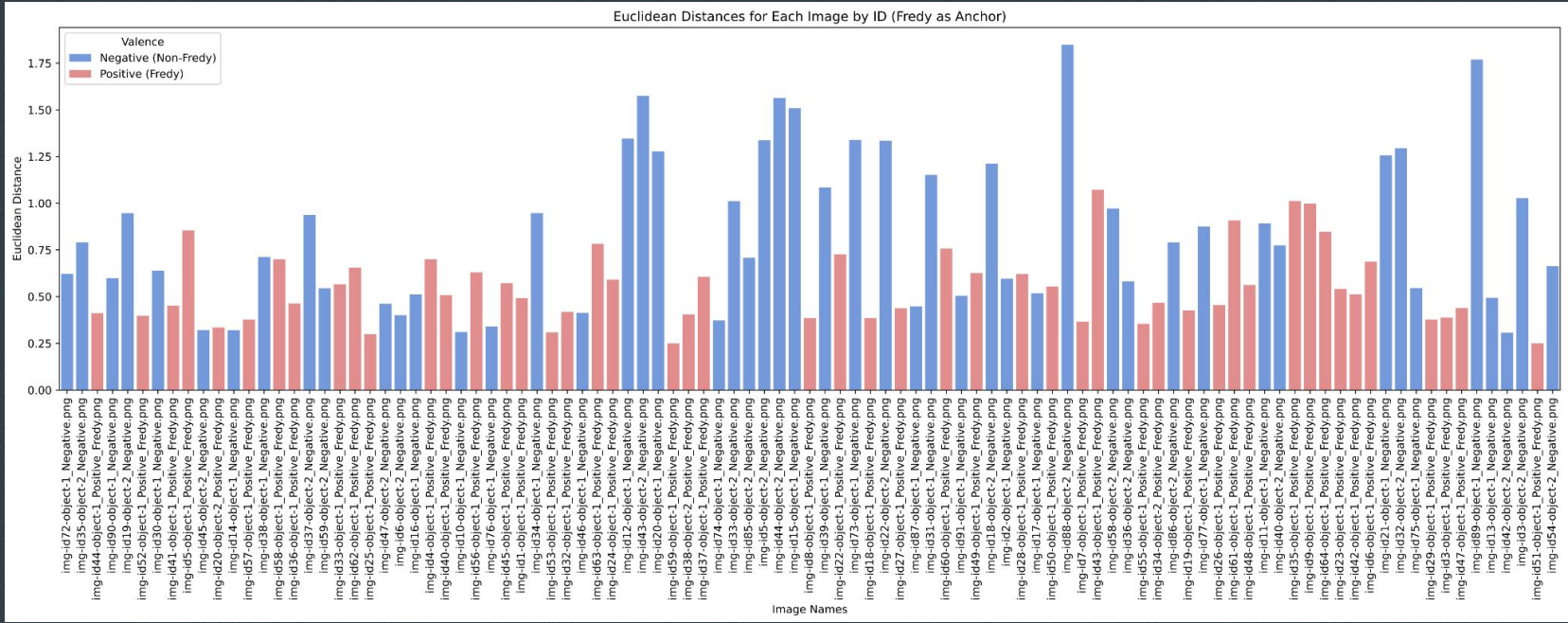
Negative/Positive/Anchor Images

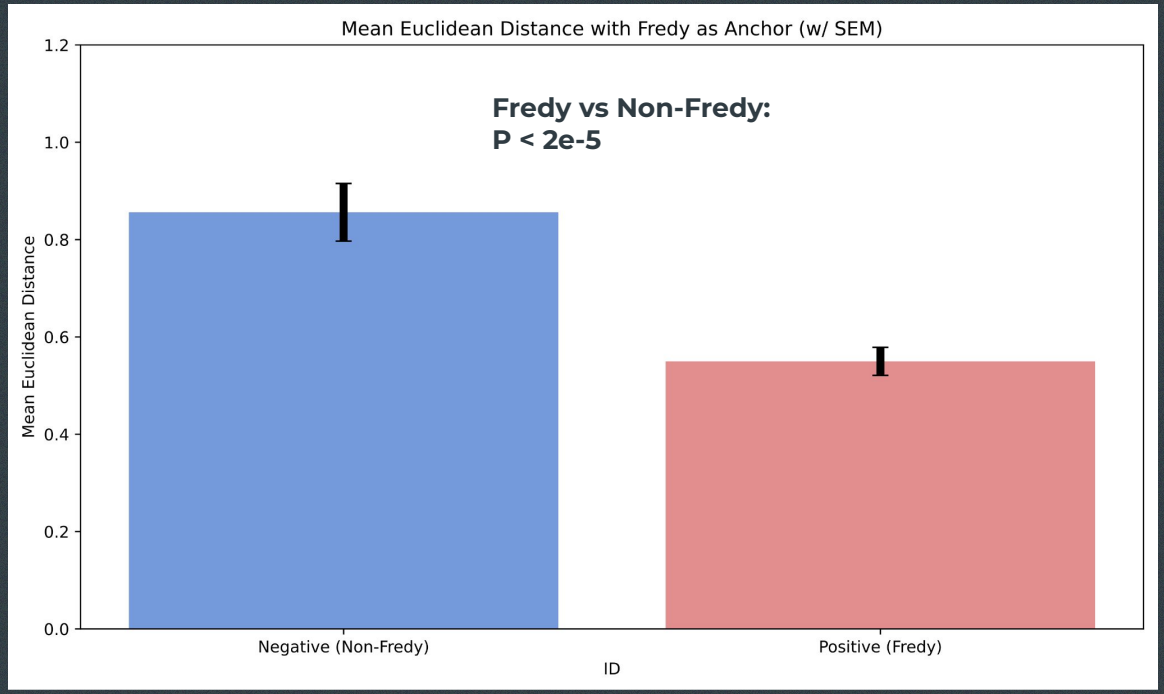
Positive: 49 Other Fredy Images

Anchor: Fredy (Image ID #54)



Negative: 50 Non-Fredy Chimp Images


Euclidean Distances for Each Image by ID (Fredy as Anchor)
Valence
Negative (Non-Fredy)
Positive (Fredy)
Euclidean Distance
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Image Names


Mean Euclidean Distance with Fredy as Anchor (w/ SEM)
Fredy vs Non-Fredy:
P < 2e-5
Mean Euclidean Distance
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Negative (Non-Fredy)
Positive (Fredy)
ID

Question 2

Can FaceNet discriminate between gender within species?

Description of Dataset (Question 2-4)

Name: PrimFace (Face database of non-human primates)
https://visiome.neuroinf.jp/primface/

Primate Types: Japanese Monkey, Rhesus Macaque, Chimpanzee with metadata on gender and age

30 Images of n=3 for each of the primate types were used

Negative/Positive/Anchor Images

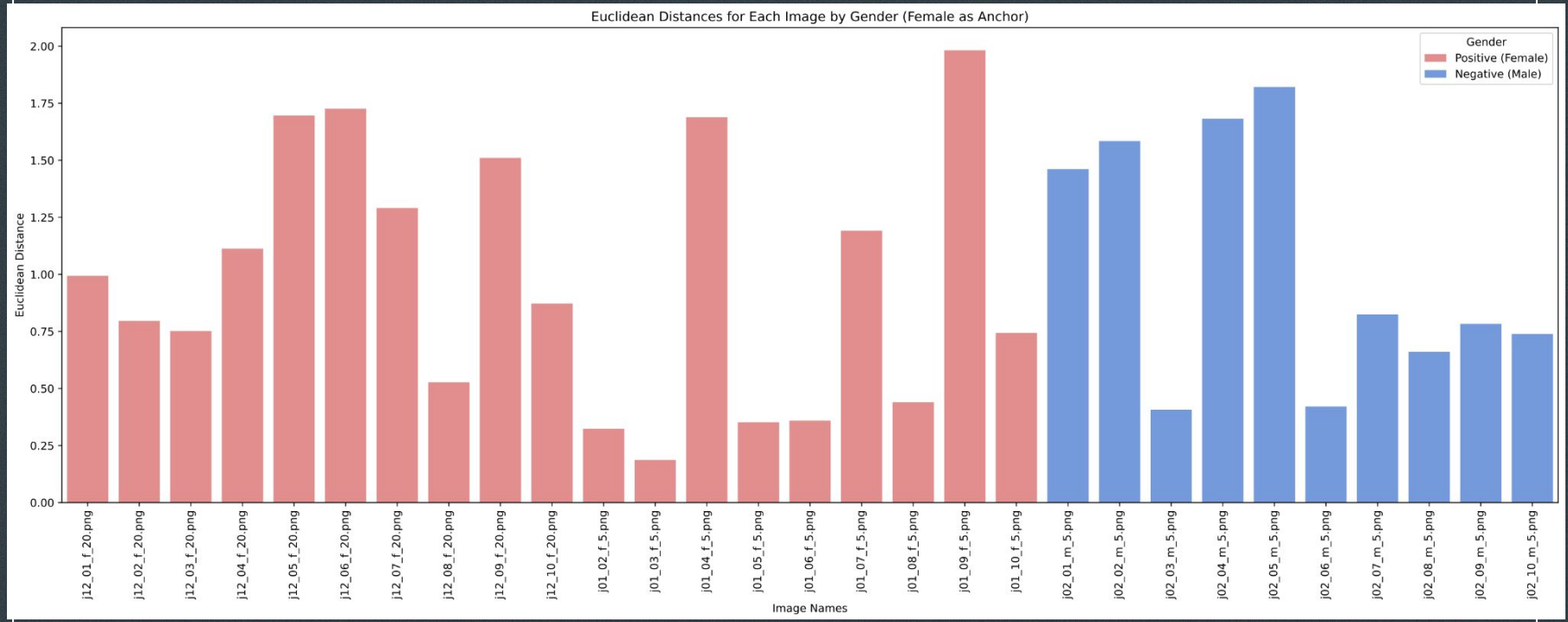
Anchor:
Rhesus Macaque
(Female/Age:5)

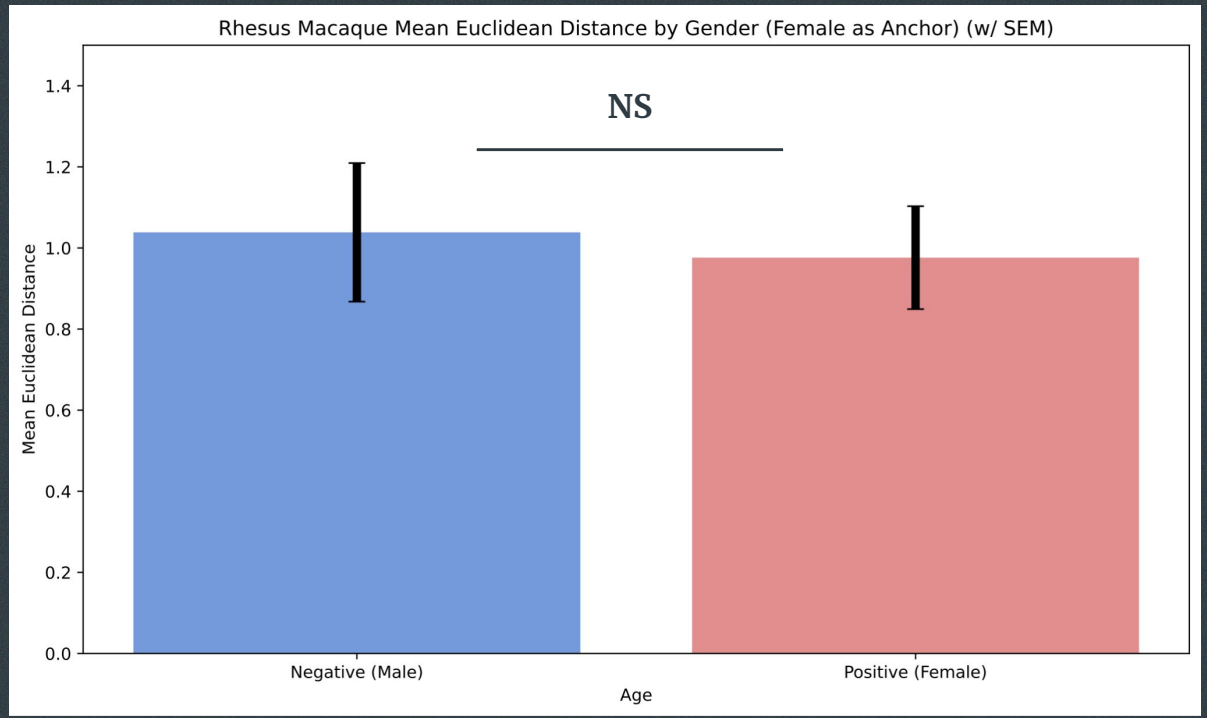
Positive:
Rhesus Macaque
(Female/Age:5)
Different angled images

Negative:
Rhesus Macaque
(Female/Age:20)

Rhesus Macaque
(Male/Age:5)

This design allows us to investigate discriminative capacity of FaceNet on Rhesus Macaque gender, but also Age (Question 3)


Euclidean Distances for Each Image by Gender (Female as Anchor)
Gender
Positive (Female)
Negative (Male)
Euclidean Distance
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
j12_01_f_20.png
j12_02_f_20.png
j12_03_f_20.png
j12_04_f_20.png
j12_05_f_20.png
j12_06_f_20.png
j12_07_f_20.png
j12_08_f_20.png
j12_09_f_20.png
j12_10_f_20.png
j01_02_f_5.png
j01_03_f_5.png
j01_04_f_5.png
j01_05_f_5.png
j01_06_f_5.png
j01_07_f_5.png
j01_08_f_5.png
j01_09_f_5.png
j01_10_f_5.png
j02_01_m_5.png
j02_02_m_5.png
j02_03_m_5.png
j02_04_m_5.png
j02_05_m_5.png
j02_06_m_5.png
j02_07_m_5.png
j02_08_m_5.png
j02_09_m_5.png
j02_10_m_5.png
Image Names


Rhesus Macaque Mean Euclidean Distance by Gender (Female as Anchor) (w/ SEM)
NS
Mean Euclidean Distance
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Negative (Male)
Positive (Female)
Age

Can Facenet recognize males more accurately than females?

```
        Welch Two Sample t-test

data:  Distance by Gender
t = 0.90026, df = 93.878, p-value = 0.3703
alternative hypothesis: true difference in means between group FE and group MA is not equal to 0
95 percent confidence interval:
 -0.08671091  0.23056604
sample estimates:
mean in group FE mean in group MA
        1.262022         1.190094
```

Can Facenet recognize males more accurately than females, controlling for age?

```
Call:
lm(formula = Distance ~ Gender + Age, data = data)

Residuals:
     Min       1Q   Median       3Q      Max
-0.90429 -0.25136  0.02597  0.31291  0.69682

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.207785   0.104450  11.563   <2e-16 ***
GenderMA    -0.048396   0.090840  -0.533    0.595
Age          0.001856   0.003399   0.546    0.586
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4053 on 94 degrees of freedom
Multiple R-squared:  0.01061,   Adjusted R-squared:  -0.01044
F-statistic: 0.5042 on 2 and 94 DF,  p-value: 0.6056
```

```
Analysis of Variance Table

Response: Distance
           Df  Sum Sq  Mean Sq F value Pr(>F)
Gender      1  0.1167 0.116694  0.7102 0.4015
Age         1  0.0490 0.048993  0.2982 0.5863
Residuals 94 15.4446 0.164304
```

Can Facenet recognize males more accurately than females, controlling for age groups?

```
Call:
lm(formula = Distance ~ Gender + Age_Group, data = data)

Residuals:
     Min       1Q   Median       3Q      Max
-0.90936 -0.24341  0.00943  0.28484  0.74404

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)      1.24963    0.06647  18.801   <2e-16 ***
GenderMA        -0.04345    0.09254  -0.470   0.6398
Age_GroupElderly  0.02187    0.14311   0.153   0.8789
Age_GroupInfant   0.05714    0.10274   0.556   0.5795
Age_GroupJuvenile -0.28612    0.15743  -1.817   0.0724 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4008 on 92 degrees of freedom
Multiple R-squared:  0.05339,   Adjusted R-squared:  0.01223
F-statistic: 1.297 on 4 and 92 DF,  p-value: 0.277
```

```
Analysis of Variance Table

Response: Distance
           Df  Sum Sq Mean Sq F value Pr(>F)
Gender      1  0.1167 0.11669  0.7265 0.3962
Age_Group   3  0.7167 0.23890  1.4874 0.2232
Residuals  92 14.7768 0.16062
```

Exploratory Analysis: Can we predict euclidean distance based on age group while controlling for gender?

```
Call:
lm(formula = Distance ~ Age_Group + Gender, data = data)

Residuals:
     Min       1Q   Median       3Q      Max
-0.90936 -0.24341  0.00943  0.28484  0.74404

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)        1.24963    0.06647  18.801   <2e-16 ***
Age_GroupElderly   0.02187    0.14311   0.153   0.8789
Age_GroupInfant    0.05714    0.10274   0.556   0.5795
Age_GroupJuvenile -0.28612    0.15743  -1.817   0.0724 .
GenderMA          -0.04345    0.09254  -0.470   0.6398
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4008 on 92 degrees of freedom
Multiple R-squared:  0.05339,   Adjusted R-squared:  0.01223
F-statistic: 1.297 on 4 and 92 DF,  p-value: 0.277
```

```
Analysis of Variance Table

Response: Distance
           Df  Sum Sq  Mean Sq F value Pr(>F)
Age_Group   3  0.7980 0.265994  1.6561 0.1820
Gender      1  0.0354 0.035417  0.2205 0.6398
Residuals 92 14.7768 0.160618
```

Exploratory Analysis: Can we predict euclidean distance based on age group while controlling for gender?

```
Call:
lm(formula = Distance ~ Age + Gender, data = data)

Residuals:
     Min       1Q   Median       3Q      Max
-0.90429 -0.25136  0.02597  0.31291  0.69682

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.207785   0.104450  11.563   <2e-16 ***
Age          0.001856   0.003399   0.546    0.586
GenderMA    -0.048396   0.090840  -0.533    0.595
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4053 on 94 degrees of freedom
Multiple R-squared:  0.01061,   Adjusted R-squared:  -0.01044
F-statistic: 0.5042 on 2 and 94 DF,  p-value: 0.6056
```

```
Analysis of Variance Table

Response: Distance
           Df  Sum Sq  Mean Sq F value Pr(>F)
Age         1  0.1191 0.119053  0.7246 0.3968
Gender      1  0.0466 0.046634  0.2838 0.5955
Residuals 94 15.4446 0.164304
```

Discussion (Broad)

- Facenet's sensitivity to Chimp faces:
  - Training data bias
  - Feature emphasis discrepancy: Facenet is trained to emphasize and distinguish among human faces (eye spacing, facial symmetry, etc) which might not be as pronounced in Chimps
  - Facial structure and variability differences: can lead to misinterpretation or overlooked by algorithm
- Gender differences in chimp:
  - gender differences are not pronounced enough to be detected
- Age as a confounding factor:
- Sample Size and Study design:
  - Can replicate using different chimps as "anchor"
  - if effect size is small, larger sample sizes are necessary to detect significant differences

Discussion (Algorithm)

- **Triplet Loss Function**: used to ensure that an image of a specific person's face is closer to all other images of the same person than to any image of any other person in the dataset
    - Chimps: struggle with subtle differences or misaligned of features

- **CNN**: used for feature extraction, tuned to human facial features (eyes, noses, mouths) in specific configurations and proportions

- **Embedding layer**: Used to compare faces and determine similarity

Question 3

Can FaceNet discriminate **age** within species?

Negative/Positive/Anchor Images

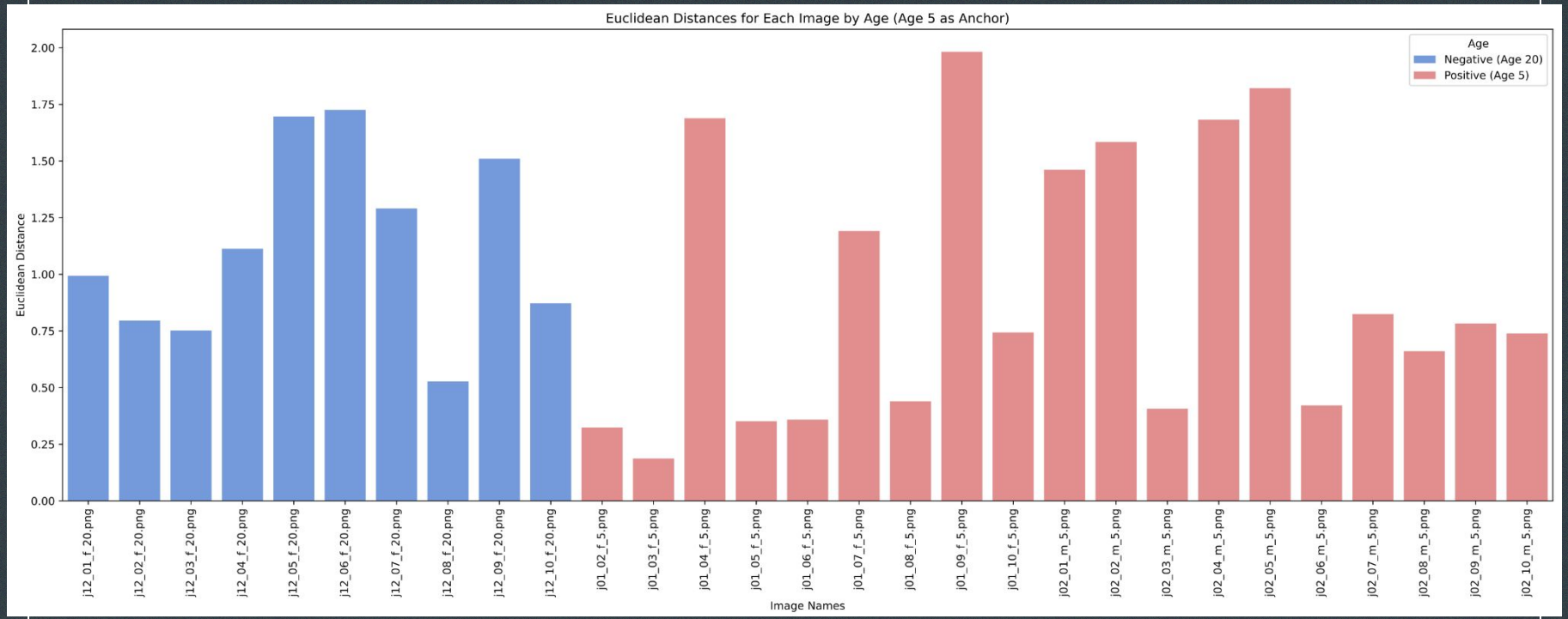
Anchor:
Rhesus Macaque
(Female/Age:5)

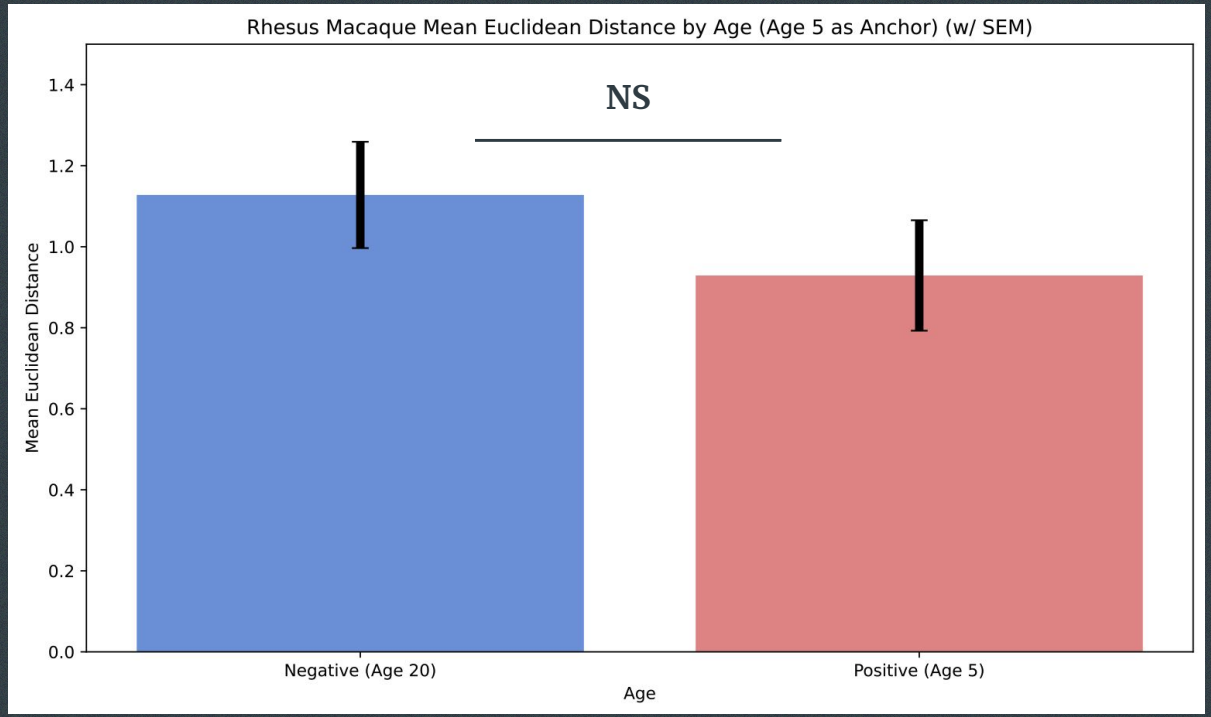
Positive:
Rhesus Macaque
(Female/Age:5)
Different angled images

Negative:
Rhesus Macaque
(Female/Age:20)

Rhesus Macaque
(Male/Age:5)

This design allows us to investigate discriminative capacity of FaceNet on Rhesus Macaque gender, but also Age (Question 3)


Euclidean Distances for Each Image by Age (Age 5 as Anchor)
Euclidean Distance
Image Names
Age
Negative (Age 20)
Positive (Age 5)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
j12_01_f_20.png
j12_02_f_20.png
j12_03_f_20.png
j12_04_f_20.png
j12_05_f_20.png
j12_06_f_20.png
j12_07_f_20.png
j12_08_f_20.png
j12_09_f_20.png
j12_10_f_20.png
j01_02_f_5.png
j01_03_f_5.png
j01_04_f_5.png
j01_05_f_5.png
j01_06_f_5.png
j01_07_f_5.png
j01_08_f_5.png
j01_09_f_5.png
j01_10_f_5.png
j02_01_m_5.png
j02_02_m_5.png
j02_03_m_5.png
j02_04_m_5.png
j02_05_m_5.png
j02_06_m_5.png
j02_07_m_5.png
j02_08_m_5.png
j02_09_m_5.png
j02_10_m_5.png


Rhesus Macaque Mean Euclidean Distance by Age (Age 5 as Anchor) (w/ SEM)
NS
Mean Euclidean Distance
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Negative (Age 20)
Positive (Age 5)
Age

Question 4

Can FaceNet discriminate across species?
(Chimps vs Rhesus vs Jap. Monkey)

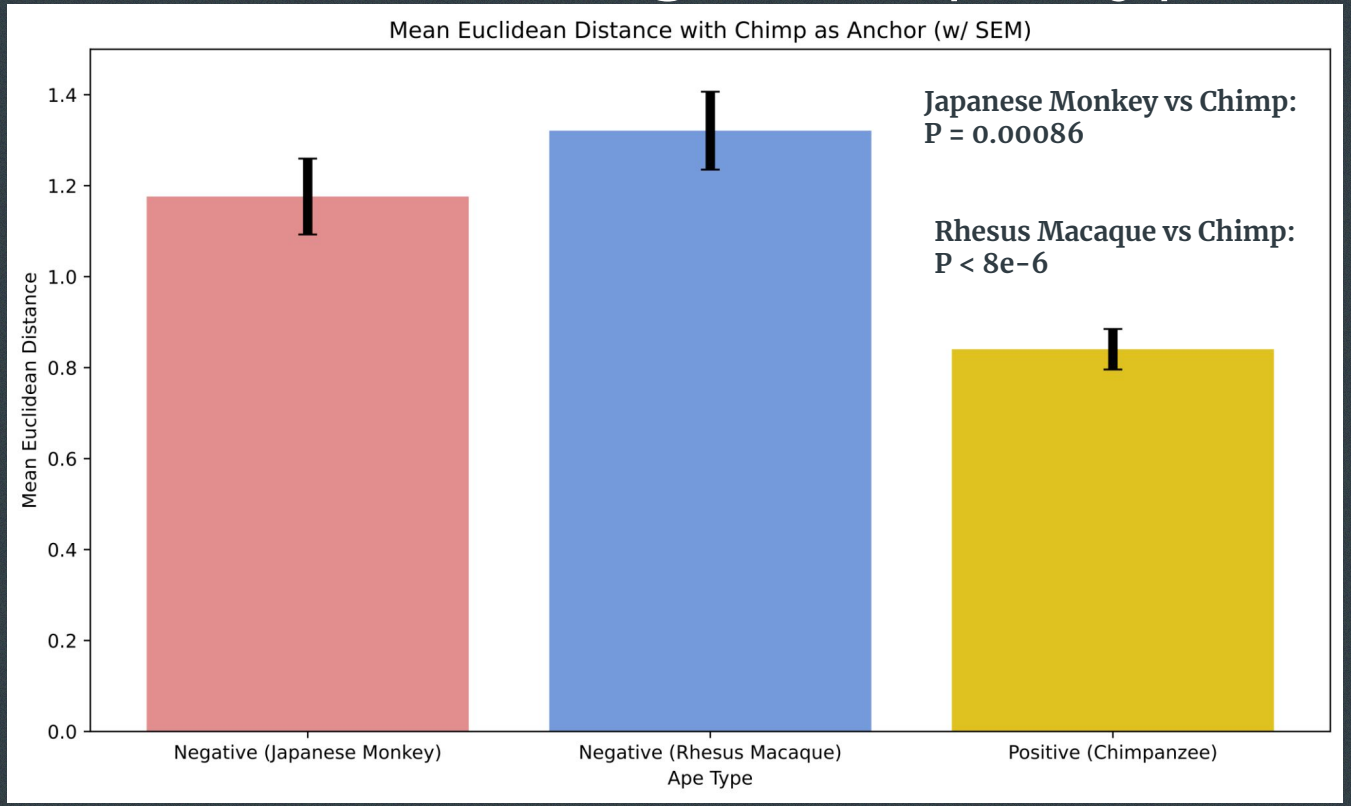
Negative/Positive/Anchor Images

Anchor:
Chimpanzee
(Female/Age:34)

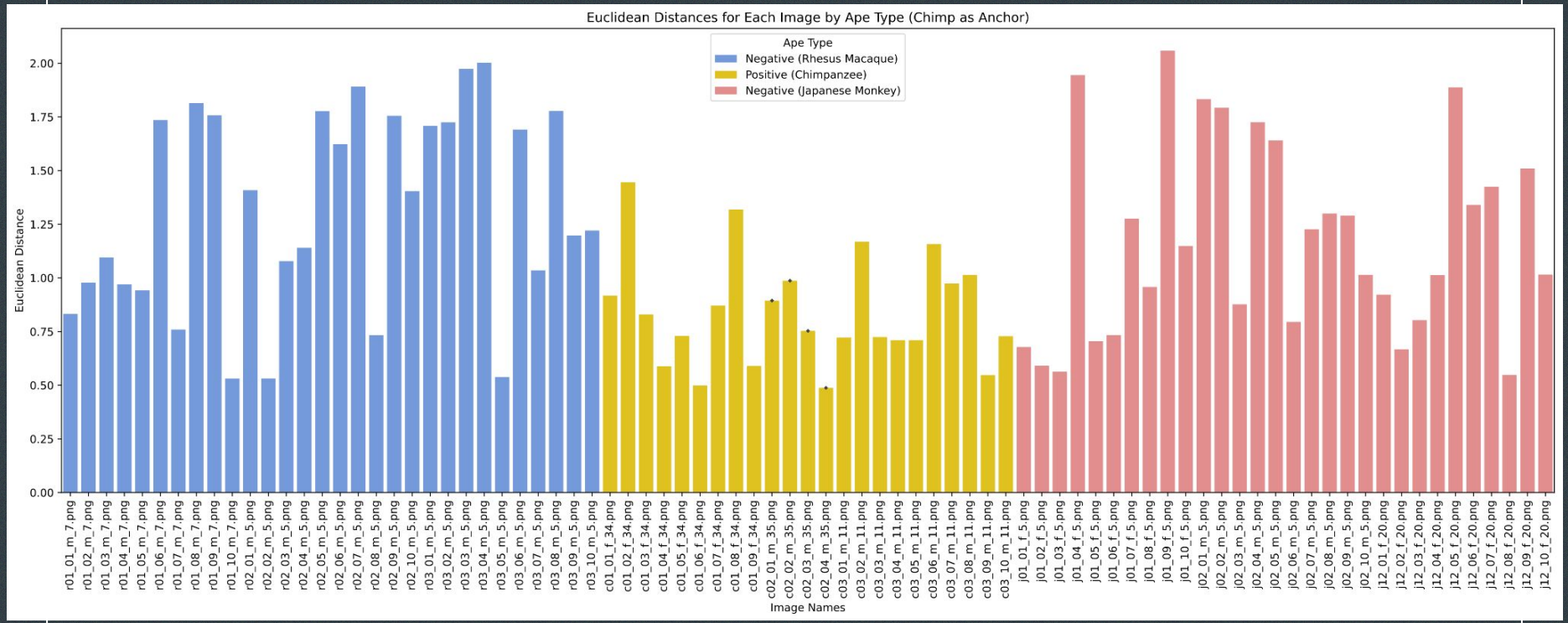
Positive:
30 Images of 3
Chimpanzees

Negative:
30 Images of 3 Rhesus Macaques,
30 Images of Japanese Monkeys

Can FaceNet distinguish Ape Types?



Can FaceNet distinguish Ape Types?



Discussion

Chimpanzees: Chimpanzees are part of the ‘Great Apes’, which also includes humans, gorillas, and orangutans. Chimpanzees are more closely related to humans than they are to either rhesus macaques or Japanese monkeys.

Rhesus Macaque (Macaca mulatta) and Japanese Monkey (Macaca fuscata): Both of these species belong to ‘Old World monkeys’. This family distinction places them further from chimpanzees on the evolutionary tree. **Since rhesus macaques and Japanese macaques are both part of the same genus, they are more closely related to each other than either is to the chimpanzee.**

Results: Using a Chimp face as an anchor, FaceNet calculated lowest euclidean distances for positive Chimp example images, and higher for negative Rhesus Macaque and Japanese Monkeys.

Side Result (Trend): Rhesus Macaque and Japanese Monkeys had similar level of euclidean distance away from the Chimp anchor - which may indicate FaceNet capturing phenotypic similarities of these two species

Conclusion

FaceNet was able to distinguish between:

- Different individuals in our chimp data set

FaceNet was unable to distinguish between:

- Different genders within a species in our chimp data set

FaceNet was able to somewhat distinguish between:

- Different species (chimps v. rhesus v. jap. monkey)
- Different aged individuals in our rhesus macaque data set

FaceNet might have the capability to recognize facial features of animal species that are more closely related to humans on the evolutionary or phylogenetic tree

- Evidence: better recognition of chimpanzee data set than rhesus macaque or japanese monkey

Q&A

thank you for your time and attention!