

faceMobileNet_TransferLearning

May 29, 2021

```
[ ]: # Mounting Google Drive
from google.colab import drive
from os.path import join
ROOT = '/content/drive'
print(ROOT)
drive.mount(ROOT)
```

```
/content/drive
Mounted at /content/drive
```

```
[ ]: %cd /content
```

```
/content
```

```
[1]: holly_face_path = '/content/drive/My Drive/Colab Notebooks/ProjectData/
→FaceRecognition/archive.zip'
```

```
face_path = '/content/drive/My Drive/Colab Notebooks/ProjectData/
→FaceRecognition/dataset2/'
```

```
VM_path = '/content'
drive_path = '/content/drive/MyDrive/Colab Notebooks/ProjectData/
→FaceRecognition/'
VM_face_path = '/content/dataset2'
VM_face_aug_path = '/content/dataset'
face_detection_path= "/content/drive/MyDrive/Colab Notebooks/ProjectData/
→FaceRecognition/face_detection_model/res10_300x300_ssd_iter_140000.
→caffemodel"
proto_path = "/content/drive/MyDrive/Colab Notebooks/ProjectData/
→FaceRecognition/face_detection_model/deploy.prototxt"
```

```
[2]: !cp '{holly_face_path}' '/content'
```

```
[3]: !unzip -q /content/archive.zip -d /content
```

```
[4]: #!cp -r '{face_path}' '{VM_path}'
```

```
[5]: #run this if you want to save augmented images
!mkdir /content/dataset
```

```
[ ]: # run this to clear all in dataset folder
!rm -r /content/dataset/*
```

```
rm: cannot remove '/content/dataset/*': No such file or directory
```

```
[ ]: # run this if you want to save face roi
!mkdir /content/dataset2
```

```
[ ]: #run this to clear all in dataset2 folder
!rm -r /content/dataset2/*
```

```
rm: cannot remove '/content/dataset2/*': No such file or directory
```

```
[ ]: %ls /content/dataset/
```

```
[6]: # Always run this
from keras.layers import Input, Lambda, Dense, Flatten, ↵
    ↵GlobalAveragePooling2D, Dropout
from keras.models import Model
from keras.applications.inception_v3 import InceptionV3
from keras.applications.mobilenet_v2 import MobileNetV2
from keras.applications.vgg16 import VGG16
from keras.applications.vgg16 import preprocess_input
from keras.preprocessing import image
from keras.preprocessing.image import ImageDataGenerator
from keras.callbacks import ModelCheckpoint
from keras.models import Sequential , load_model
import keras
import numpy as np
from glob import glob
import matplotlib.pyplot as plt
import os
import cv2
from google.colab.patches import cv2_imshow
import pickle
import random
import tensorflow as tf
from sklearn.model_selection import train_test_split
```

```
[ ]: #@title run this if do not have the face roi. What this code does is it ↵
    ↵produces 5 augmentations for each image in the dataset and saves it in the VM ↵
    ↵disk
# run this if do not have the face roi. What this code does is it produces 5 ↵
    ↵augmentations for each image in the dataset
```

```

datagen = ImageDataGenerator(
    rotation_range = 10,
    width_shift_range = 0.2,
    height_shift_range = 0.2,
    zoom_range = 0.2,
    horizontal_flip = True,
    fill_mode='nearest')

image_size = 224
NUMBER_TO_AUGMENT = 5
c = 0
labelConverter = {}
dirpath = face_path
paths = os.listdir(dirpath)
#known_face = []

for directory in paths:
    !mkdir '/content/dataset/{directory}'
    labelConverter[directory] = c
    c+=1
print(labelConverter)
for p in paths:
    label = labelConverter[p]
    aug_save_path = VM_face_aug_path+'/' +p
    for p1 in os.listdir(dirpath+'/'+p):
        num_aug = 0
        try:
            path = dirpath+'/'+p+'/'+p1
            img = cv2.imread(path)
            #img = cv2.resize(img, (image_size, image_size))
            img_np = np.asarray(img)
            img_np = np.expand_dims(img_np,0)
            print("Image size = ",img_np.shape)
            it = datagen.flow(img_np, batch_size=1, save_to_dir=aug_save_path,save_prefix='celeb', save_format='png')
            while num_aug < NUMBER_TO_AUGMENT:
                it.next()
                print(num_aug+1,'th augmentation of ',path)
                num_aug += 1
        except Exception as e:
            print("Error",e)

```

```
[ ]: #@title this uploads the augmented dataset from VM to drive
# this uploads the augmented dataset from VM to drive
!cp -r '{VM_face_aug_path}' '/content/drive/MyDrive/'
```

```
[ ]: #@title Run This if you need Face detector model
# Run This if you need Face detector
print("Loading face detector.....")
detector = cv2.dnn.readNetFromCaffe(proto_path, face_detection_path)

[ ]: #@title run this if you need Haar Face detector model
# run this if you need Haar Face detector
face_dec = cv2.CascadeClassifier(cv2.data.
→haarcascades+'haarcascade_frontalface_default.xml')

[ ]: #@title run this if you need DNN Face detector fucntion
# run this if you need DNN Face detector
def getFace_CV2DNN(image):
    (h,w) = image.shape[:2]
    blob = cv2.dnn.blobFromImage(cv2.resize(image, (300,300)),1.0, (300,300),(104.
→0, 177.0, 123.0), swapRB= False, crop = False)
    detector.setInput(blob)
    detections = detector.forward()
    max = -1
    fHM = 0
    fWM = 0
    x1 = 0
    x2=0
    y1=0
    y2 = 0
    for i in range(0,detections.shape[2]):
        confidence = detections[0,0,i,2];

        if confidence < 0.7:
            continue

        box = detections[0, 0, i, 3:7] * np.array([w, h, w, h])
        (startX, startY, endX, endY) = box.astype("int")
        cv2.rectangle(image, (startX, startY), (endX, endY), (0,0,255), 2)

        fH = endX - startX
        fW = endY - startY
        #print("ggg-",fW,fH)
        if fH < 20 or fW < 20:
            continue
        area = fH*fW
        if max < area:
            max = area
            x1 = startX
            x2 = endX
            y1 = startY
```

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    y2 = endY
    return x1,x2,y1,y2

```

[]: *#@title run this if you need Haar Face detector function*

```

# run this if you need Haar Face detector
def getFace_haar(image):
    max = -1
    x1 = 0
    x2=0
    y1=0
    y2 = 0
    faces = face_dec.detectMultiScale(image, 1.3,5)
    for (x,y,w,h) in faces:
        #print(w,h)
        if w < 20 or h <20:
            continue
        area = h*w
        if max < area:
            max = area
            x1 = x
            y1 = y
            x2 = x+w
            y2 = y+h

    return x1, x2, y1, y2

```

[]: *#@title Run this if you want to get face_roi from augmented images*

```

# Run this if you want to get face_roi from augmented images
#knownface = []
count = 0
k = 1
facelabels = os.listdir(VM_face_aug_path)
for f in facelabels:
    sorc = VM_face_aug_path+'/'+f
    dest = VM_face_path+'/'+f
    os.mkdir(dest)
    img_list = os.listdir(sorc)
    print('Processing ',f, str(k), 'out of ', str(len(facelabels)), 'classes')
    k += 1
    for img in img_list:
        imgPath = sorc+'/'+img
        image = cv2.imread(imgPath)
        #faces = face_dec.detectMultiScale(image)
        print(image.shape)
        cord = getFace_CV2DNN(image)

```

```

if cord == None:
    continue
x1,x2, y1, y2 = cord
try:
    image = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
    face = image[y1:y2, x1:x2]

    savepath = dest+'/'+str(count)+'.png'
    count += 1

    cv2.imwrite(savepath, face)
except Exception as e:
    print('Error: ',e)

```

[]: *#@title run this if you want to upload the face_roi from VM to google drive
run this if you want to upload the face_roi from VM to google drive
%cp -r '/content/dataset2' '/content/drive/MyDrive'*

[]: *#@title run this if you want to download the face_roi from google drive to VM
run this if you want to download the face_roi from google drive to VM
!cp -r '/content/drive/MyDrive/dataset2' '/content'*

[7]: !ls -la /content/105_classes_pins_dataset/

```

total 1176
drwxr-xr-x 107 root root 4096 May 28 16:56 .
drwxr-xr-x 1 root root 4096 May 28 16:56 ..
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Adriana Lima'
drwxr-xr-x 2 root root 16384 May 28 16:55 'pins_Alexandra Daddario'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Alex Lawther'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Alvaro Morte'
drwxr-xr-x 2 root root 16384 May 28 16:55 'pins_alycia dabnem carey'
drwxr-xr-x 2 root root 4096 May 28 16:55 'pins_Amanda Crew'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_amber heard'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Any Samberg'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Anne Hathaway'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Anthony Mackie'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Avril Lavigne'
drwxr-xr-x 2 root root 4096 May 28 16:55 'pins_barack obama'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_barbara palvin'
drwxr-xr-x 2 root root 4096 May 28 16:55 'pins_Ben Affleck'
drwxr-xr-x 2 root root 4096 May 28 16:55 'pins_Bill Gates'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Bobby Morley'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Brenton Thwaites'
drwxr-xr-x 2 root root 4096 May 28 16:55 'pins_Brian J. Smith'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Brie Larson'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_camila mendes'

```

```
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Chris Evans'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Chris Hemsworth'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Chris Pratt'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Christian Bale'
drwxr-xr-x  2 root root  4096 May 28 16:55 'pins_Cristiano Ronaldo'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Danielle Panabaker'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Dominic Purcell'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Dwayne Johnson'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Elizabeth Lail'
drwxr-xr-x  2 root root 16384 May 28 16:55 'pins_elizabeth olsen'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Eliza Taylor'
drwxr-xr-x  2 root root 12288 May 28 16:56 'pins_ellen page'
drwxr-xr-x  2 root root 12288 May 28 16:56 'pins_elon musk'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Emilie Clarke'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Emma Stone'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Emma Watson'
drwxr-xr-x  2 root root 12288 May 28 16:56 'pins_gal gadot'
drwxr-xr-x  2 root root 12288 May 28 16:56 'pins_grant gustin'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Gwyneth Paltrow'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Henry Cavil'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Hugh Jackman'
drwxr-xr-x  2 root root  4096 May 28 16:55 'pins_Inbar Lavi'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Irina Shayk'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Jake Mcdorman'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Jason Momoa'
drwxr-xr-x  2 root root  4096 May 28 16:56 'pins_jeff bezos'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Jennifer Lawrence'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Jeremy Renner'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Jessica Barden'
drwxr-xr-x  2 root root  4096 May 28 16:55 'pins_Jimmy Fallon'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Johnny Depp'
drwxr-xr-x  2 root root  4096 May 28 16:55 'pins_Josh Radnor'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Katharine Mcphee'
drwxr-xr-x  2 root root 20480 May 28 16:55 'pins_Katherine Langford'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Keanu Reeves'
drwxr-xr-x  2 root root 12288 May 28 16:56 'pins_kiernen shipka'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Krysten Ritter'
drwxr-xr-x  2 root root 16384 May 28 16:55 'pins_Leonardo DiCaprio'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Lili Reinhart'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Lindsey Morgan'
drwxr-xr-x  2 root root  4096 May 28 16:55 'pins_Lionel Messi'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Logan Lerman'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Madelaine Petsch'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Maisie Williams'
drwxr-xr-x  2 root root 12288 May 28 16:56 'pins_margot robbie'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Maria Pedraza'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Marie Avgeropoulos'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Mark Ruffalo'
```

```

drwxr-xr-x  2 root root  4096 May 28 16:55 'pins_Mark Zuckerberg'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Megan Fox'
drwxr-xr-x  2 root root 12288 May 28 16:56 'pins_melissa fumero'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Miley Cyrus'
drwxr-xr-x  2 root root 16384 May 28 16:55 'pins_Millie Bobby Brown'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Morena Baccarin'
drwxr-xr-x  2 root root  4096 May 28 16:55 'pins_Morgan Freeman'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Nadia Hilker'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Natalie Dormer'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Natalie Portman'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Neil Patrick Harris'
drwxr-xr-x  2 root root  4096 May 28 16:55 'pins_Pedro Alonso'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Penn Badgley'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Rami Malek'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Rebecca Ferguson'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Richard Harmon'
drwxr-xr-x  2 root root  4096 May 28 16:55 pins_Rihanna
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Robert De Niro'
drwxr-xr-x  2 root root 16384 May 28 16:55 'pins_Robert Downey Jr'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Sarah Wayne Callies'
drwxr-xr-x  2 root root 16384 May 28 16:56 'pins_scarlett johansson'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Selena Gomez'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Shakira Isabel Mebarak'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Sophie Turner'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Stephen Amell'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Taylor Swift'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Tom Cruise'
drwxr-xr-x  2 root root 12288 May 28 16:56 'pins_tom ellis'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Tom Hardy'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Tom Hiddleston'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Tom Holland'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Tuppence Middleton'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Ursula Corbero'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Wentworth Miller'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Zac Efron'
drwxr-xr-x  2 root root  4096 May 28 16:55 pins_Zendaya
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Zoe Saldana'

```

[8]: # set the dataset on which you want to train
train_path1 = '/content/105_classes_pins_dataset/'
train_path = '/content/dataset'

[9]: #@title Takes 20 classes from 105_classes_pins_dataset and saves it a new
↳ folder /content/dataset
count = 0
NB_CLASS = 20
l = os.listdir(train_path1)

```

for li in l:
    count += 1
    sor = '"105_classes_pins_dataset/'+li+'"'
    dest = 'dataset'
    cmd = 'cp -r '+ sor+' '+ dest
    cmd1 = 'rm -r'+ sor
    os.system(cmd)
    os.system(cmd1)
    if count >= NB_CLASS:
        break

```

[10]: #*title Contains Image Data generator to generate augmented images and save it in variable. Also contains code to take all the images and make a list out of it*

```

datagen = ImageDataGenerator(
    rotation_range = 10,
    width_shift_range = 0.2,
    height_shift_range = 0.2,
    zoom_range = 0.2,
    horizontal_flip = True,
    fill_mode='nearest')
NUM_AUG = 1
knownface = []
labels = []
labelEncoder = {}
count = 0
c = 0
dir = '/content/dataset/'
'''
for d in os.listdir(dir):
    labelEncoder[count] = d
    print('Processing for ....',d)
    for k in os.listdir(dir+d):
        image = cv2.imread(dir+d+'/'+k)
        img_np = np.asarray(image)
        img_np = img_np[np.newaxis,:,:,:]

    for im in datagen.flow(img_np, batch_size=1):
        imnp = cv2.resize(im[0], (224,224))

        knownface.append(imnp)
        labels.append(count)
        c+=1
        if c >= NUM_AUG:
            break
        c = 0
    count += 1

```

```

    ...
for d in os.listdir(dir):
    labelEncoder[count] = d
    print('Processig for ....',d)
    for k in os.listdir(dir+d):
        image = cv2.imread(dir+d+'/'+k)
        #img_np = np.asarray(image)
        imnp = cv2.resize(image, (224,224))
        knownface.append(imnp)
        labels.append(count)
    count += 1

```

Processig for ... pins_Miley Cyrus
 Processig for ... pins_Emilie Clarke
 Processig for ... pins_Rebecca Ferguson
 Processig for ... pins_Millie Bobby Brown
 Processig for ... pins_grant gustin
 Processig for ... pins_Mark Zuckerberg
 Processig for ... pins_amber heard
 Processig for ... pins_Neil Patrick Harris
 Processig for ... pins_Bill Gates
 Processig for ... pins_Krysten Ritter
 Processig for ... pins_Brenton Thwaites
 Processig for ... pins_Alexandra Daddario
 Processig for ... pins_Taylor Swift
 Processig for ... pins_Stephen Amell
 Processig for ... pins_Madelaine Petsch
 Processig for ... pins_Jeremy Renner
 Processig for ... pins_Katherine Langford
 Processig for ... pins_Jennifer Lawrence
 Processig for ... pins_Anne Hathaway
 Processig for ... pins_Zoe Saldana

[11]:

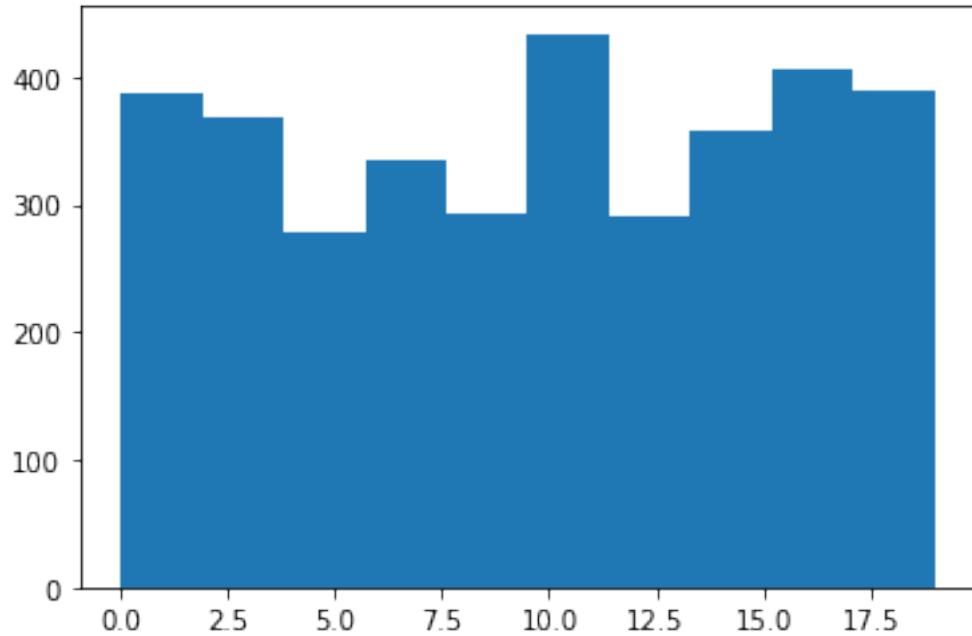
```
X = np.array(knownface)
y = np.array(labels)
num_classes = len(labelEncoder)
```

[12]:

```
plt.hist(y)
```

[12]:

```
(array([388., 369., 278., 334., 293., 434., 290., 359., 406., 389.]),
 array([ 0. ,  1.9,  3.8,  5.7,  7.6,  9.5, 11.4, 13.3, 15.2, 17.1, 19. ]),
 <a list of 10 Patch objects>)
```



```
[13]: labelEncoder
```

```
[13]: {0: 'pins_Miley Cyrus',
 1: 'pins_Emilia Clarke',
 2: 'pins_Rebecca Ferguson',
 3: 'pins_Millie Bobby Brown',
 4: 'pins_grant gustin',
 5: 'pins_Mark Zuckerberg',
 6: 'pins_amber heard',
 7: 'pins_Neil Patrick Harris',
 8: 'pins_Bill Gates',
 9: 'pins_Krysten Ritter',
 10: 'pins_Brenton Thwaites',
 11: 'pins_Alexandra Daddario',
 12: 'pins_Taylor Swift',
 13: 'pins_Stephen Amell',
 14: 'pins_Madelaine Petsch',
 15: 'pins_Jeremy Renner',
 16: 'pins_Katherine Langford',
 17: 'pins_Jennifer Lawrence',
 18: 'pins_Anne Hathaway',
 19: 'pins_Zoe Saldana'}
```

```
[14]: print(len(knownface))
```

3540

```
[15]: X_1, X_test, y_1, y_test = train_test_split( X, y, shuffle=True,random_state = 100,test_size=0.2,stratify=y)
```

```
[16]: X_train, X_val, y_train, y_val = train_test_split( X_1,y_1,shuffle=True,random_state = 100,test_size=0.25,stratify=y_1)
```

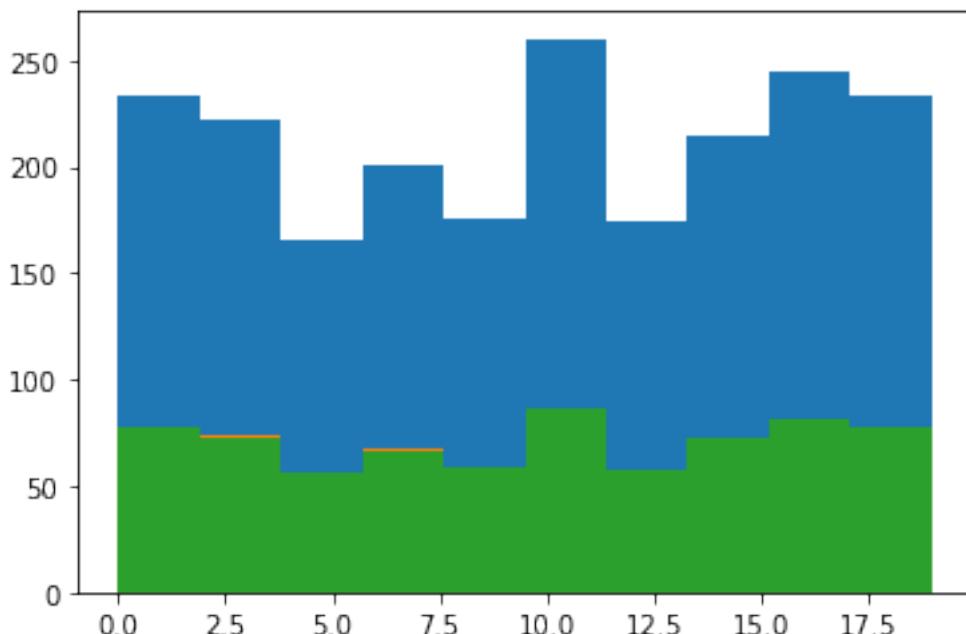
```
[17]: y_val
```

```
[17]: array([13,  2, 18, 11, 10,  2, 10, 16, 14, 14, 18, 11,  2,  3, 19, 10,  1,
       9,  6,  2,  5, 19, 17,  6, 11,  7,  1,  8,  3, 11, 16,  0, 18,  9,
       0, 11, 12,  4, 16, 16,  9, 17, 11,  9, 18,  0, 15,  8, 14, 13,  1,
       9,  1,  4,  8, 18, 12, 19,  4, 19, 11, 11, 16, 18,  1, 10,  4, 14,
       3,  1, 16,  5, 16, 17,  4,  4,  3, 10, 14, 14,  3, 11,  7,  3,  9,
       18,  1, 18, 13,  6, 16,  3,  1,  5, 16, 16,  6, 13, 11,  9,  4,  4,
       18,  0, 11, 19, 15, 16, 13, 19,  6, 19, 11,  2, 10, 16, 12,  8,  1,
       3,  0,  0, 13,  0,  6,  9, 17, 14, 11, 16,  8,  6, 10,  2,  9,  1,
       16, 11, 19, 13, 10,  8, 16,  6, 15,  0, 12, 18,  8, 17,  6,  7, 19,
       13, 11,  2, 17, 16, 17,  4,  2, 15, 16,  7, 14,  5,  1, 17, 13,  3,
       15, 16,  1,  9,  0, 18,  9,  6, 16,  4, 18, 11,  0,  8, 18,  3, 15,
       17,  0,  2, 19, 14, 11,  9, 18,  6,  3, 19, 13,  8, 12, 11,  9,  0,
       16,  6, 15,  3,  2,  0, 11,  3,  2,  1, 14,  6,  6,  9,  8,  2, 10,
       2,  5, 15, 13, 15,  6, 10,  4,  1,  7, 17, 12, 19, 13,  1, 15,  5,
       10,  6, 10,  2, 13,  0,  8, 18,  9, 11, 11, 15,  6,  4, 15,  6,  2,
       18, 19,  1, 19, 17, 17, 19, 19, 15,  6,  1, 15,  9,  6, 13, 10, 19,
       13, 19,  1, 14, 17, 12, 11, 17,  3, 18,  8,  4,  9, 19,  1,  7, 18,
       5, 10,  6,  3, 17, 16, 11, 13,  5, 13, 17, 12, 17, 16,  9, 11,  7,
       10,  9, 18,  7, 16,  8,  5, 16, 17,  6, 16, 17,  2, 16,  0,  4,  2,
       3, 19, 14,  3,  1,  1,  0, 12, 11, 14, 14, 15,  3, 17, 17, 18,  6,
       3, 15,  2, 11, 13,  3, 17,  9, 14,  4,  0,  7,  4,  5,  0, 10,  7,
       11, 13, 12,  0, 18,  0, 18, 15,  8, 15, 14, 10,  1,  1,  3, 19,  4,
       9,  2,  4, 18,  8,  8, 16, 17,  5, 10,  4, 10, 10,  8, 15, 13, 14,
       7,  7, 11, 18,  0, 16,  6,  3, 15,  0,  8,  0, 12, 11,  2, 14, 12,
       4, 10, 11, 11,  1, 19, 18, 12, 18, 19, 15, 17,  4,  3, 14,  7, 14,
       10,  6, 19,  0, 14, 18, 10, 15,  6, 12, 16, 17, 11,  6,  4, 12, 14,
       17, 14, 11,  9,  0, 15, 10,  8, 19, 13,  6, 19,  4, 10, 14,  7, 12,
       17, 14, 16, 19, 13, 14,  5,  6, 16, 12,  7,  6,  0, 13, 16, 13,  6,
       4, 16,  3,  2, 19, 10, 18,  1,  4,  9, 14, 18,  4, 16,  1,  3,  9,
       1, 10, 16,  9, 15, 19, 17,  3,  5,  3,  3, 12, 11, 10, 17, 18, 16,
       17,  3,  7, 16,  6, 12,  0,  8, 11, 14, 16, 17, 15, 14, 11, 19,  9,
       15,  6, 16, 10, 16, 10, 16,  4, 14,  2, 13,  4, 15,  9, 14, 11, 16,
       11,  9, 10, 17, 14,  4,  1,  4, 19,  0, 18, 10, 12,  6, 16, 10,  3,
       9, 14,  6,  7,  8, 18,  0,  6,  8, 10,  5, 11,  2,  4,  1, 13, 18,
       14, 10,  2, 17,  4,  3, 12, 10, 16, 15,  5, 18, 12,  6,  1,  2,  2,
       3, 10,  1, 18,  7, 19, 12,  9, 13,  8,  1,  0,  6,  2, 10, 13, 11,
       13, 19, 17, 12, 18,  1, 18,  6, 16, 14, 19, 12,  8,  4, 11, 15,  3,
       0,  1, 14,  5,  7, 15,  7,  1,  9, 10,  5, 13,  2,  9, 19,  1,  1,
       4, 10, 17, 14,  1,  1, 15,  6,  7,  9,  6,  4,  2,  4, 14, 11, 11,
```

```
10,  9,  7, 14, 11,  5,  3, 10,  0, 15,  1,  0, 13, 19, 11,  3,  2,
2,  7, 13, 17, 12,  0, 18, 15,  3,  4,  6,  3,  3, 18,  1, 15,  6,
2, 18,  1, 18,  2,  0,  5,  2, 19,  2,  8])
```

```
[18]: plt.hist(y_train)
plt.hist(y_test)
plt.hist(y_val)
```

```
[18]: (array([77., 73., 56., 66., 59., 87., 58., 73., 81., 78.]),
array([ 0. , 1.9, 3.8, 5.7, 7.6, 9.5, 11.4, 13.3, 15.2, 17.1, 19. ]),
<a list of 10 Patch objects>)
```



```
[19]: y_train = tf.keras.utils.to_categorical(y_train, num_classes)
y_test = tf.keras.utils.to_categorical(y_test, num_classes)
y_val = tf.keras.utils.to_categorical(y_val, num_classes)
```

```
[20]: print(X_test.shape)
print(X_val.shape)
print(X_train.shape)
```

```
(708, 224, 224, 3)
(708, 224, 224, 3)
(2124, 224, 224, 3)
```

```
[21]: from keras.preprocessing.image import ImageDataGenerator
'''
```

```

train_datagen = ImageDataGenerator(rescale = 1./255,
                                   rotation_range=10,
                                   horizontal_flip=True,
                                   brightness_range = [0.5,1.5],
                                   validation_split=0.2)

training_set = train_datagen.flow_from_directory(train_path,
                                                target_size = IMAGE_SIZE,
                                                batch_size = 32,
                                                class_mode = 'categorical',
                                                subset='training')

testing_set = train_datagen.flow_from_directory(train_path,
                                                target_size = IMAGE_SIZE,
                                                batch_size = 32,
                                                class_mode = 'categorical',
                                                subset='validation')

'''

from keras.preprocessing.image import ImageDataGenerator

train_datagen = ImageDataGenerator(rescale = 1./255,
                                   rotation_range=10,
                                   horizontal_flip=True,
                                   width_shift_range = 0.2,
                                   height_shift_range = 0.1,
                                   zoom_range = 0.2,
                                   brightness_range = [0.5,1.5])

training_set = train_datagen.flow(x = X_train,y = y_train,batch_size = 32)

testing_set = train_datagen.flow(x = X_test,y = y_test,batch_size = 32)

validation_set = train_datagen.flow(x= X_val, y = y_val, batch_size=32)

```

```

[22]: # re-size all the images to this
IMAGE_SIZE = [224, 224]

# add preprocessing layer to the front of VGG
#vgg = VGG16(input_shape=IMAGE_SIZE + [3], weights='imagenet',include_top=False)
vgg = MobileNetV2(include_top=False,weights='imagenet', input_shape=(224,224,3))

# don't train existing weights

```

```

vgg.trainable=True

# useful for getting number of classes
folders = glob(train_path+'/*')

print("Number of classes = ", len(folders))

```

Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/mobilenet_v2/mobilenet_v2_weights_tf_dim_ordering_tf_kernels_1.0_224_no_top.h5
9412608/9406464 [=====] - 0s 0us/step
9420800/9406464 [=====] - 0s 0us/step
Number of classes = 20

```

[23]: '''
unfrozen_layer = -43 # InceptionV3
#unfrozen_layer = -1 # VGG16
for l in vgg.layers[unfrozen_layer:]:
    l.trainable = True
'''

vgg.summary()
for l in vgg.layers:
    print(l, l.trainable)

```

Model: "mobilenetv2_1.00_224"

| Layer (type) | Output Shape | Param # | Connected to |
|---|----------------------|---------|------------------|
| input_1 (InputLayer) | [None, 224, 224, 3] | 0 | |
| Conv1 (Conv2D) | (None, 112, 112, 32) | 864 | input_1[0][0] |
| bn_Conv1 (BatchNormalization) | (None, 112, 112, 32) | 128 | Conv1[0][0] |
| Conv1_relu (ReLU) | (None, 112, 112, 32) | 0 | bn_Conv1[0][0] |
| expanded_conv_depthwise (DepthwiseConv2D) | (None, 112, 112, 32) | 288 | Conv1_relu[0][0] |
| expanded_conv_depthwise_BN (BatchNormalization) | (None, 112, 112, 32) | 128 | |

```
expanded_conv_depthwise[0] [0]
-----
-----  
expanded_conv_depthwise_relu (R (None, 112, 112, 32) 0  
expanded_conv_depthwise_BN[0] [0]
-----
-----  
expanded_conv_project (Conv2D) (None, 112, 112, 16) 512  
expanded_conv_depthwise_relu[0] [0]
-----
-----  
expanded_conv_project_BN (Batch (None, 112, 112, 16) 64  
expanded_conv_project[0] [0]
-----
-----  
block_1_expand (Conv2D) (None, 112, 112, 96) 1536  
expanded_conv_project_BN[0] [0]
-----
-----  
block_1_expand_BN (BatchNormali (None, 112, 112, 96) 384  
block_1_expand[0] [0]
-----
-----  
block_1_expand_relu (ReLU) (None, 112, 112, 96) 0  
block_1_expand_BN[0] [0]
-----
-----  
block_1_pad (ZeroPadding2D) (None, 113, 113, 96) 0  
block_1_expand_relu[0] [0]
-----
-----  
block_1_depthwise (DepthwiseCon (None, 56, 56, 96) 864  
block_1_pad[0] [0]
-----
-----  
block_1_depthwise_BN (BatchNorm (None, 56, 56, 96) 384  
block_1_depthwise[0] [0]
-----
-----  
block_1_depthwise_relu (ReLU) (None, 56, 56, 96) 0  
block_1_depthwise_BN[0] [0]
-----
-----  
block_1_project (Conv2D) (None, 56, 56, 24) 2304  
block_1_depthwise_relu[0] [0]
-----
-----  
block_1_project_BN (BatchNormal (None, 56, 56, 24) 96
```

```
block_1_project[0] [0]
-----
block_2_expand (Conv2D)           (None, 56, 56, 144)  3456
block_1_project_BN[0] [0]
-----
block_2_expand_BN (BatchNormali (None, 56, 56, 144)  576
block_2_expand[0] [0]
-----
block_2_expand_relu (ReLU)        (None, 56, 56, 144)  0
block_2_expand_BN[0] [0]
-----
block_2_depthwise (DepthwiseCon (None, 56, 56, 144)  1296
block_2_expand_relu[0] [0]
-----
block_2_depthwise_BN (BatchNorm (None, 56, 56, 144)  576
block_2_depthwise[0] [0]
-----
block_2_depthwise_relu (ReLU)    (None, 56, 56, 144)  0
block_2_depthwise_BN[0] [0]
-----
block_2_project (Conv2D)         (None, 56, 56, 24)   3456
block_2_depthwise_relu[0] [0]
-----
block_2_project_BN (BatchNormal (None, 56, 56, 24)   96
block_2_project[0] [0]
-----
block_2_add (Add)               (None, 56, 56, 24)   0
block_1_project_BN[0] [0]
block_2_project_BN[0] [0]
-----
block_3_expand (Conv2D)         (None, 56, 56, 144)  3456
block_2_add[0] [0]
-----
block_3_expand_BN (BatchNormali (None, 56, 56, 144)  576
block_3_expand[0] [0]
```

```
block_3_expand_relu (ReLU)      (None, 56, 56, 144)  0
block_3_expand_BN[0] [0]

-----
block_3_pad (ZeroPadding2D)    (None, 57, 57, 144)  0
block_3_expand_relu[0] [0]

-----
block_3_depthwise (DepthwiseCon (None, 28, 28, 144)  1296
block_3_pad[0] [0]

-----
block_3_depthwise_BN (BatchNorm (None, 28, 28, 144)  576
block_3_depthwise[0] [0]

-----
block_3_depthwise_relu (ReLU)   (None, 28, 28, 144)  0
block_3_depthwise_BN[0] [0]

-----
block_3_project (Conv2D)       (None, 28, 28, 32)   4608
block_3_depthwise_relu[0] [0]

-----
block_3_project_BN (BatchNormal (None, 28, 28, 32)   128
block_3_project[0] [0]

-----
block_4_expand (Conv2D)        (None, 28, 28, 192)  6144
block_3_project_BN[0] [0]

-----
block_4_expand_BN (BatchNormali (None, 28, 28, 192)  768
block_4_expand[0] [0]

-----
block_4_expand_relu (ReLU)     (None, 28, 28, 192)  0
block_4_expand_BN[0] [0]

-----
block_4_depthwise (DepthwiseCon (None, 28, 28, 192)  1728
block_4_expand_relu[0] [0]

-----
block_4_depthwise_BN (BatchNorm (None, 28, 28, 192)  768
block_4_depthwise[0] [0]
```

```
block_4_depthwise_relu (ReLU)      (None, 28, 28, 192)  0
block_4_depthwise_BN[0] [0]

-----
-----  
block_4_project (Conv2D)          (None, 28, 28, 32)   6144
block_4_depthwise_relu[0] [0]

-----
-----  
block_4_project_BN (BatchNormal (None, 28, 28, 32)   128
block_4_project[0] [0]

-----
-----  
block_4_add (Add)                (None, 28, 28, 32)  0
block_3_project_BN[0] [0]
block_4_project_BN[0] [0]

-----
-----  
block_5_expand (Conv2D)          (None, 28, 28, 192)  6144
block_4_add[0] [0]

-----
-----  
block_5_expand_BN (BatchNormali (None, 28, 28, 192)  768
block_5_expand[0] [0]

-----
-----  
block_5_expand_relu (ReLU)       (None, 28, 28, 192)  0
block_5_expand_BN[0] [0]

-----
-----  
block_5_depthwise (DepthwiseCon (None, 28, 28, 192)  1728
block_5_expand_relu[0] [0]

-----
-----  
block_5_depthwise_BN (BatchNorm (None, 28, 28, 192)  768
block_5_depthwise[0] [0]

-----
-----  
block_5_depthwise_relu (ReLU)    (None, 28, 28, 192)  0
block_5_depthwise_BN[0] [0]

-----
-----  
block_5_project (Conv2D)         (None, 28, 28, 32)   6144
block_5_depthwise_relu[0] [0]

-----
-----  
block_5_project_BN (BatchNormal (None, 28, 28, 32)   128
block_5_project[0] [0]
```

```
-----  
block_5_add (Add)           (None, 28, 28, 32)  0  
block_4_add[0] [0]  
block_5_project_BN[0] [0]  
-----  
block_6_expand (Conv2D)      (None, 28, 28, 192) 6144  
block_5_add[0] [0]  
-----  
block_6_expand_BN (BatchNormali (None, 28, 28, 192) 768  
block_6_expand[0] [0]  
-----  
block_6_expand_relu (ReLU)    (None, 28, 28, 192)  0  
block_6_expand_BN[0] [0]  
-----  
block_6_pad (ZeroPadding2D)   (None, 29, 29, 192)  0  
block_6_expand_relu[0] [0]  
-----  
block_6_depthwise (DepthwiseCon (None, 14, 14, 192) 1728  
block_6_pad[0] [0]  
-----  
block_6_depthwise_BN (BatchNorm (None, 14, 14, 192) 768  
block_6_depthwise[0] [0]  
-----  
block_6_depthwise_relu (ReLU)  (None, 14, 14, 192)  0  
block_6_depthwise_BN[0] [0]  
-----  
block_6_project (Conv2D)      (None, 14, 14, 64)   12288  
block_6_depthwise_relu[0] [0]  
-----  
block_6_project_BN (BatchNormal (None, 14, 14, 64)  256  
block_6_project[0] [0]  
-----  
block_7_expand (Conv2D)      (None, 14, 14, 384)  24576  
block_6_project_BN[0] [0]  
-----  
block_7_expand_BN (BatchNormali (None, 14, 14, 384) 1536  
block_7_expand[0] [0]
```

```
-----  
block_7_expand_relu (ReLU)      (None, 14, 14, 384)  0  
block_7_expand_BN[0] [0]  
  
-----  
block_7_depthwise (DepthwiseCon (None, 14, 14, 384)  3456  
block_7_expand_relu[0] [0]  
  
-----  
block_7_depthwise_BN (BatchNorm (None, 14, 14, 384)  1536  
block_7_depthwise[0] [0]  
  
-----  
block_7_depthwise_relu (ReLU)   (None, 14, 14, 384)  0  
block_7_depthwise_BN[0] [0]  
  
-----  
block_7_project (Conv2D)       (None, 14, 14, 64)   24576  
block_7_depthwise_relu[0] [0]  
  
-----  
block_7_project_BN (BatchNormal (None, 14, 14, 64)  256  
block_7_project[0] [0]  
  
-----  
block_7_add (Add)             (None, 14, 14, 64)   0  
block_6_project_BN[0] [0]  
block_7_project_BN[0] [0]  
  
-----  
block_8_expand (Conv2D)       (None, 14, 14, 384)  24576  
block_7_add[0] [0]  
  
-----  
block_8_expand_BN (BatchNormali (None, 14, 14, 384)  1536  
block_8_expand[0] [0]  
  
-----  
block_8_expand_relu (ReLU)     (None, 14, 14, 384)  0  
block_8_expand_BN[0] [0]  
  
-----  
block_8_depthwise (DepthwiseCon (None, 14, 14, 384)  3456  
block_8_expand_relu[0] [0]  
  
-----  
block_8_depthwise_BN (BatchNorm (None, 14, 14, 384)  1536
```

```
block_8_depthwise[0] [0]
-----
block_8_depthwise_relu (ReLU)      (None, 14, 14, 384)  0
block_8_depthwise_BN[0] [0]
-----
block_8_project (Conv2D)          (None, 14, 14, 64)   24576
block_8_depthwise_relu[0] [0]
-----
block_8_project_BN (BatchNormal (None, 14, 14, 64)   256
block_8_project[0] [0]
-----
block_8_add (Add)                (None, 14, 14, 64)  0
block_7_add[0] [0]
block_8_project_BN[0] [0]
-----
block_9_expand (Conv2D)          (None, 14, 14, 384)  24576
block_8_add[0] [0]
-----
block_9_expand_BN (BatchNormali (None, 14, 14, 384)  1536
block_9_expand[0] [0]
-----
block_9_expand_relu (ReLU)        (None, 14, 14, 384)  0
block_9_expand_BN[0] [0]
-----
block_9_depthwise (DepthwiseCon (None, 14, 14, 384)  3456
block_9_expand_relu[0] [0]
-----
block_9_depthwise_BN (BatchNorm (None, 14, 14, 384)  1536
block_9_depthwise[0] [0]
-----
block_9_depthwise_relu (ReLU)    (None, 14, 14, 384)  0
block_9_depthwise_BN[0] [0]
-----
block_9_project (Conv2D)          (None, 14, 14, 64)   24576
block_9_depthwise_relu[0] [0]
```

```
block_9_project_BN (BatchNormal (None, 14, 14, 64) 256
block_9_project[0] [0]
-----
-----  
block_9_add (Add)          (None, 14, 14, 64) 0
block_8_add[0] [0]
block_9_project_BN[0] [0]
-----
-----  
block_10_expand (Conv2D)      (None, 14, 14, 384) 24576
block_9_add[0] [0]
-----
-----  
block_10_expand_BN (BatchNormal (None, 14, 14, 384) 1536
block_10_expand[0] [0]
-----
-----  
block_10_expand_relu (ReLU)    (None, 14, 14, 384) 0
block_10_expand_BN[0] [0]
-----
-----  
block_10_depthwise (DepthwiseCo (None, 14, 14, 384) 3456
block_10_expand_relu[0] [0]
-----
-----  
block_10_depthwise_BN (BatchNor (None, 14, 14, 384) 1536
block_10_depthwise[0] [0]
-----
-----  
block_10_depthwise_relu (ReLU)  (None, 14, 14, 384) 0
block_10_depthwise_BN[0] [0]
-----
-----  
block_10_project (Conv2D)      (None, 14, 14, 96) 36864
block_10_depthwise_relu[0] [0]
-----
-----  
block_10_project_BN (BatchNorma (None, 14, 14, 96) 384
block_10_project[0] [0]
-----
-----  
block_11_expand (Conv2D)      (None, 14, 14, 576) 55296
block_10_project_BN[0] [0]
-----
-----  
block_11_expand_BN (BatchNormal (None, 14, 14, 576) 2304
block_11_expand[0] [0]
```

```
-----  
block_11_expand_relu (ReLU)      (None, 14, 14, 576)  0  
block_11_expand_BN[0] [0]  
-----  
-----  
block_11_depthwise (DepthwiseCo (None, 14, 14, 576)  5184  
block_11_expand_relu[0] [0]  
-----  
-----  
block_11_depthwise_BN (BatchNor (None, 14, 14, 576)  2304  
block_11_depthwise[0] [0]  
-----  
-----  
block_11_depthwise_relu (ReLU)  (None, 14, 14, 576)  0  
block_11_depthwise_BN[0] [0]  
-----  
-----  
block_11_project (Conv2D)       (None, 14, 14, 96)   55296  
block_11_depthwise_relu[0] [0]  
-----  
-----  
block_11_project_BN (BatchNorma (None, 14, 14, 96)   384  
block_11_project[0] [0]  
-----  
-----  
block_11_add (Add)             (None, 14, 14, 96)   0  
block_10_project_BN[0] [0]  
block_11_project_BN[0] [0]  
-----  
-----  
block_12_expand (Conv2D)       (None, 14, 14, 576)  55296  
block_11_add[0] [0]  
-----  
-----  
block_12_expand_BN (BatchNormal (None, 14, 14, 576)  2304  
block_12_expand[0] [0]  
-----  
-----  
block_12_expand_relu (ReLU)     (None, 14, 14, 576)  0  
block_12_expand_BN[0] [0]  
-----  
-----  
block_12_depthwise (DepthwiseCo (None, 14, 14, 576)  5184  
block_12_expand_relu[0] [0]  
-----  
-----  
block_12_depthwise_BN (BatchNor (None, 14, 14, 576)  2304  
block_12_depthwise[0] [0]
```

```
-----  
block_12_depthwise_relu (ReLU)  (None, 14, 14, 576)  0  
block_12_depthwise_BN[0] [0]  
  
-----  
block_12_project (Conv2D)      (None, 14, 14, 96)   55296  
block_12_depthwise_relu[0] [0]  
  
-----  
block_12_project_BN (BatchNorma (None, 14, 14, 96)   384  
block_12_project[0] [0]  
  
-----  
block_12_add (Add)           (None, 14, 14, 96)   0  
block_11_add[0] [0]  
block_12_project_BN[0] [0]  
  
-----  
block_13_expand (Conv2D)     (None, 14, 14, 576)  55296  
block_12_add[0] [0]  
  
-----  
block_13_expand_BN (BatchNormal (None, 14, 14, 576) 2304  
block_13_expand[0] [0]  
  
-----  
block_13_expand_relu (ReLU)   (None, 14, 14, 576)  0  
block_13_expand_BN[0] [0]  
  
-----  
block_13_pad (ZeroPadding2D) (None, 15, 15, 576)  0  
block_13_expand_relu[0] [0]  
  
-----  
block_13_depthwise (DepthwiseCo (None, 7, 7, 576)   5184  
block_13_pad[0] [0]  
  
-----  
block_13_depthwise_BN (BatchNor (None, 7, 7, 576)   2304  
block_13_depthwise[0] [0]  
  
-----  
block_13_depthwise_relu (ReLU)  (None, 7, 7, 576)   0  
block_13_depthwise_BN[0] [0]  
  
-----  
block_13_project (Conv2D)     (None, 7, 7, 160)    92160
```

```
block_13_depthwise_relu[0] [0]
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block_13_project_BN (BatchNorma (None, 7, 7, 160)      640
block_13_project[0] [0]
-----
block_14_expand (Conv2D)          (None, 7, 7, 960)    153600
block_13_project_BN[0] [0]
-----
block_14_expand_BN (BatchNormal (None, 7, 7, 960)    3840
block_14_expand[0] [0]
-----
block_14_expand_relu (ReLU)      (None, 7, 7, 960)    0
block_14_expand_BN[0] [0]
-----
block_14_depthwise (DepthwiseCo (None, 7, 7, 960)    8640
block_14_expand_relu[0] [0]
-----
block_14_depthwise_BN (BatchNor (None, 7, 7, 960)    3840
block_14_depthwise[0] [0]
-----
block_14_depthwise_relu (ReLU)   (None, 7, 7, 960)    0
block_14_depthwise_BN[0] [0]
-----
block_14_project (Conv2D)        (None, 7, 7, 160)    153600
block_14_depthwise_relu[0] [0]
-----
block_14_project_BN (BatchNorma (None, 7, 7, 160)    640
block_14_project[0] [0]
-----
block_14_add (Add)              (None, 7, 7, 160)    0
block_13_project_BN[0] [0]
block_14_project_BN[0] [0]
-----
block_15_expand (Conv2D)        (None, 7, 7, 960)    153600
block_14_add[0] [0]
```

```
block_15_expand_BN (BatchNormal (None, 7, 7, 960)      3840
block_15_expand[0] [0]
-----
-----  
block_15_expand_relu (ReLU)      (None, 7, 7, 960)      0
block_15_expand_BN[0] [0]
-----
-----  
block_15_depthwise (DepthwiseCo (None, 7, 7, 960)     8640
block_15_expand_relu[0] [0]
-----
-----  
block_15_depthwise_BN (BatchNor (None, 7, 7, 960)      3840
block_15_depthwise[0] [0]
-----
-----  
block_15_depthwise_relu (ReLU)   (None, 7, 7, 960)      0
block_15_depthwise_BN[0] [0]
-----
-----  
block_15_project (Conv2D)        (None, 7, 7, 160)     153600
block_15_depthwise_relu[0] [0]
-----
-----  
block_15_project_BN (BatchNorma (None, 7, 7, 160)      640
block_15_project[0] [0]
-----
-----  
block_15_add (Add)              (None, 7, 7, 160)      0
block_14_add[0] [0]
block_15_project_BN[0] [0]
-----
-----  
block_16_expand (Conv2D)        (None, 7, 7, 960)     153600
block_15_add[0] [0]
-----
-----  
block_16_expand_BN (BatchNormal (None, 7, 7, 960)      3840
block_16_expand[0] [0]
-----
-----  
block_16_expand_relu (ReLU)      (None, 7, 7, 960)      0
block_16_expand_BN[0] [0]
-----
-----  
block_16_depthwise (DepthwiseCo (None, 7, 7, 960)     8640
block_16_expand_relu[0] [0]
```

```

-----
block_16_depthwise_BN (BatchNor (None, 7, 7, 960)      3840
block_16_depthwise[0] [0]

-----
block_16_depthwise_relu (ReLU)  (None, 7, 7, 960)      0
block_16_depthwise_BN[0] [0]

-----
block_16_project (Conv2D)      (None, 7, 7, 320)      307200
block_16_depthwise_relu[0] [0]

-----
block_16_project_BN (BatchNorma (None, 7, 7, 320)     1280
block_16_project[0] [0]

-----
Conv_1 (Conv2D)                (None, 7, 7, 1280)    409600
block_16_project_BN[0] [0]

-----
Conv_1_bn (BatchNormalization) (None, 7, 7, 1280)    5120      Conv_1[0] [0]

=====
out_relu (ReLU)                (None, 7, 7, 1280)    0          Conv_1_bn[0] [0]
=====

=====
Total params: 2,257,984
Trainable params: 2,223,872
Non-trainable params: 34,112

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```

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```

[24] :

```

x = GlobalAveragePooling2D()(vgg.get_layer('out_relu').output)
x = Dropout(0.8)(x)
prediction = Dense(len(folders), activation='softmax')(x)

```

```

# create a model object
model = Model(inputs=vgg.input, outputs=prediction)

# view the structure of the model
model.summary()

```

Model: "model"

| Layer (type) | Output Shape | Param # | Connected to |
|-------------------------------------|----------------------|---------|-----------------|
| input_1 (InputLayer) | [None, 224, 224, 3] | 0 | |
| Conv1 (Conv2D) | (None, 112, 112, 32) | 864 | input_1[0] [0] |
| bn_Conv1 (BatchNormalization) | (None, 112, 112, 32) | 128 | Conv1[0] [0] |
| Conv1_relu (ReLU) | (None, 112, 112, 32) | 0 | bn_Conv1[0] [0] |
| expanded_conv_depthwise (Depthwise) | (None, 112, 112, 32) | 288 | |
| Conv1_relu[0] [0] | | | |
| expanded_conv_depthwise_BN (Batch) | (None, 112, 112, 32) | 128 | |
| expanded_conv_depthwise[0] [0] | | | |
| expanded_conv_depthwise_relu (ReLU) | (None, 112, 112, 32) | 0 | |
| expanded_conv_depthwise_BN[0] [0] | | | |
| expanded_conv_project (Conv2D) | (None, 112, 112, 16) | 512 | |
| expanded_conv_depthwise_relu[0] [0] | | | |
| expanded_conv_project_BN (Batch) | (None, 112, 112, 16) | 64 | |
| expanded_conv_project[0] [0] | | | |
| block_1_expand (Conv2D) | (None, 112, 112, 96) | 1536 | |
| expanded_conv_project_BN[0] [0] | | | |

```
-----  
block_1_expand_BN (BatchNormali (None, 112, 112, 96) 384  
block_1_expand[0] [0]  
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-----  
block_1_expand_relu (ReLU)      (None, 112, 112, 96) 0  
block_1_expand_BN[0] [0]  
-----  
-----  
block_1_pad (ZeroPadding2D)    (None, 113, 113, 96) 0  
block_1_expand_relu[0] [0]  
-----  
-----  
block_1_depthwise (DepthwiseCon (None, 56, 56, 96) 864  
block_1_pad[0] [0]  
-----  
-----  
block_1_depthwise_BN (BatchNorm (None, 56, 56, 96) 384  
block_1_depthwise[0] [0]  
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-----  
block_1_depthwise_relu (ReLU)   (None, 56, 56, 96) 0  
block_1_depthwise_BN[0] [0]  
-----  
-----  
block_1_project (Conv2D)       (None, 56, 56, 24) 2304  
block_1_depthwise_relu[0] [0]  
-----  
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block_1_project_BN (BatchNormal (None, 56, 56, 24) 96  
block_1_project[0] [0]  
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block_2_expand (Conv2D)        (None, 56, 56, 144) 3456  
block_1_project_BN[0] [0]  
-----  
-----  
block_2_expand_BN (BatchNormali (None, 56, 56, 144) 576  
block_2_expand[0] [0]  
-----  
-----  
block_2_expand_relu (ReLU)     (None, 56, 56, 144) 0  
block_2_expand_BN[0] [0]  
-----  
-----  
block_2_depthwise (DepthwiseCon (None, 56, 56, 144) 1296  
block_2_expand_relu[0] [0]  
-----
```

```
-----  
block_2_depthwise_BN (BatchNorm (None, 56, 56, 144) 576  
block_2_depthwise[0] [0]  
  
-----  
block_2_depthwise_relu (ReLU)      (None, 56, 56, 144)  0  
block_2_depthwise_BN[0] [0]  
  
-----  
block_2_project (Conv2D)          (None, 56, 56, 24)   3456  
block_2_depthwise_relu[0] [0]  
  
-----  
block_2_project_BN (BatchNormal (None, 56, 56, 24)   96  
block_2_project[0] [0]  
  
-----  
block_2_add (Add)                (None, 56, 56, 24)   0  
block_1_project_BN[0] [0]  
block_2_project_BN[0] [0]  
  
-----  
block_3_expand (Conv2D)          (None, 56, 56, 144)  3456  
block_2_add[0] [0]  
  
-----  
block_3_expand_BN (BatchNormali (None, 56, 56, 144) 576  
block_3_expand[0] [0]  
  
-----  
block_3_expand_relu (ReLU)       (None, 56, 56, 144)  0  
block_3_expand_BN[0] [0]  
  
-----  
block_3_pad (ZeroPadding2D)     (None, 57, 57, 144)  0  
block_3_expand_relu[0] [0]  
  
-----  
block_3_depthwise (DepthwiseCon (None, 28, 28, 144) 1296  
block_3_pad[0] [0]  
  
-----  
block_3_depthwise_BN (BatchNorm (None, 28, 28, 144) 576  
block_3_depthwise[0] [0]  
  
-----  
block_3_depthwise_relu (ReLU)    (None, 28, 28, 144)  0  
block_3_depthwise_BN[0] [0]
```

```
-----  
block_3_project (Conv2D)      (None, 28, 28, 32)  4608  
block_3_depthwise_relu[0] [0]  
  
-----  
block_3_project_BN (BatchNormal (None, 28, 28, 32)  128  
block_3_project[0] [0]  
  
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block_4_expand (Conv2D)      (None, 28, 28, 192)  6144  
block_3_project_BN[0] [0]  
  
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block_4_expand_BN (BatchNormali (None, 28, 28, 192)  768  
block_4_expand[0] [0]  
  
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block_4_expand_relu (ReLU)    (None, 28, 28, 192)  0  
block_4_expand_BN[0] [0]  
  
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block_4_depthwise (DepthwiseCon (None, 28, 28, 192)  1728  
block_4_expand_relu[0] [0]  
  
-----  
block_4_depthwise_BN (BatchNorm (None, 28, 28, 192)  768  
block_4_depthwise[0] [0]  
  
-----  
block_4_depthwise_relu (ReLU)  (None, 28, 28, 192)  0  
block_4_depthwise_BN[0] [0]  
  
-----  
block_4_project (Conv2D)      (None, 28, 28, 32)  6144  
block_4_depthwise_relu[0] [0]  
  
-----  
block_4_project_BN (BatchNormal (None, 28, 28, 32)  128  
block_4_project[0] [0]  
  
-----  
block_4_add (Add)            (None, 28, 28, 32)  0  
block_3_project_BN[0] [0]  
block_4_project_BN[0] [0]  
  
-----  
block_5_expand (Conv2D)      (None, 28, 28, 192)  6144
```

```
block_4_add[0] [0]
-----
block_5_expand_BN (BatchNormali (None, 28, 28, 192) 768
block_5_expand[0] [0]
-----
block_5_expand_relu (ReLU)      (None, 28, 28, 192)  0
block_5_expand_BN[0] [0]
-----
block_5_depthwise (DepthwiseCon (None, 28, 28, 192) 1728
block_5_expand_relu[0] [0]
-----
block_5_depthwise_BN (BatchNorm (None, 28, 28, 192) 768
block_5_depthwise[0] [0]
-----
block_5_depthwise_relu (ReLU)   (None, 28, 28, 192)  0
block_5_depthwise_BN[0] [0]
-----
block_5_project (Conv2D)       (None, 28, 28, 32)   6144
block_5_depthwise_relu[0] [0]
-----
block_5_project_BN (BatchNormal (None, 28, 28, 32) 128
block_5_project[0] [0]
-----
block_5_add (Add)             (None, 28, 28, 32)   0
block_4_add[0] [0]
block_5_project_BN[0] [0]
-----
block_6_expand (Conv2D)        (None, 28, 28, 192) 6144
block_5_add[0] [0]
-----
block_6_expand_BN (BatchNormali (None, 28, 28, 192) 768
block_6_expand[0] [0]
-----
block_6_expand_relu (ReLU)     (None, 28, 28, 192)  0
block_6_expand_BN[0] [0]
```

```
block_6_pad (ZeroPadding2D)      (None, 29, 29, 192)  0
block_6_expand_relu[0] [0]

-----
-----  
block_6_depthwise (DepthwiseCon (None, 14, 14, 192)  1728
block_6_pad[0] [0]

-----
-----  
block_6_depthwise_BN (BatchNorm (None, 14, 14, 192)  768
block_6_depthwise[0] [0]

-----
-----  
block_6_depthwise_relu (ReLU)    (None, 14, 14, 192)  0
block_6_depthwise_BN[0] [0]

-----
-----  
block_6_project (Conv2D)        (None, 14, 14, 64)   12288
block_6_depthwise_relu[0] [0]

-----
-----  
block_6_project_BN (BatchNormal (None, 14, 14, 64)  256
block_6_project[0] [0]

-----
-----  
block_7_expand (Conv2D)         (None, 14, 14, 384)  24576
block_6_project_BN[0] [0]

-----
-----  
block_7_expand_BN (BatchNormali (None, 14, 14, 384)  1536
block_7_expand[0] [0]

-----
-----  
block_7_expand_relu (ReLU)     (None, 14, 14, 384)  0
block_7_expand_BN[0] [0]

-----
-----  
block_7_depthwise (DepthwiseCon (None, 14, 14, 384)  3456
block_7_expand_relu[0] [0]

-----
-----  
block_7_depthwise_BN (BatchNorm (None, 14, 14, 384)  1536
block_7_depthwise[0] [0]

-----
-----  
block_7_depthwise_relu (ReLU)   (None, 14, 14, 384)  0
block_7_depthwise_BN[0] [0]
```

```
block_7_project (Conv2D)           (None, 14, 14, 64)  24576
block_7_depthwise_relu[0] [0]

-----
-----  
block_7_project_BN (BatchNormal (None, 14, 14, 64)  256
block_7_project[0] [0]

-----
-----  
block_7_add (Add)                 (None, 14, 14, 64)  0
block_6_project_BN[0] [0]
block_7_project_BN[0] [0]

-----
-----  
block_8_expand (Conv2D)           (None, 14, 14, 384) 24576
block_7_add[0] [0]

-----
-----  
block_8_expand_BN (BatchNormali (None, 14, 14, 384) 1536
block_8_expand[0] [0]

-----
-----  
block_8_expand_relu (ReLU)        (None, 14, 14, 384) 0
block_8_expand_BN[0] [0]

-----
-----  
block_8_depthwise (DepthwiseCon (None, 14, 14, 384) 3456
block_8_expand_relu[0] [0]

-----
-----  
block_8_depthwise_BN (BatchNorm (None, 14, 14, 384) 1536
block_8_depthwise[0] [0]

-----
-----  
block_8_depthwise_relu (ReLU)    (None, 14, 14, 384) 0
block_8_depthwise_BN[0] [0]

-----
-----  
block_8_project (Conv2D)           (None, 14, 14, 64)  24576
block_8_depthwise_relu[0] [0]

-----
-----  
block_8_project_BN (BatchNormal (None, 14, 14, 64)  256
block_8_project[0] [0]

-----
-----  
block_8_add (Add)                 (None, 14, 14, 64)  0
block_7_add[0] [0]
block_8_project_BN[0] [0]
```

```
-----  
block_9_expand (Conv2D)           (None, 14, 14, 384)  24576  
block_8_add[0] [0]  
  
-----  
block_9_expand_BN (BatchNormali (None, 14, 14, 384)  1536  
block_9_expand[0] [0]  
  
-----  
block_9_expand_relu (ReLU)        (None, 14, 14, 384)  0  
block_9_expand_BN[0] [0]  
  
-----  
block_9_depthwise (DepthwiseCon (None, 14, 14, 384)  3456  
block_9_expand_relu[0] [0]  
  
-----  
block_9_depthwise_BN (BatchNorm (None, 14, 14, 384)  1536  
block_9_depthwise[0] [0]  
  
-----  
block_9_depthwise_relu (ReLU)    (None, 14, 14, 384)  0  
block_9_depthwise_BN[0] [0]  
  
-----  
block_9_project (Conv2D)         (None, 14, 14, 64)   24576  
block_9_depthwise_relu[0] [0]  
  
-----  
block_9_project_BN (BatchNormal (None, 14, 14, 64)   256  
block_9_project[0] [0]  
  
-----  
block_9_add (Add)               (None, 14, 14, 64)   0  
block_8_add[0] [0]  
block_9_project_BN[0] [0]  
  
-----  
block_10_expand (Conv2D)        (None, 14, 14, 384)  24576  
block_9_add[0] [0]  
  
-----  
block_10_expand_BN (BatchNormal (None, 14, 14, 384)  1536  
block_10_expand[0] [0]  
  
-----  
block_10_expand_relu (ReLU)     (None, 14, 14, 384)  0
```

```
block_10_expand_BN[0] [0]
-----
block_10_depthwise (DepthwiseCo (None, 14, 14, 384)  3456
block_10_expand_relu[0] [0]
-----
block_10_depthwise_BN (BatchNor (None, 14, 14, 384)  1536
block_10_depthwise[0] [0]
-----
block_10_depthwise_relu (ReLU)  (None, 14, 14, 384)  0
block_10_depthwise_BN[0] [0]
-----
block_10_project (Conv2D)      (None, 14, 14, 96)   36864
block_10_depthwise_relu[0] [0]
-----
block_10_project_BN (BatchNorma (None, 14, 14, 96)   384
block_10_project[0] [0]
-----
block_11_expand (Conv2D)      (None, 14, 14, 576)  55296
block_10_project_BN[0] [0]
-----
block_11_expand_BN (BatchNormal (None, 14, 14, 576)  2304
block_11_expand[0] [0]
-----
block_11_expand_relu (ReLU)    (None, 14, 14, 576)  0
block_11_expand_BN[0] [0]
-----
block_11_depthwise (DepthwiseCo (None, 14, 14, 576)  5184
block_11_expand_relu[0] [0]
-----
block_11_depthwise_BN (BatchNor (None, 14, 14, 576)  2304
block_11_depthwise[0] [0]
-----
block_11_depthwise_relu (ReLU)  (None, 14, 14, 576)  0
block_11_depthwise_BN[0] [0]
-----
block_11_project (Conv2D)      (None, 14, 14, 96)   55296
```

```
block_11_depthwise_relu[0] [0]
-----
block_11_project_BN (BatchNorma (None, 14, 14, 96) 384
block_11_project[0] [0]
-----
block_11_add (Add)          (None, 14, 14, 96)  0
block_10_project_BN[0] [0]
block_11_project_BN[0] [0]
-----
block_12_expand (Conv2D)    (None, 14, 14, 576) 55296
block_11_add[0] [0]
-----
block_12_expand_BN (BatchNormal (None, 14, 14, 576) 2304
block_12_expand[0] [0]
-----
block_12_expand_relu (ReLU) (None, 14, 14, 576)  0
block_12_expand_BN[0] [0]
-----
block_12_depthwise (DepthwiseCo (None, 14, 14, 576) 5184
block_12_expand_relu[0] [0]
-----
block_12_depthwise_BN (BatchNor (None, 14, 14, 576) 2304
block_12_depthwise[0] [0]
-----
block_12_depthwise_relu (ReLU) (None, 14, 14, 576)  0
block_12_depthwise_BN[0] [0]
-----
block_12_project (Conv2D)    (None, 14, 14, 96)  55296
block_12_depthwise_relu[0] [0]
-----
block_12_project_BN (BatchNorma (None, 14, 14, 96) 384
block_12_project[0] [0]
-----
block_12_add (Add)          (None, 14, 14, 96)  0
block_11_add[0] [0]
block_12_project_BN[0] [0]
```

```
-----  
block_13_expand (Conv2D)      (None, 14, 14, 576)  55296  
block_12_add[0] [0]  
-----  
-----  
block_13_expand_BN (BatchNormal (None, 14, 14, 576)  2304  
block_13_expand[0] [0]  
-----  
-----  
block_13_expand_relu (ReLU)    (None, 14, 14, 576)  0  
block_13_expand_BN[0] [0]  
-----  
-----  
block_13_pad (ZeroPadding2D)   (None, 15, 15, 576)  0  
block_13_expand_relu[0] [0]  
-----  
-----  
block_13_depthwise (DepthwiseCo (None, 7, 7, 576)  5184  
block_13_pad[0] [0]  
-----  
-----  
block_13_depthwise_BN (BatchNor (None, 7, 7, 576)  2304  
block_13_depthwise[0] [0]  
-----  
-----  
block_13_depthwise_relu (ReLU) (None, 7, 7, 576)  0  
block_13_depthwise_BN[0] [0]  
-----  
-----  
block_13_project (Conv2D)     (None, 7, 7, 160)    92160  
block_13_depthwise_relu[0] [0]  
-----  
-----  
block_13_project_BN (BatchNorma (None, 7, 7, 160)  640  
block_13_project[0] [0]  
-----  
-----  
block_14_expand (Conv2D)      (None, 7, 7, 960)   153600  
block_13_project_BN[0] [0]  
-----  
-----  
block_14_expand_BN (BatchNormal (None, 7, 7, 960)  3840  
block_14_expand[0] [0]  
-----  
-----  
block_14_expand_relu (ReLU)    (None, 7, 7, 960)   0  
block_14_expand_BN[0] [0]  
-----
```

```
-----  
block_14_depthwise (DepthwiseCo (None, 7, 7, 960)      8640  
block_14_expand_relu[0] [0]  
  
-----  
block_14_depthwise_BN (BatchNor (None, 7, 7, 960)      3840  
block_14_depthwise[0] [0]  
  
-----  
block_14_depthwise_relu (ReLU)   (None, 7, 7, 960)      0  
block_14_depthwise_BN[0] [0]  
  
-----  
block_14_project (Conv2D)        (None, 7, 7, 160)      153600  
block_14_depthwise_relu[0] [0]  
  
-----  
block_14_project_BN (BatchNorma (None, 7, 7, 160)      640  
block_14_project[0] [0]  
  
-----  
block_14_add (Add)              (None, 7, 7, 160)      0  
block_13_project_BN[0] [0]  
block_14_project_BN[0] [0]  
  
-----  
block_15_expand (Conv2D)        (None, 7, 7, 960)      153600  
block_14_add[0] [0]  
  
-----  
block_15_expand_BN (BatchNormal (None, 7, 7, 960)      3840  
block_15_expand[0] [0]  
  
-----  
block_15_expand_relu (ReLU)     (None, 7, 7, 960)      0  
block_15_expand_BN[0] [0]  
  
-----  
block_15_depthwise (DepthwiseCo (None, 7, 7, 960)      8640  
block_15_expand_relu[0] [0]  
  
-----  
block_15_depthwise_BN (BatchNor (None, 7, 7, 960)      3840  
block_15_depthwise[0] [0]  
  
-----  
block_15_depthwise_relu (ReLU)  (None, 7, 7, 960)      0  
block_15_depthwise_BN[0] [0]
```

```
-----  
block_15_project (Conv2D)      (None, 7, 7, 160)    153600  
block_15_depthwise_relu[0] [0]  
  
-----  
block_15_project_BN (BatchNorma (None, 7, 7, 160)    640  
block_15_project[0] [0]  
  
-----  
block_15_add (Add)            (None, 7, 7, 160)    0  
block_14_add[0] [0]  
block_15_project_BN[0] [0]  
  
-----  
block_16_expand (Conv2D)      (None, 7, 7, 960)    153600  
block_15_add[0] [0]  
  
-----  
block_16_expand_BN (BatchNormal (None, 7, 7, 960)    3840  
block_16_expand[0] [0]  
  
-----  
block_16_expand_relu (ReLU)    (None, 7, 7, 960)    0  
block_16_expand_BN[0] [0]  
  
-----  
block_16_depthwise (DepthwiseCo (None, 7, 7, 960)    8640  
block_16_expand_relu[0] [0]  
  
-----  
block_16_depthwise_BN (BatchNor (None, 7, 7, 960)    3840  
block_16_depthwise[0] [0]  
  
-----  
block_16_depthwise_relu (ReLU)  (None, 7, 7, 960)    0  
block_16_depthwise_BN[0] [0]  
  
-----  
block_16_project (Conv2D)      (None, 7, 7, 320)    307200  
block_16_depthwise_relu[0] [0]  
  
-----  
block_16_project_BN (BatchNorma (None, 7, 7, 320)    1280  
block_16_project[0] [0]  
  
-----  
Conv_1 (Conv2D)              (None, 7, 7, 1280)    409600
```

```

block_16_project_BN[0] [0]
-----
Conv_1_bn (BatchNormalization) (None, 7, 7, 1280) 5120 Conv_1[0] [0]
-----
out_relu (ReLU) (None, 7, 7, 1280) 0 Conv_1_bn[0] [0]
-----
global_average_pooling2d (GlobalAveragePooling2D) (None, 1280) 0 out_relu[0] [0]
-----
dropout (Dropout) (None, 1280) 0 global_average_pooling2d[0] [0]
-----
dense (Dense) (None, 20) 25620 dropout[0] [0]
=====
=====
Total params: 2,283,604
Trainable params: 2,249,492
Non-trainable params: 34,112
-----

```

```
[25]: drive_path_checkpoint = '/content/drive/My Drive/Colab Notebooks/ProjectData/  
FaceRecognition/pickle/checkpoint/holly_MobileNet_2.hdf5'  
model_checkpoint = ModelCheckpoint(  
    filepath=drive_path_checkpoint,  
    save_weights_only=True,  
    monitor='val_accuracy',  
    mode='max',  
    save_best_only=True, save_freq='epoch')
```

```
[26]: # tell the model what cost and optimization method to use  
model.compile(  
    loss='categorical_crossentropy',  
    optimizer=tf.keras.optimizers.Adam(1e-4),  
    metrics=['accuracy',  
            tf.keras.metrics.Precision(),  
            tf.keras.metrics.Recall()])
```

```
[27]: r = model.fit(  
    training_set,  
    validation_data=testing_set,  
    epochs=64,
```

```

    callbacks = [model_checkpoint]
)

Epoch 1/64
67/67 [=====] - 94s 572ms/step - loss: 3.9832 -
accuracy: 0.0622 - precision: 0.0664 - recall: 0.0117 - val_loss: 3.2644 -
val_accuracy: 0.0805 - val_precision: 0.1024 - val_recall: 0.0087
Epoch 2/64
67/67 [=====] - 34s 509ms/step - loss: 3.0313 -
accuracy: 0.1071 - precision: 0.1070 - recall: 0.0073 - val_loss: 3.2795 -
val_accuracy: 0.1088 - val_precision: 0.1261 - val_recall: 0.0067
Epoch 3/64
67/67 [=====] - 34s 511ms/step - loss: 2.7347 -
accuracy: 0.1781 - precision: 0.1474 - recall: 0.0078 - val_loss: 3.8654 -
val_accuracy: 0.1384 - val_precision: 0.2138 - val_recall: 0.0143
Epoch 4/64
67/67 [=====] - 35s 515ms/step - loss: 2.4077 -
accuracy: 0.2708 - precision: 0.2395 - recall: 0.0193 - val_loss: 4.0460 -
val_accuracy: 0.1568 - val_precision: 0.3032 - val_recall: 0.0295
Epoch 5/64
67/67 [=====] - 34s 513ms/step - loss: 2.1056 -
accuracy: 0.3631 - precision: 0.3259 - recall: 0.0364 - val_loss: 3.6691 -
val_accuracy: 0.1808 - val_precision: 0.3906 - val_recall: 0.0536
Epoch 6/64
67/67 [=====] - 34s 511ms/step - loss: 1.7947 -
accuracy: 0.4349 - precision: 0.3994 - recall: 0.0614 - val_loss: 3.6404 -
val_accuracy: 0.1766 - val_precision: 0.4380 - val_recall: 0.0814
Epoch 7/64
67/67 [=====] - 34s 508ms/step - loss: 1.4892 -
accuracy: 0.5416 - precision: 0.4410 - recall: 0.0902 - val_loss: 3.4426 -
val_accuracy: 0.1949 - val_precision: 0.4828 - val_recall: 0.1147
Epoch 8/64
67/67 [=====] - 34s 504ms/step - loss: 1.1976 -
accuracy: 0.6129 - precision: 0.4882 - recall: 0.1243 - val_loss: 3.1087 -
val_accuracy: 0.2768 - val_precision: 0.5284 - val_recall: 0.1508
Epoch 9/64
67/67 [=====] - 34s 507ms/step - loss: 0.9635 -
accuracy: 0.7007 - precision: 0.5350 - recall: 0.1608 - val_loss: 2.7948 -
val_accuracy: 0.3164 - val_precision: 0.5685 - val_recall: 0.1872
Epoch 10/64
67/67 [=====] - 34s 509ms/step - loss: 0.8120 -
accuracy: 0.7446 - precision: 0.5765 - recall: 0.1977 - val_loss: 2.3808 -
val_accuracy: 0.3376 - val_precision: 0.6049 - val_recall: 0.2243
Epoch 11/64
67/67 [=====] - 34s 510ms/step - loss: 0.6894 -
accuracy: 0.7863 - precision: 0.6107 - recall: 0.2337 - val_loss: 2.1364 -
val_accuracy: 0.3969 - val_precision: 0.6342 - val_recall: 0.2591

```

Epoch 12/64
67/67 [=====] - 34s 513ms/step - loss: 0.5762 -
accuracy: 0.8144 - precision: 0.6405 - recall: 0.2685 - val_loss: 2.0099 -
val_accuracy: 0.4435 - val_precision: 0.6607 - val_recall: 0.2920
Epoch 13/64
67/67 [=====] - 34s 513ms/step - loss: 0.4591 -
accuracy: 0.8558 - precision: 0.6663 - recall: 0.3012 - val_loss: 1.6664 -
val_accuracy: 0.5226 - val_precision: 0.6855 - val_recall: 0.3247
Epoch 14/64
67/67 [=====] - 35s 515ms/step - loss: 0.4245 -
accuracy: 0.8581 - precision: 0.6902 - recall: 0.3329 - val_loss: 1.7042 -
val_accuracy: 0.5099 - val_precision: 0.7048 - val_recall: 0.3538
Epoch 15/64
67/67 [=====] - 35s 520ms/step - loss: 0.3336 -
accuracy: 0.8984 - precision: 0.7091 - recall: 0.3618 - val_loss: 1.3807 -
val_accuracy: 0.6116 - val_precision: 0.7231 - val_recall: 0.3819
Epoch 16/64
67/67 [=====] - 35s 528ms/step - loss: 0.2811 -
accuracy: 0.9079 - precision: 0.7281 - recall: 0.3897 - val_loss: 1.5845 -
val_accuracy: 0.5438 - val_precision: 0.7389 - val_recall: 0.4072
Epoch 17/64
67/67 [=====] - 34s 508ms/step - loss: 0.2604 -
accuracy: 0.9233 - precision: 0.7419 - recall: 0.4138 - val_loss: 1.2526 -
val_accuracy: 0.6271 - val_precision: 0.7530 - val_recall: 0.4308
Epoch 18/64
67/67 [=====] - 34s 511ms/step - loss: 0.2341 -
accuracy: 0.9236 - precision: 0.7563 - recall: 0.4371 - val_loss: 1.4304 -
val_accuracy: 0.5946 - val_precision: 0.7651 - val_recall: 0.4527
Epoch 19/64
67/67 [=====] - 34s 510ms/step - loss: 0.1866 -
accuracy: 0.9464 - precision: 0.7677 - recall: 0.4585 - val_loss: 1.0678 -
val_accuracy: 0.6992 - val_precision: 0.7762 - val_recall: 0.4733
Epoch 20/64
67/67 [=====] - 35s 516ms/step - loss: 0.1714 -
accuracy: 0.9488 - precision: 0.7791 - recall: 0.4792 - val_loss: 0.7050 -
val_accuracy: 0.7867 - val_precision: 0.7876 - val_recall: 0.4934
Epoch 21/64
67/67 [=====] - 34s 512ms/step - loss: 0.1321 -
accuracy: 0.9611 - precision: 0.7907 - recall: 0.4991 - val_loss: 0.7550 -
val_accuracy: 0.7712 - val_precision: 0.7983 - val_recall: 0.5123
Epoch 22/64
67/67 [=====] - 34s 508ms/step - loss: 0.1098 -
accuracy: 0.9720 - precision: 0.8012 - recall: 0.5177 - val_loss: 0.7125 -
val_accuracy: 0.7910 - val_precision: 0.8077 - val_recall: 0.5298
Epoch 23/64
67/67 [=====] - 34s 509ms/step - loss: 0.1118 -
accuracy: 0.9670 - precision: 0.8103 - recall: 0.5348 - val_loss: 0.6226 -
val_accuracy: 0.8192 - val_precision: 0.8164 - val_recall: 0.5464

Epoch 24/64
67/67 [=====] - 34s 512ms/step - loss: 0.1218 -
accuracy: 0.9672 - precision: 0.8187 - recall: 0.5510 - val_loss: 0.7826 -
val_accuracy: 0.7811 - val_precision: 0.8239 - val_recall: 0.5613
Epoch 25/64
67/67 [=====] - 34s 510ms/step - loss: 0.1098 -
accuracy: 0.9628 - precision: 0.8254 - recall: 0.5652 - val_loss: 0.6634 -
val_accuracy: 0.8093 - val_precision: 0.8303 - val_recall: 0.5751
Epoch 26/64
67/67 [=====] - 34s 509ms/step - loss: 0.1202 -
accuracy: 0.9638 - precision: 0.8320 - recall: 0.5790 - val_loss: 0.5821 -
val_accuracy: 0.8107 - val_precision: 0.8364 - val_recall: 0.5881
Epoch 27/64
67/67 [=====] - 34s 507ms/step - loss: 0.0798 -
accuracy: 0.9756 - precision: 0.8380 - recall: 0.5918 - val_loss: 0.6806 -
val_accuracy: 0.7994 - val_precision: 0.8420 - val_recall: 0.6004
Epoch 28/64
67/67 [=====] - 34s 507ms/step - loss: 0.0798 -
accuracy: 0.9779 - precision: 0.8433 - recall: 0.6037 - val_loss: 0.7928 -
val_accuracy: 0.7698 - val_precision: 0.8467 - val_recall: 0.6116
Epoch 29/64
67/67 [=====] - 34s 508ms/step - loss: 0.0862 -
accuracy: 0.9772 - precision: 0.8478 - recall: 0.6148 - val_loss: 0.7497 -
val_accuracy: 0.7910 - val_precision: 0.8509 - val_recall: 0.6222
Epoch 30/64
67/67 [=====] - 34s 507ms/step - loss: 0.0841 -
accuracy: 0.9764 - precision: 0.8520 - recall: 0.6252 - val_loss: 0.7217 -
val_accuracy: 0.8008 - val_precision: 0.8550 - val_recall: 0.6322
Epoch 31/64
67/67 [=====] - 34s 512ms/step - loss: 0.0818 -
accuracy: 0.9696 - precision: 0.8559 - recall: 0.6349 - val_loss: 0.5524 -
val_accuracy: 0.8234 - val_precision: 0.8587 - val_recall: 0.6415
Epoch 32/64
67/67 [=====] - 34s 511ms/step - loss: 0.0568 -
accuracy: 0.9831 - precision: 0.8598 - recall: 0.6443 - val_loss: 0.5812 -
val_accuracy: 0.8291 - val_precision: 0.8627 - val_recall: 0.6508
Epoch 33/64
67/67 [=====] - 34s 507ms/step - loss: 0.0774 -
accuracy: 0.9819 - precision: 0.8637 - recall: 0.6533 - val_loss: 0.4815 -
val_accuracy: 0.8573 - val_precision: 0.8665 - val_recall: 0.6596
Epoch 34/64
67/67 [=====] - 34s 507ms/step - loss: 0.0436 -
accuracy: 0.9862 - precision: 0.8675 - recall: 0.6621 - val_loss: 0.4499 -
val_accuracy: 0.8517 - val_precision: 0.8703 - val_recall: 0.6681
Epoch 35/64
67/67 [=====] - 34s 505ms/step - loss: 0.0597 -
accuracy: 0.9833 - precision: 0.8711 - recall: 0.6705 - val_loss: 0.5466 -
val_accuracy: 0.8531 - val_precision: 0.8735 - val_recall: 0.6761

Epoch 36/64
67/67 [=====] - 34s 506ms/step - loss: 0.0527 -
accuracy: 0.9848 - precision: 0.8743 - recall: 0.6783 - val_loss: 0.5085 -
val_accuracy: 0.8658 - val_precision: 0.8765 - val_recall: 0.6835
Epoch 37/64
67/67 [=====] - 34s 506ms/step - loss: 0.0518 -
accuracy: 0.9830 - precision: 0.8773 - recall: 0.6857 - val_loss: 0.4399 -
val_accuracy: 0.8672 - val_precision: 0.8794 - val_recall: 0.6908
Epoch 38/64
67/67 [=====] - 34s 507ms/step - loss: 0.0458 -
accuracy: 0.9877 - precision: 0.8802 - recall: 0.6929 - val_loss: 0.5017 -
val_accuracy: 0.8376 - val_precision: 0.8822 - val_recall: 0.6976
Epoch 39/64
67/67 [=====] - 34s 506ms/step - loss: 0.0467 -
accuracy: 0.9882 - precision: 0.8828 - recall: 0.6995 - val_loss: 0.4062 -
val_accuracy: 0.8715 - val_precision: 0.8847 - val_recall: 0.7040
Epoch 40/64
67/67 [=====] - 34s 513ms/step - loss: 0.0435 -
accuracy: 0.9849 - precision: 0.8854 - recall: 0.7058 - val_loss: 0.4348 -
val_accuracy: 0.8743 - val_precision: 0.8872 - val_recall: 0.7102
Epoch 41/64
67/67 [=====] - 34s 506ms/step - loss: 0.0528 -
accuracy: 0.9833 - precision: 0.8879 - recall: 0.7120 - val_loss: 0.4755 -
val_accuracy: 0.8573 - val_precision: 0.8897 - val_recall: 0.7161
Epoch 42/64
67/67 [=====] - 34s 506ms/step - loss: 0.0439 -
accuracy: 0.9832 - precision: 0.8902 - recall: 0.7177 - val_loss: 0.5265 -
val_accuracy: 0.8489 - val_precision: 0.8917 - val_recall: 0.7215
Epoch 43/64
67/67 [=====] - 34s 507ms/step - loss: 0.0474 -
accuracy: 0.9853 - precision: 0.8922 - recall: 0.7230 - val_loss: 0.4414 -
val_accuracy: 0.8799 - val_precision: 0.8938 - val_recall: 0.7268
Epoch 44/64
67/67 [=====] - 34s 504ms/step - loss: 0.0489 -
accuracy: 0.9844 - precision: 0.8943 - recall: 0.7283 - val_loss: 0.5234 -
val_accuracy: 0.8644 - val_precision: 0.8957 - val_recall: 0.7319
Epoch 45/64
67/67 [=====] - 34s 505ms/step - loss: 0.0357 -
accuracy: 0.9881 - precision: 0.8961 - recall: 0.7333 - val_loss: 0.4909 -
val_accuracy: 0.8588 - val_precision: 0.8975 - val_recall: 0.7368
Epoch 46/64
67/67 [=====] - 34s 507ms/step - loss: 0.0351 -
accuracy: 0.9879 - precision: 0.8980 - recall: 0.7382 - val_loss: 0.5704 -
val_accuracy: 0.8559 - val_precision: 0.8993 - val_recall: 0.7415
Epoch 47/64
67/67 [=====] - 34s 506ms/step - loss: 0.0368 -
accuracy: 0.9891 - precision: 0.8997 - recall: 0.7428 - val_loss: 0.4735 -
val_accuracy: 0.8602 - val_precision: 0.9009 - val_recall: 0.7460

Epoch 48/64
67/67 [=====] - 34s 504ms/step - loss: 0.0507 -
accuracy: 0.9870 - precision: 0.9013 - recall: 0.7472 - val_loss: 0.4785 -
val_accuracy: 0.8672 - val_precision: 0.9025 - val_recall: 0.7503
Epoch 49/64
67/67 [=====] - 34s 502ms/step - loss: 0.0452 -
accuracy: 0.9842 - precision: 0.9028 - recall: 0.7514 - val_loss: 0.4913 -
val_accuracy: 0.8701 - val_precision: 0.9039 - val_recall: 0.7543
Epoch 50/64
67/67 [=====] - 34s 505ms/step - loss: 0.0368 -
accuracy: 0.9895 - precision: 0.9043 - recall: 0.7554 - val_loss: 0.6178 -
val_accuracy: 0.8376 - val_precision: 0.9053 - val_recall: 0.7581
Epoch 51/64
67/67 [=====] - 34s 505ms/step - loss: 0.0500 -
accuracy: 0.9812 - precision: 0.9055 - recall: 0.7592 - val_loss: 0.3558 -
val_accuracy: 0.8983 - val_precision: 0.9067 - val_recall: 0.7619
Epoch 52/64
67/67 [=====] - 34s 504ms/step - loss: 0.0472 -
accuracy: 0.9859 - precision: 0.9071 - recall: 0.7630 - val_loss: 0.4604 -
val_accuracy: 0.8686 - val_precision: 0.9081 - val_recall: 0.7656
Epoch 53/64
67/67 [=====] - 34s 507ms/step - loss: 0.0375 -
accuracy: 0.9892 - precision: 0.9084 - recall: 0.7666 - val_loss: 0.3985 -
val_accuracy: 0.8898 - val_precision: 0.9094 - val_recall: 0.7692
Epoch 54/64
67/67 [=====] - 34s 505ms/step - loss: 0.0255 -
accuracy: 0.9928 - precision: 0.9098 - recall: 0.7703 - val_loss: 0.6056 -
val_accuracy: 0.8517 - val_precision: 0.9106 - val_recall: 0.7727
Epoch 55/64
67/67 [=====] - 35s 521ms/step - loss: 0.0409 -
accuracy: 0.9881 - precision: 0.9108 - recall: 0.7735 - val_loss: 0.5339 -
val_accuracy: 0.8701 - val_precision: 0.9117 - val_recall: 0.7759
Epoch 56/64
67/67 [=====] - 35s 521ms/step - loss: 0.0368 -
accuracy: 0.9861 - precision: 0.9119 - recall: 0.7768 - val_loss: 0.5519 -
val_accuracy: 0.8686 - val_precision: 0.9128 - val_recall: 0.7790
Epoch 57/64
67/67 [=====] - 34s 511ms/step - loss: 0.0389 -
accuracy: 0.9883 - precision: 0.9130 - recall: 0.7799 - val_loss: 0.3401 -
val_accuracy: 0.9025 - val_precision: 0.9139 - val_recall: 0.7822
Epoch 58/64
67/67 [=====] - 34s 504ms/step - loss: 0.0415 -
accuracy: 0.9876 - precision: 0.9142 - recall: 0.7831 - val_loss: 0.6268 -
val_accuracy: 0.8277 - val_precision: 0.9149 - val_recall: 0.7851
Epoch 59/64
67/67 [=====] - 34s 501ms/step - loss: 0.0361 -
accuracy: 0.9852 - precision: 0.9150 - recall: 0.7859 - val_loss: 0.5284 -
val_accuracy: 0.8771 - val_precision: 0.9158 - val_recall: 0.7879

```
Epoch 60/64
67/67 [=====] - 34s 505ms/step - loss: 0.0156 -
accuracy: 0.9937 - precision: 0.9160 - recall: 0.7888 - val_loss: 0.3400 -
val_accuracy: 0.9011 - val_precision: 0.9169 - val_recall: 0.7909
Epoch 61/64
67/67 [=====] - 34s 501ms/step - loss: 0.0374 -
accuracy: 0.9878 - precision: 0.9172 - recall: 0.7917 - val_loss: 0.3195 -
val_accuracy: 0.9167 - val_precision: 0.9180 - val_recall: 0.7937
Epoch 62/64
67/67 [=====] - 34s 503ms/step - loss: 0.0603 -
accuracy: 0.9814 - precision: 0.9182 - recall: 0.7945 - val_loss: 0.3635 -
val_accuracy: 0.9011 - val_precision: 0.9190 - val_recall: 0.7964
Epoch 63/64
67/67 [=====] - 34s 503ms/step - loss: 0.0277 -
accuracy: 0.9902 - precision: 0.9193 - recall: 0.7973 - val_loss: 0.5179 -
val_accuracy: 0.8658 - val_precision: 0.9199 - val_recall: 0.7991
Epoch 64/64
67/67 [=====] - 34s 502ms/step - loss: 0.0220 -
accuracy: 0.9959 - precision: 0.9201 - recall: 0.7998 - val_loss: 0.3582 -
val_accuracy: 0.9040 - val_precision: 0.9208 - val_recall: 0.8016
```

```
[28]: model_path = '/content/drive/My Drive/Colab Notebooks/ProjectData/
˓→FaceRecognition/pickle/transferMobileNet_holly_2_dataset.h5'
model.save(model_path)
```

```
/usr/local/lib/python3.7/dist-packages/keras/utils/generic_utils.py:497:
CustomMaskWarning: Custom mask layers require a config and must override
get_config. When loading, the custom mask layer must be passed to the
custom_objects argument.
category=CustomMaskWarning)
```

```
[29]: model_path = '/content/drive/My Drive/Colab Notebooks/ProjectData/
˓→FaceRecognition/pickle/transferMobileNet_holly_2_dataset_test.h5'
tf.keras.models.save_model(
    model, model_path, overwrite=False, include_optimizer=True,
    save_format='h5',
    signatures=None, options=None, save_traces=True
)
```

```
/usr/local/lib/python3.7/dist-packages/keras/utils/generic_utils.py:497:
CustomMaskWarning: Custom mask layers require a config and must override
get_config. When loading, the custom mask layer must be passed to the
custom_objects argument.
category=CustomMaskWarning)
```

```
[41]: img_weight = model.weights
```

```
[42]: outfile = open('/content/drive/My Drive/Colab Notebooks/ProjectData/  
    ↪FaceRecognition/pickle/checkpoint/transferMobileNet_holly_2_dataset.  
    ↪pickle','wb')  
pickle.dump(img_weight,outfile)  
outfile.close()
```

```
[35]: # If you want to load a model  
#model2 = load_model('/content/drive/My Drive/Colab Notebooks/ProjectData/  
    ↪FaceRecognition/pickle/transferMobileNet_holly_1_dataset.h5')  
#model.load_weights('/content/drive/My Drive/Colab Notebooks/ProjectData/  
    ↪FaceRecognition/pickle/checkpoint/holly_MobileNet_1.hdf5')
```

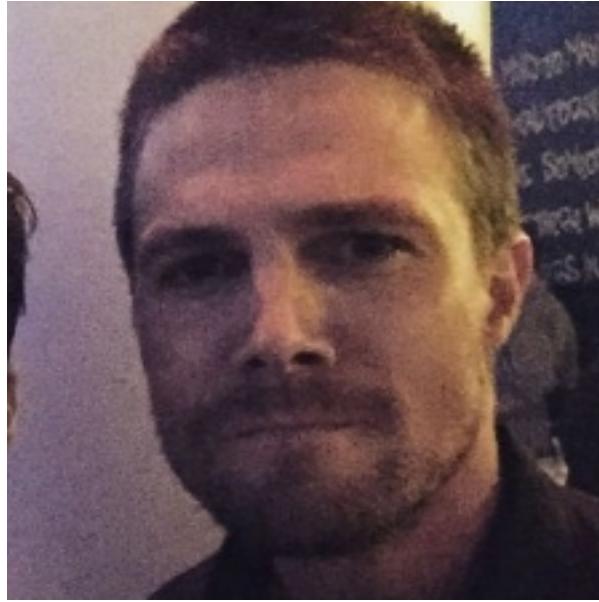
```
[32]: preds = model.evaluate(validation_set)
```

```
23/23 [=====] - 8s 328ms/step - loss: 0.4536 -  
accuracy: 0.8686 - precision: 0.9208 - recall: 0.8020
```

```
[33]: test_loss,test_accuracy, test_precision, test_recall = preds  
print("Test Loss = ", test_loss)  
print("Test Accuracy", test_accuracy)  
print("Test Precision", test_precision)  
print("Test Recall", test_recall)
```

```
Test Loss =  0.45358893275260925  
Test Accuracy 0.8686440587043762  
Test Precision 0.9207698106765747  
Test Recall 0.80196613073349
```

```
[34]: cv2_imshow(X_val[0])  
xx = X_val[0].astype(np.float32)  
xx /= 255.0
```



```
[35]: y_cat = np.argmax(y_val, axis=1)
```

```
[36]: ev = model.evaluate(x=X_val, y= y_val)
```

```
23/23 [=====] - 4s 39ms/step - loss: 4.1320 - accuracy:  
0.0678 - precision: 0.9198 - recall: 0.8004
```

```
[37]: y_cat
```

```
[37]: array([13,  2, 18, 11, 10,  2, 10, 16, 14, 14, 18, 11,  2,  3, 19, 10,  1,  
         9,  6,  2,  5, 19, 17,  6, 11,  7,  1,  8,  3, 11, 16,  0, 18,  9,  
         0, 11, 12,  4, 16, 16,  9, 17, 11,  9, 18,  0, 15,  8, 14, 13,  1,  
         9,  1,  4,  8, 18, 12, 19,  4, 19, 11, 11, 16, 18,  1, 10,  4, 14,  
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        16, 11, 19, 13, 10,  8, 16,  6, 15,  0, 12, 18,  8, 17,  6,  7, 19,  
        13, 11,  2, 17, 16, 17,  4,  2, 15, 16,  7, 14,  5,  1, 17, 13,  3,  
        15, 16,  1,  9,  0, 18,  9,  6, 16,  4, 18, 11,  0,  8, 18,  3, 15,  
        17,  0,  2, 19, 14, 11,  9, 18,  6,  3, 19, 13,  8, 12, 11,  9,  0,  
        16,  6, 15,  3,  2,  0, 11,  3,  2,  1, 14,  6,  6,  9,  8,  2, 10,  
         2,  5, 15, 13, 15,  6, 10,  4,  1,  7, 17, 12, 19, 13,  1, 15,  5,  
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        13, 19,  1, 14, 17, 12, 11, 17,  3, 18,  8,  4,  9, 19,  1,  7, 18,  
        5, 10,  6,  3, 17, 16, 11, 13,  5, 13, 17, 12, 17, 16,  9, 11,  7,  
        10,  9, 18,  7, 16,  8,  5, 16, 17,  6, 16, 17,  2, 16,  0,  4,  2,
```

```

3, 19, 14, 3, 1, 1, 0, 12, 11, 14, 14, 15, 3, 17, 17, 18, 6,
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10, 9, 7, 14, 11, 5, 3, 10, 0, 15, 1, 0, 13, 19, 11, 3, 2,
2, 7, 13, 17, 12, 0, 18, 15, 3, 4, 6, 3, 3, 18, 1, 15, 6,
2, 18, 1, 18, 2, 0, 5, 2, 19, 2, 8])

```

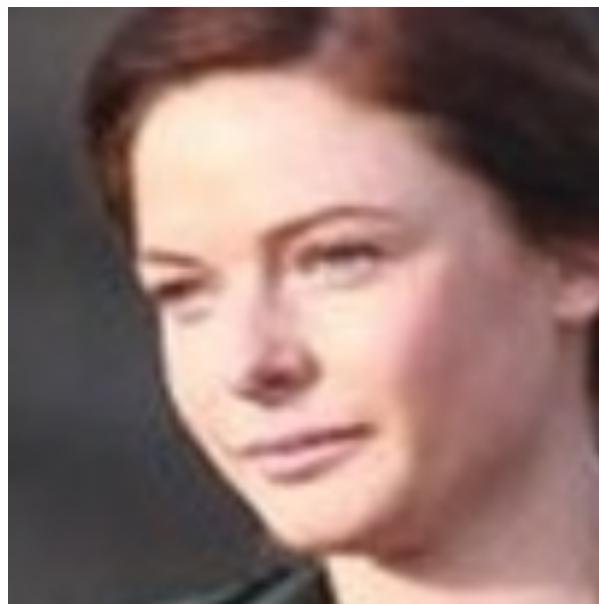
```

[45]: count = 0
for img,actual in zip(X_val, y_cat):
    img1 = img
    img = img.astype(np.float32) / 255.0
    np_img = img[np.newaxis,:,:,:]
    preds = model.predict(np_img)
    out = np.argmax(preds)
    name = labelEncoder.get(out)
    if actual == out:
        count += 1
    cv2_imshow(img1)
    print('Actual = ', labelEncoder.get(actual)[5:], 'Predicted = ', name[5:])
    ▾
    ↵print('-----\n\n')
#cv2_imshow(img)
#print('Actual = ', labelEncoder.get(actual), 'Predicted = ', name)

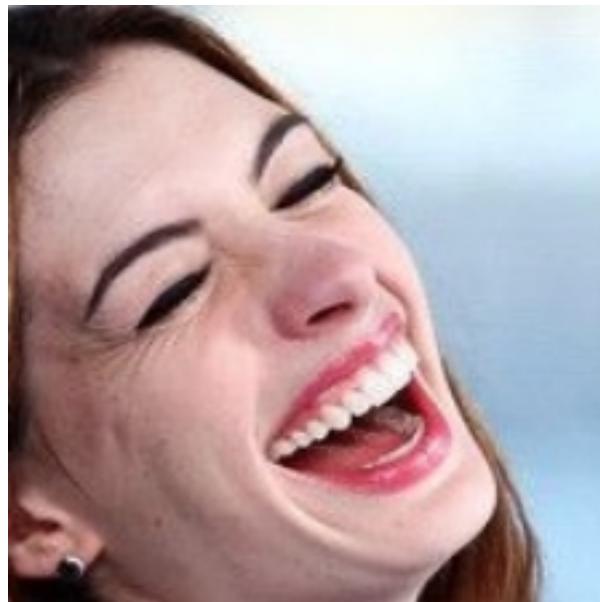
```



Actual = Stephen Amell Predicted = Stephen Amell



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



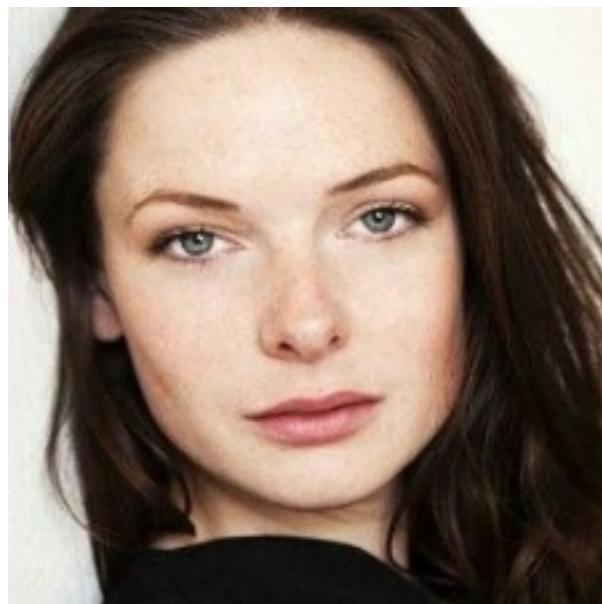
Actual = Anne Hathaway Predicted = Anne Hathaway



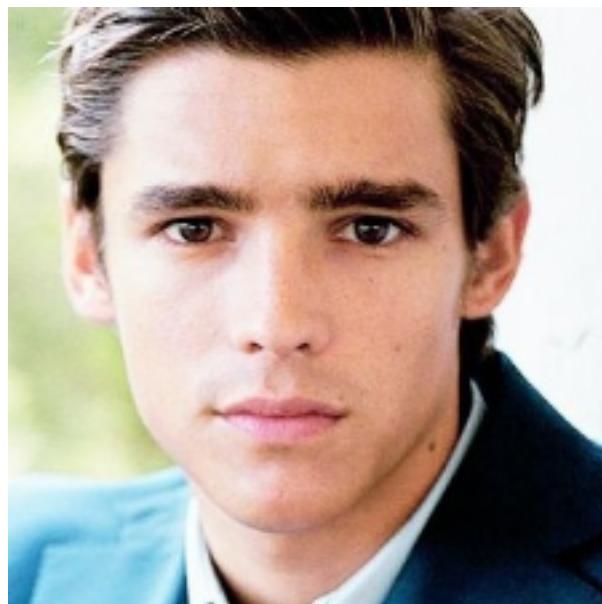
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Katherine Langford Predicted = Katherine Langford



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = Alexandra Daddario Predicted = Alexandra Daddario



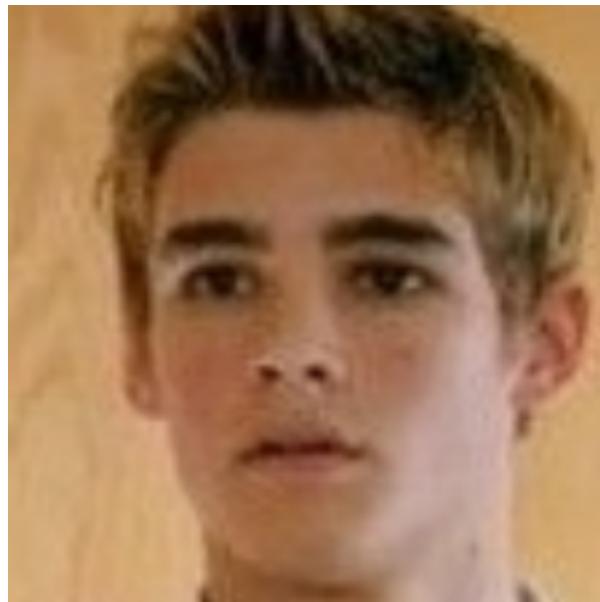
Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



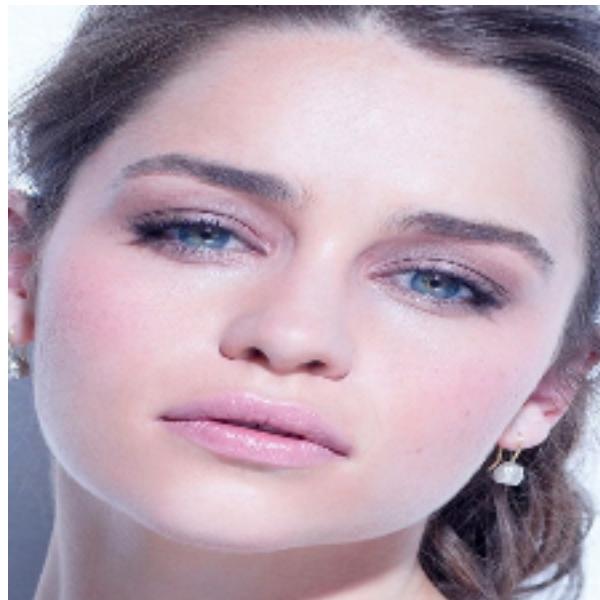
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Zoe Saldana Predicted = Zoe Saldana



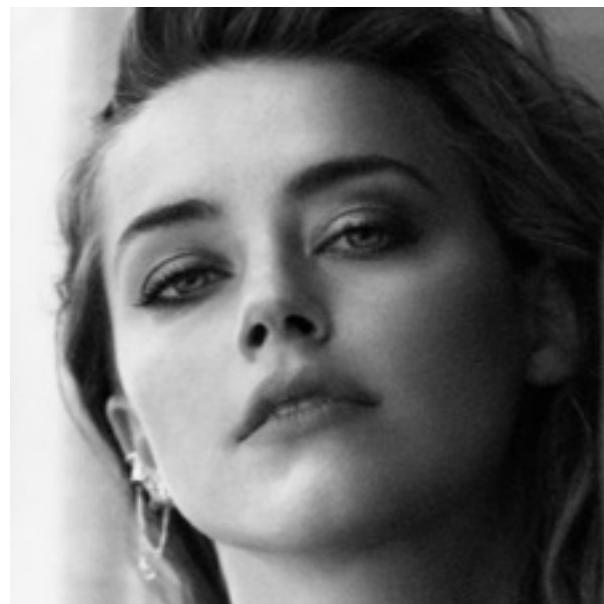
Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = amber heard Predicted = amber heard



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



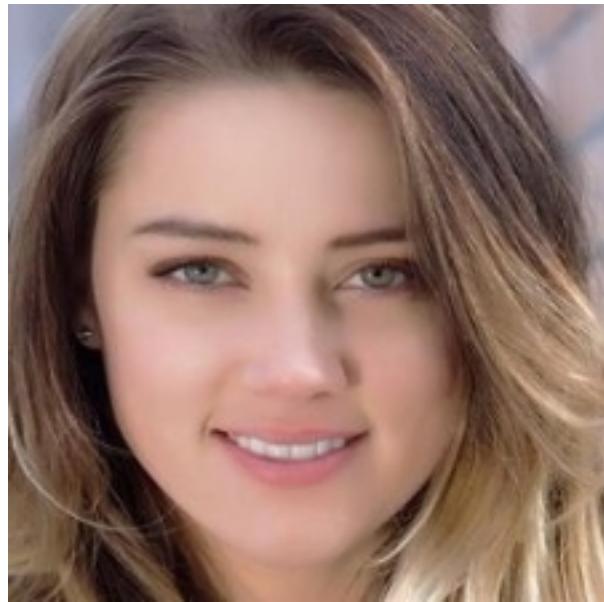
Actual = Mark Zuckerberg Predicted = Millie Bobby Brown



Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



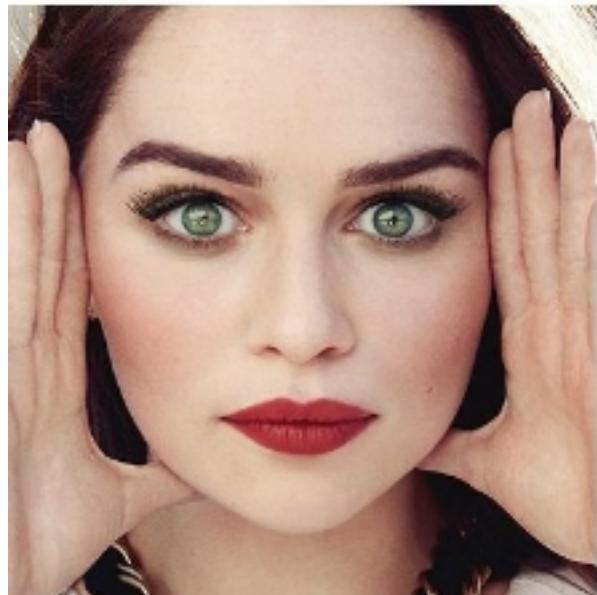
Actual = amber heard Predicted = amber heard



Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = Emilia Clarke Predicted = Katherine Langford



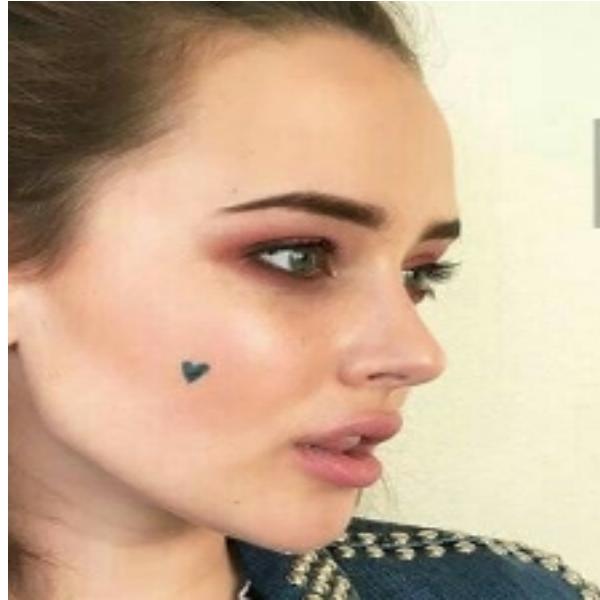
Actual = Bill Gates Predicted = Bill Gates



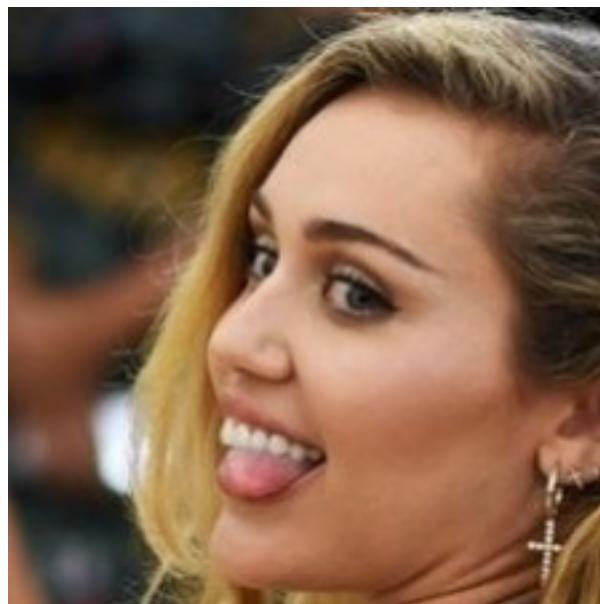
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



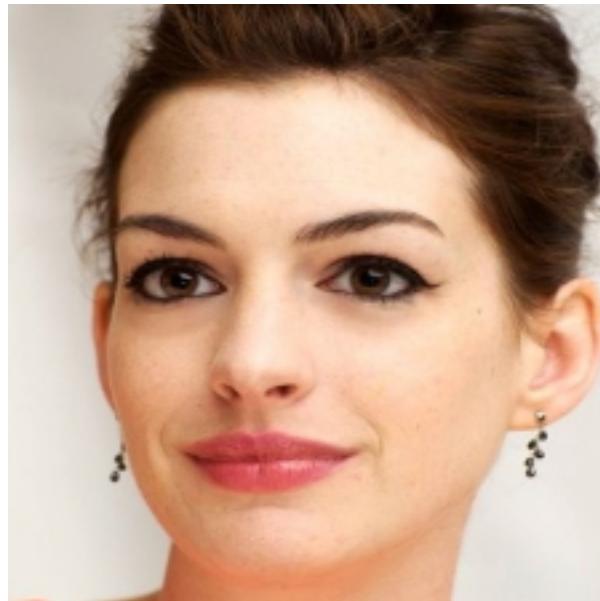
Actual = Alexandra Daddario Predicted = Alexandra Daddario



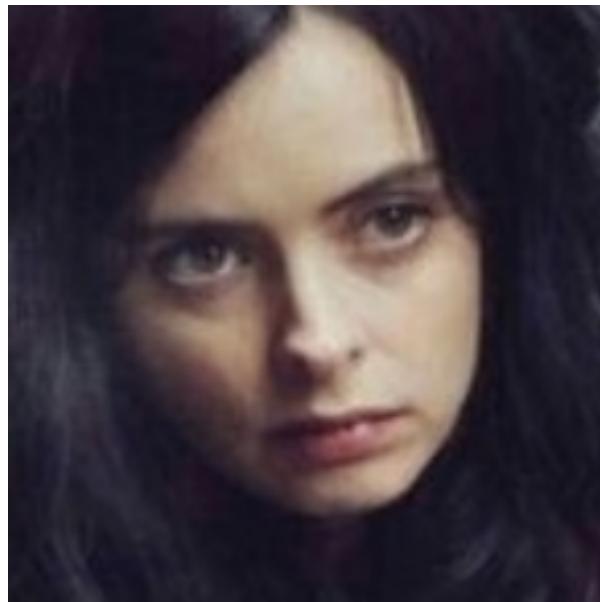
Actual = Katherine Langford Predicted = Millie Bobby Brown



Actual = Miley Cyrus Predicted = Miley Cyrus



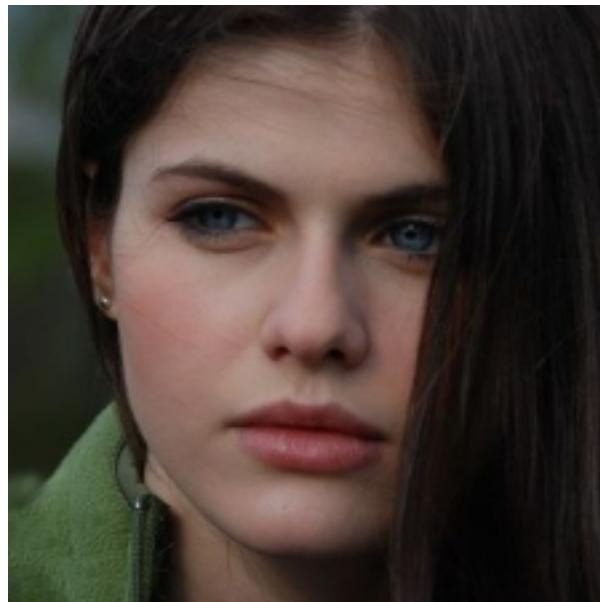
Actual = Anne Hathaway Predicted = Anne Hathaway



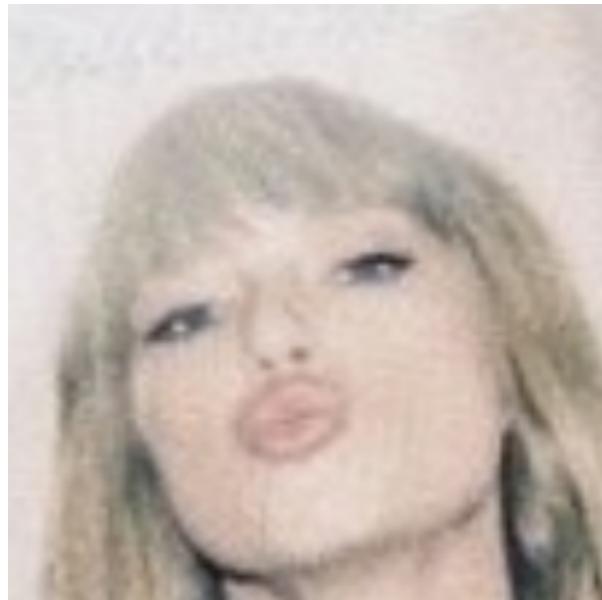
Actual = Krysten Ritter Predicted = Krysten Ritter



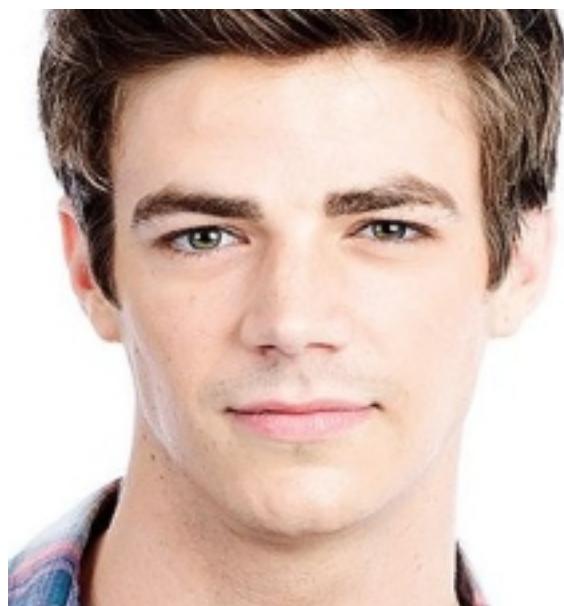
Actual = Miley Cyrus Predicted = amber heard



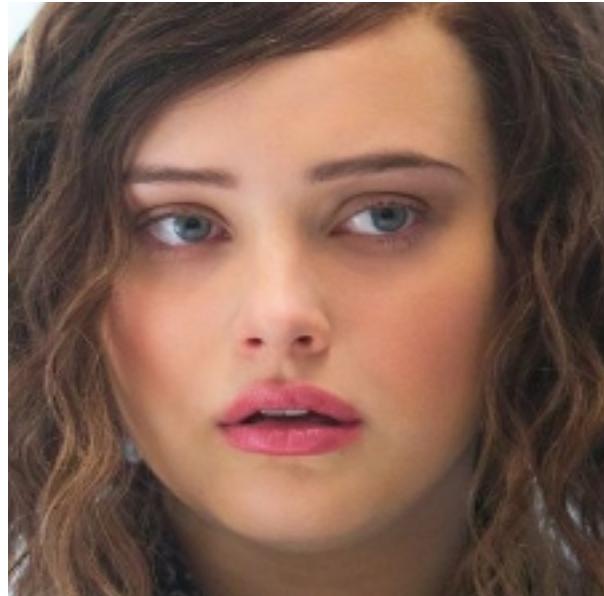
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Taylor Swift Predicted = Taylor Swift



Actual = grant gustin Predicted = grant gustin



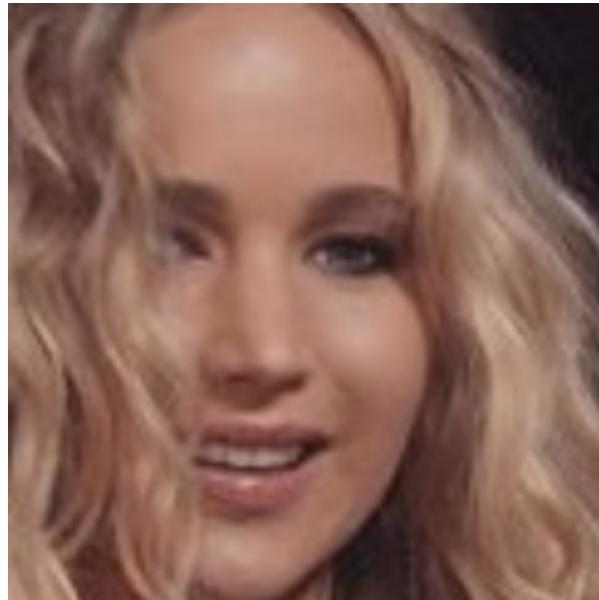
Actual = Katherine Langford Predicted = Katherine Langford



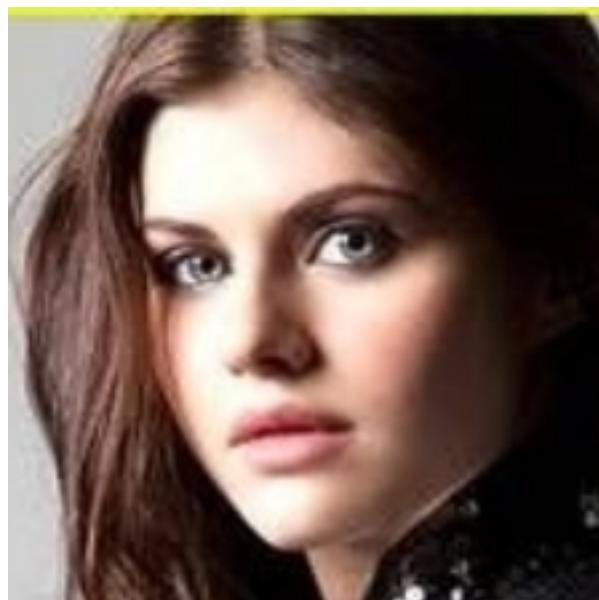
Actual = Katherine Langford Predicted = Katherine Langford



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



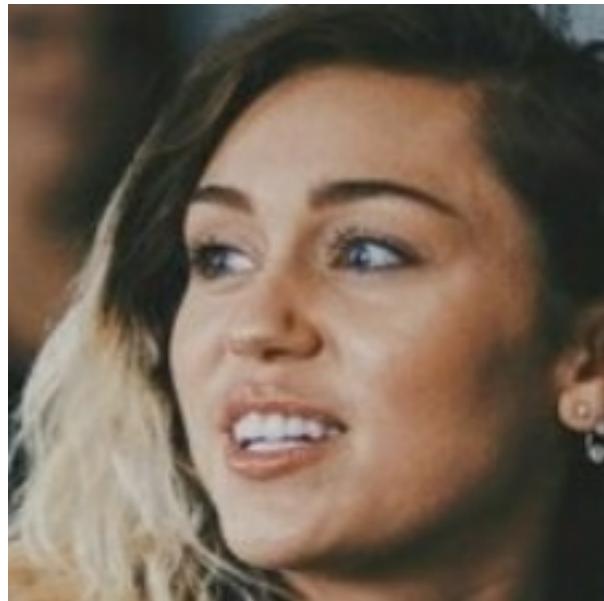
Actual = Alexandra Daddario Predicted = Millie Bobby Brown



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Anne Hathaway Predicted = Anne Hathaway



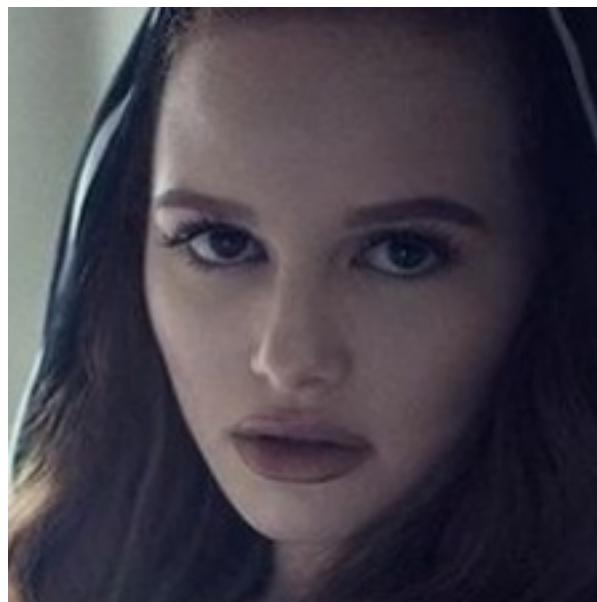
Actual = Miley Cyrus Predicted = Miley Cyrus



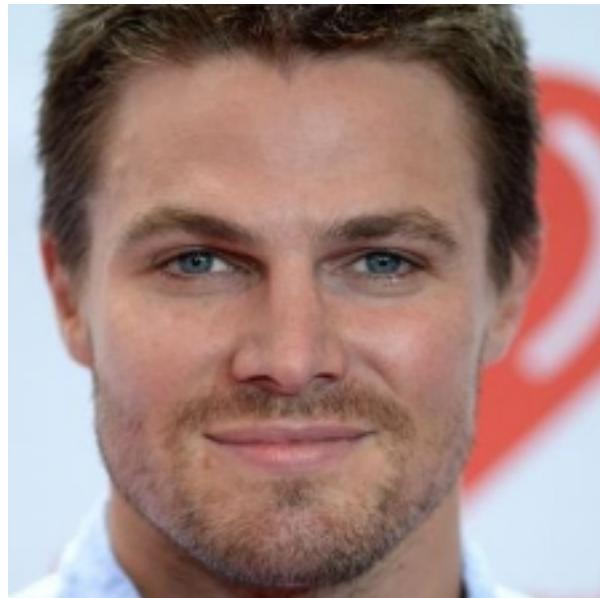
Actual = Jeremy Renner Predicted = Jeremy Renner



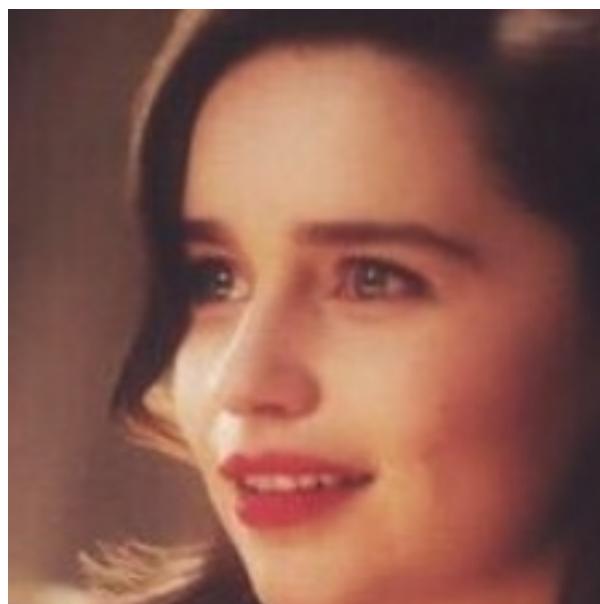
Actual = Bill Gates Predicted = Bill Gates



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Stephen Amell Predicted = Stephen Amell



Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Krysten Ritter Predicted = Krysten Ritter



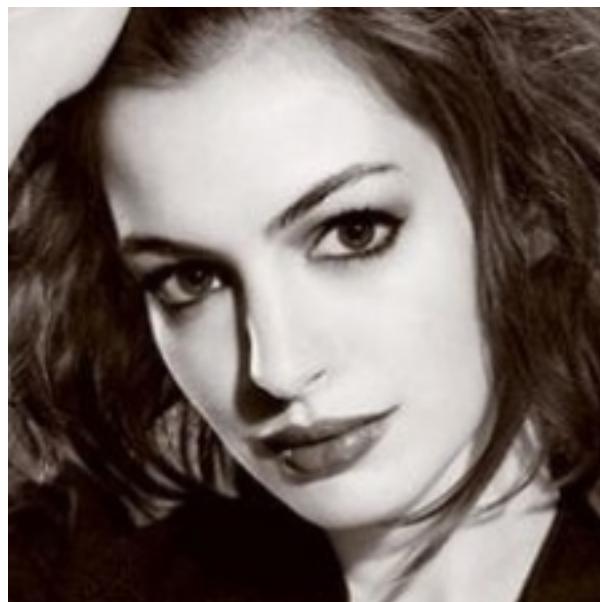
Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = grant gustin Predicted = grant gustin



Actual = Bill Gates Predicted = Millie Bobby Brown



Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = Taylor Swift Predicted = Taylor Swift



Actual = Zoe Saldana Predicted = Millie Bobby Brown



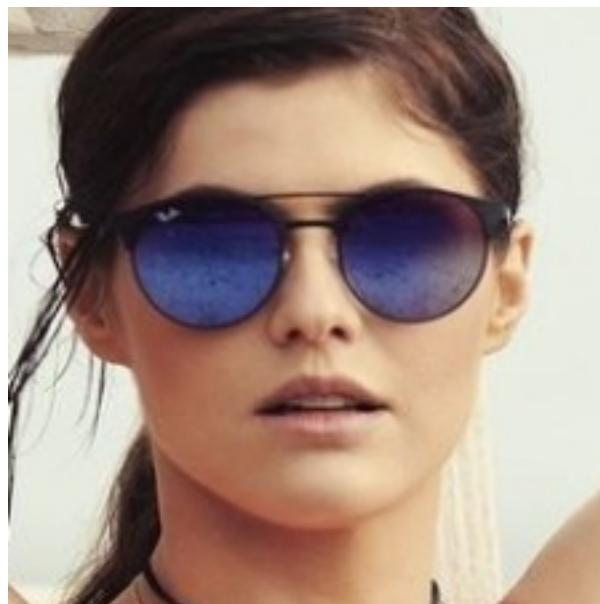
Actual = grant gustin Predicted = grant gustin



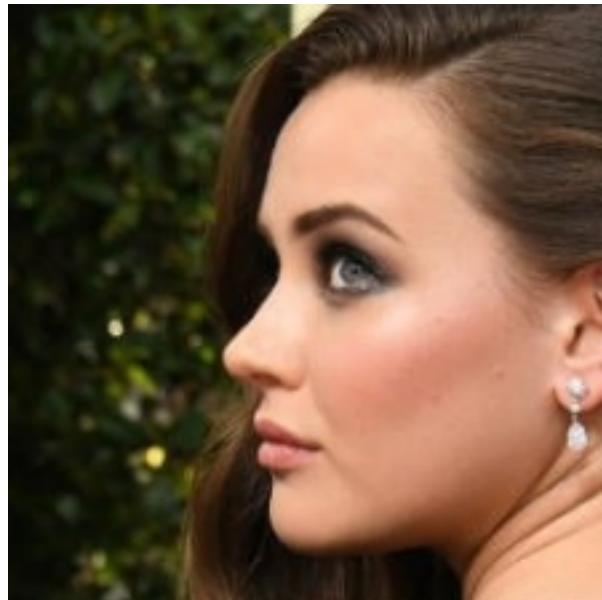
Actual = Zoe Saldana Predicted = Katherine Langford



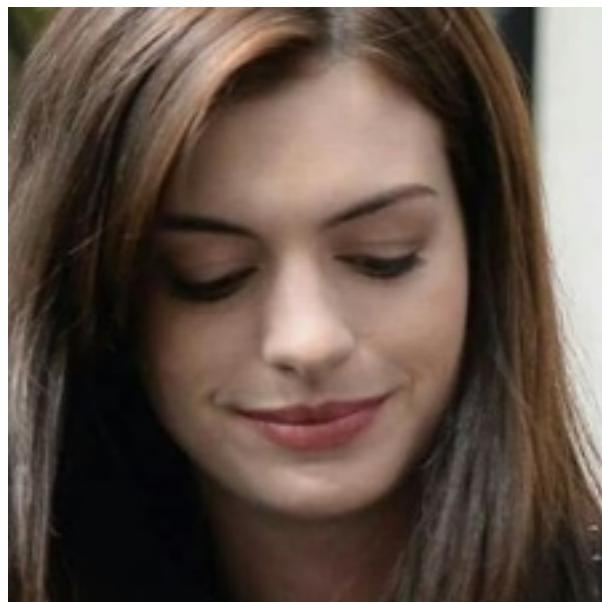
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Alexandra Daddario Predicted = Emilia Clarke



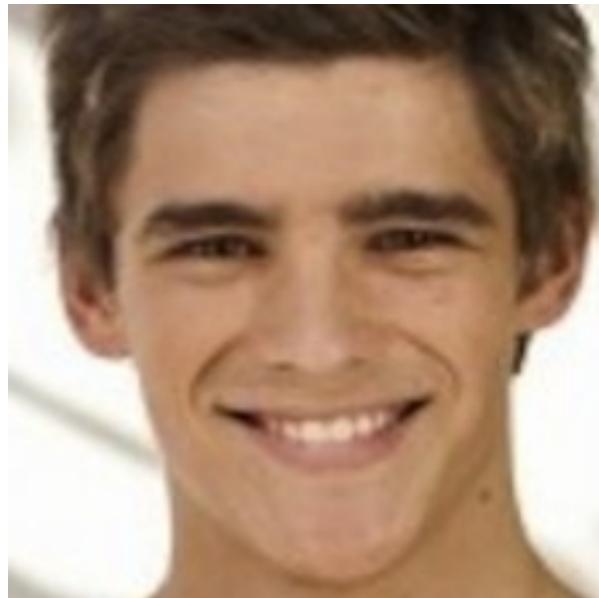
Actual = Katherine Langford Predicted = Katherine Langford



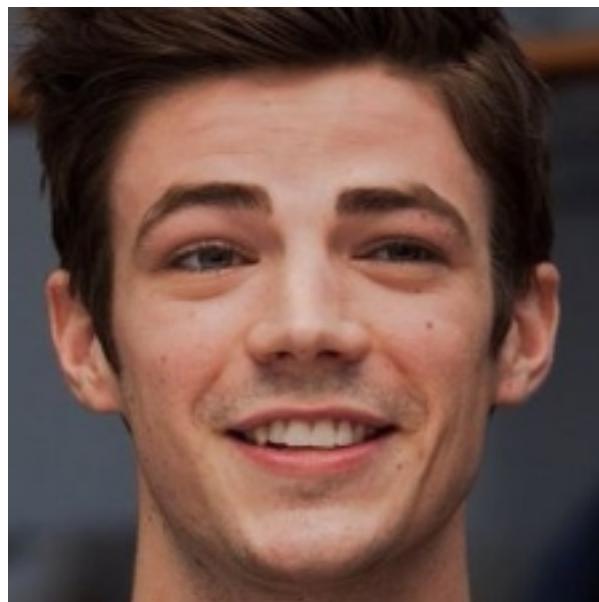
Actual = Anne Hathaway Predicted = Anne Hathaway



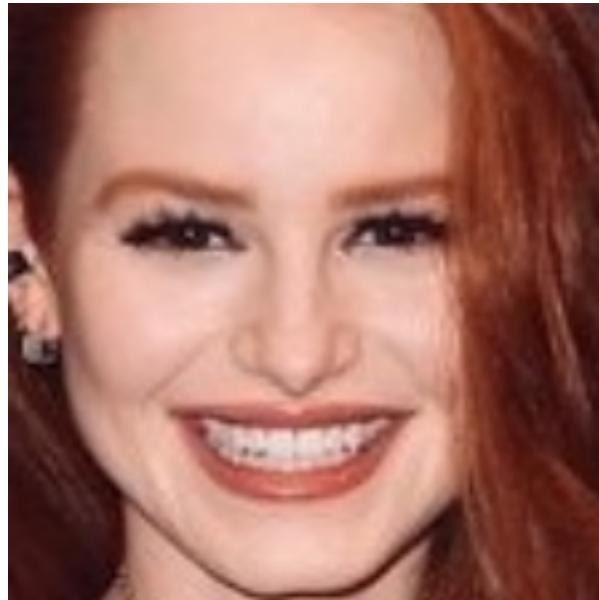
Actual = Emilia Clarke Predicted = Emilia Clarke



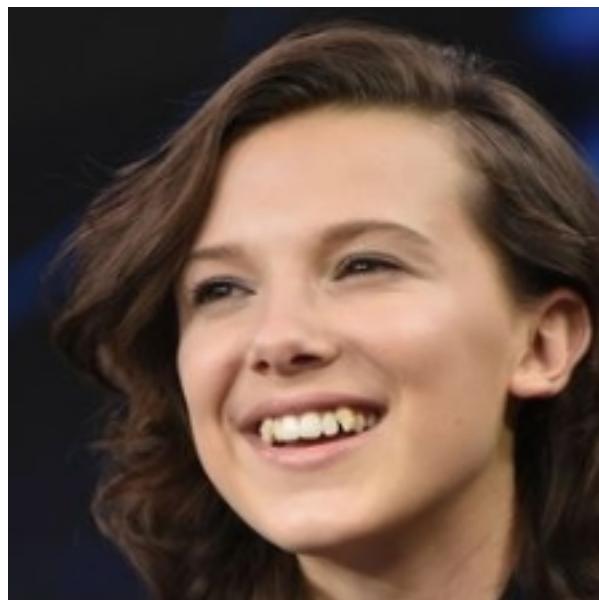
Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = grant gustin Predicted = grant gustin



Actual = Madelaine Petsch Predicted = Madelaine Petsch



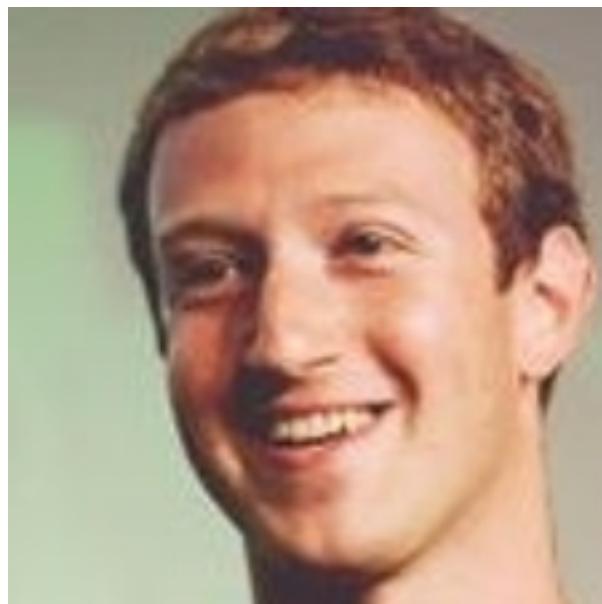
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



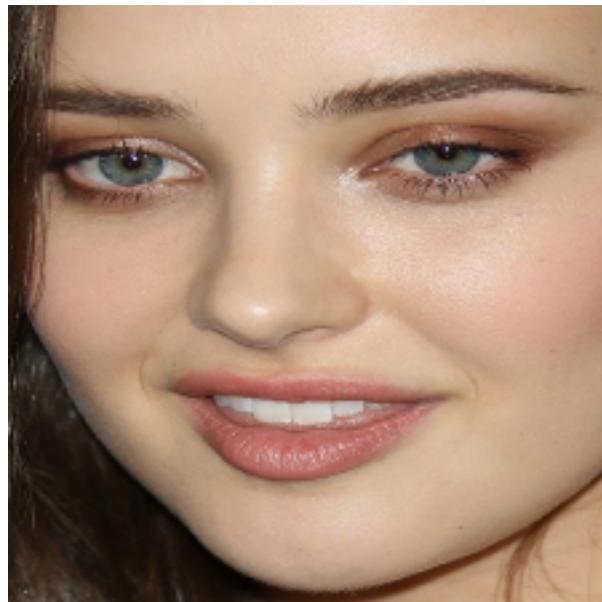
Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Katherine Langford Predicted = Katherine Langford



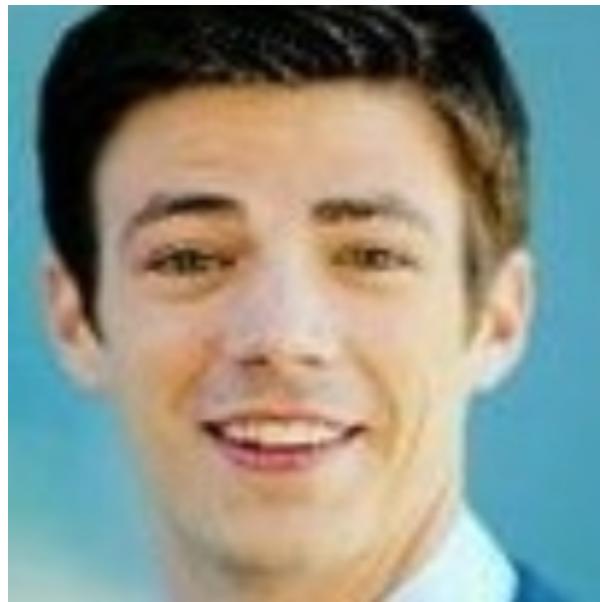
Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



Actual = Katherine Langford Predicted = Katherine Langford



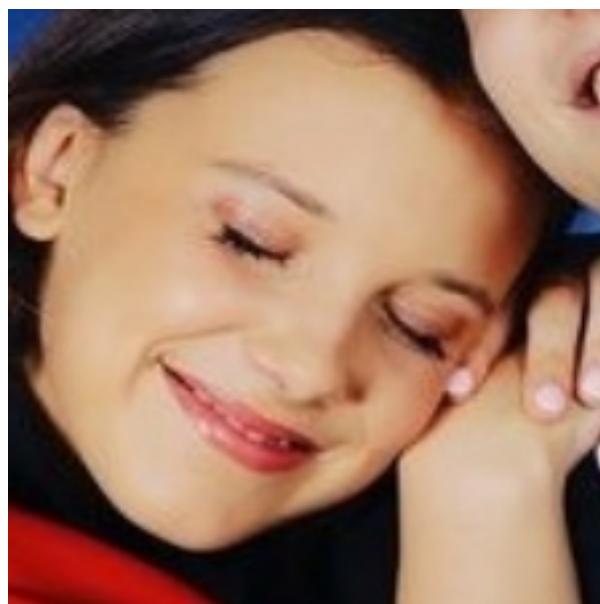
Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = grant gustin Predicted = grant gustin



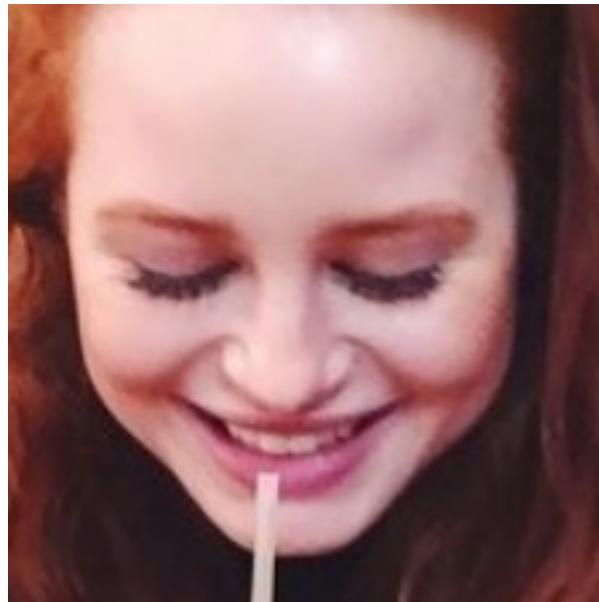
Actual = grant gustin Predicted = grant gustin



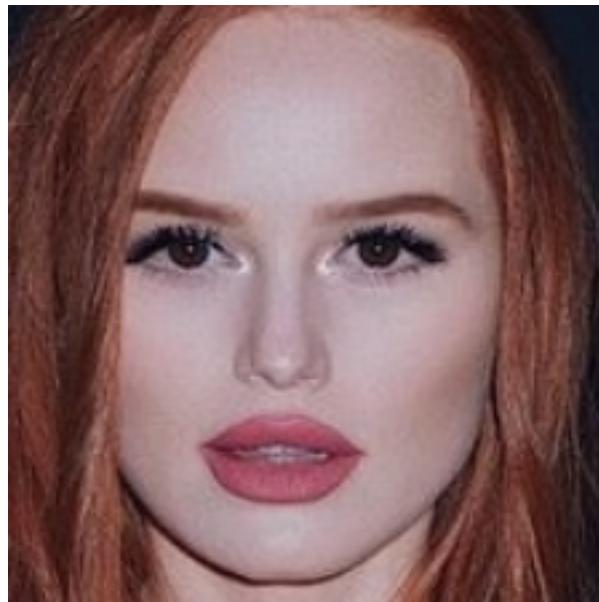
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



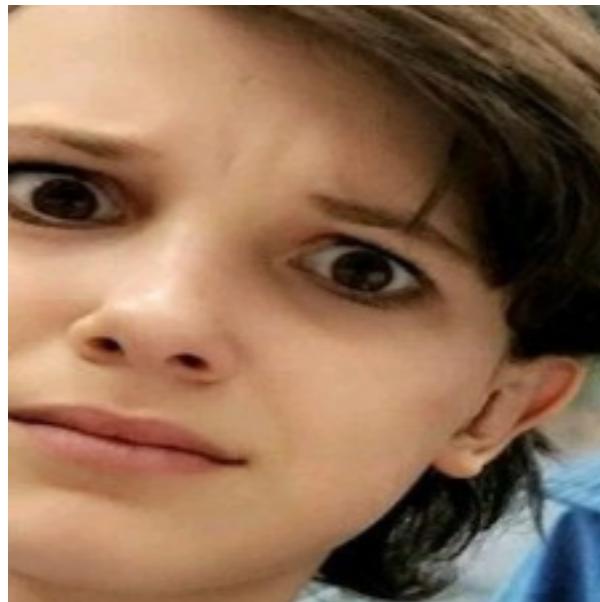
Actual = Brenton Thwaites Predicted = Jeremy Renner



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Madelaine Petsch Predicted = Madelaine Petsch



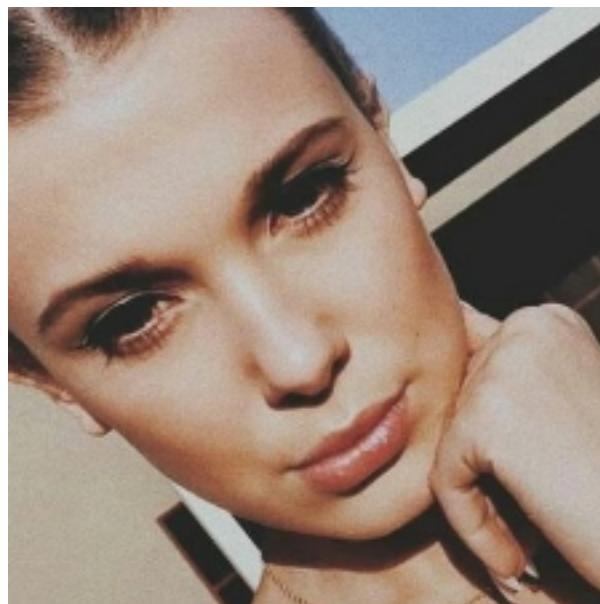
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



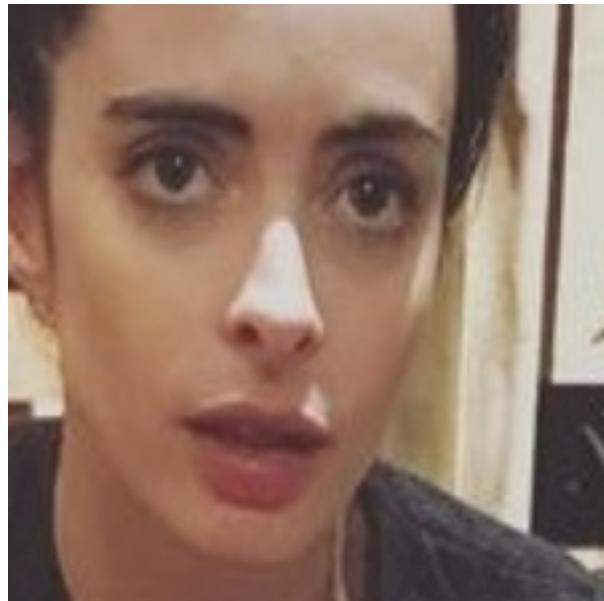
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Anne Hathaway Predicted = Anne Hathaway



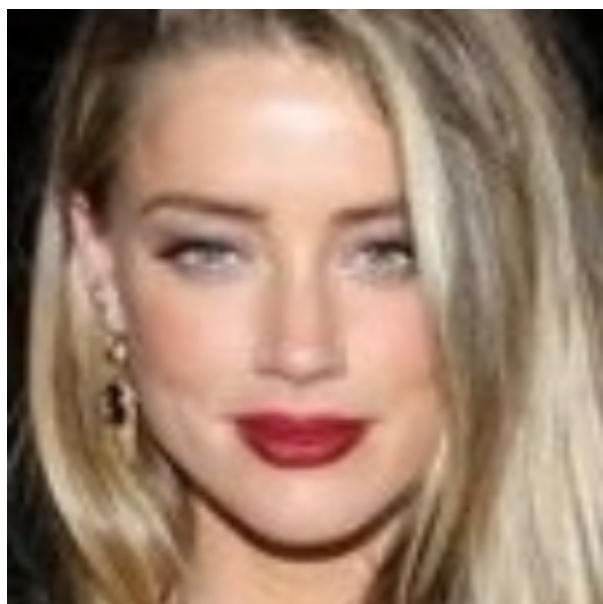
Actual = Emilia Clarke Predicted = Emilia Clarke



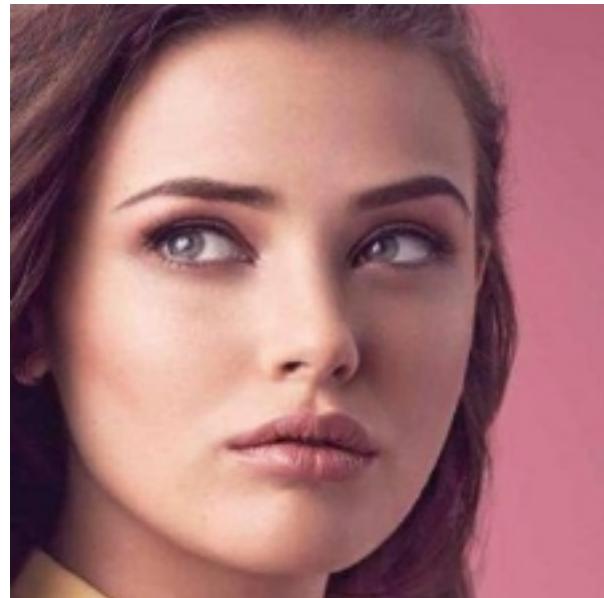
Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = Stephen Amell Predicted = Stephen Amell



Actual = amber heard Predicted = amber heard



Actual = Katherine Langford Predicted = Katherine Langford



Actual = Millie Bobby Brown Predicted = Taylor Swift



Actual = Emilia Clarke Predicted = Emilia Clarke



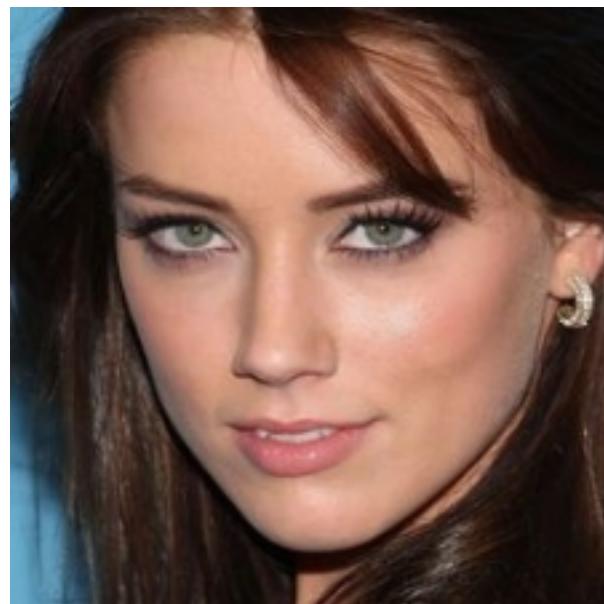
Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



Actual = Katherine Langford Predicted = Katherine Langford



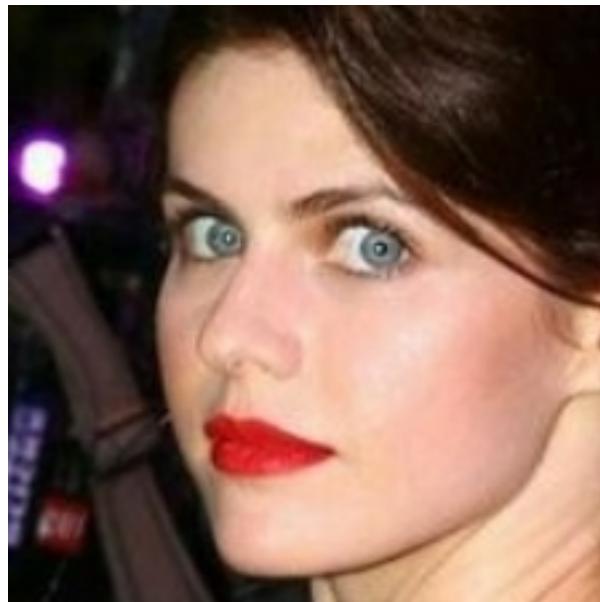
Actual = Katherine Langford Predicted = Katherine Langford



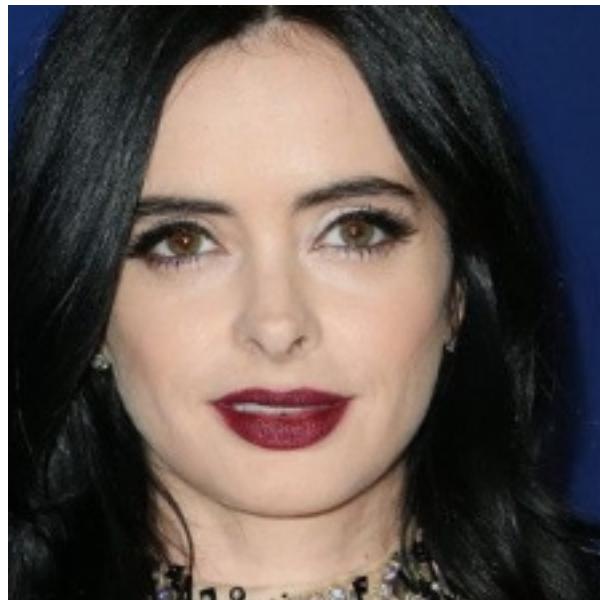
Actual = amber heard Predicted = amber heard



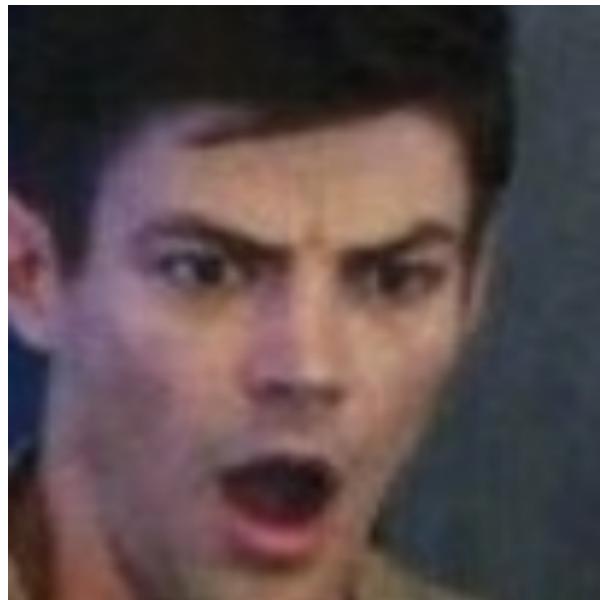
Actual = Stephen Amell Predicted = Brenton Thwaites



Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Krysten Ritter Predicted = Krysten Ritter



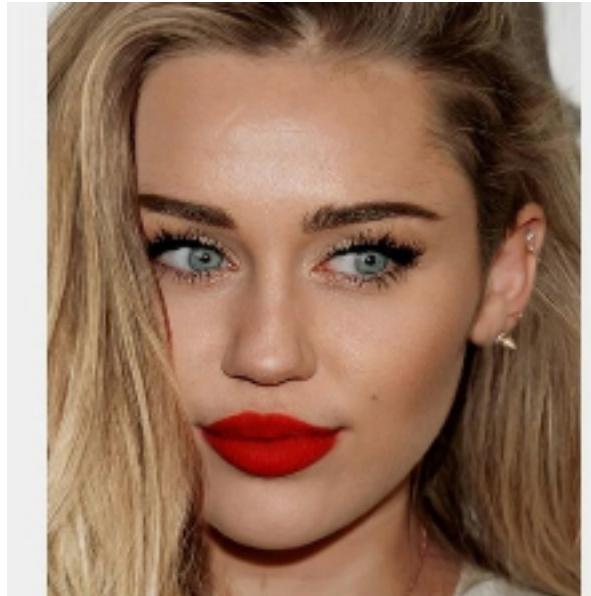
Actual = grant gustin Predicted = grant gustin



Actual = grant gustin Predicted = grant gustin



Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = Miley Cyrus Predicted = amber heard



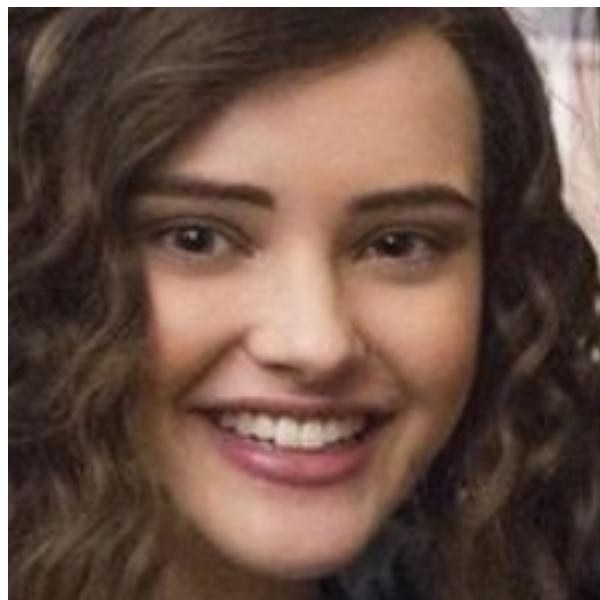
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = Katherine Langford Predicted = Katherine Langford



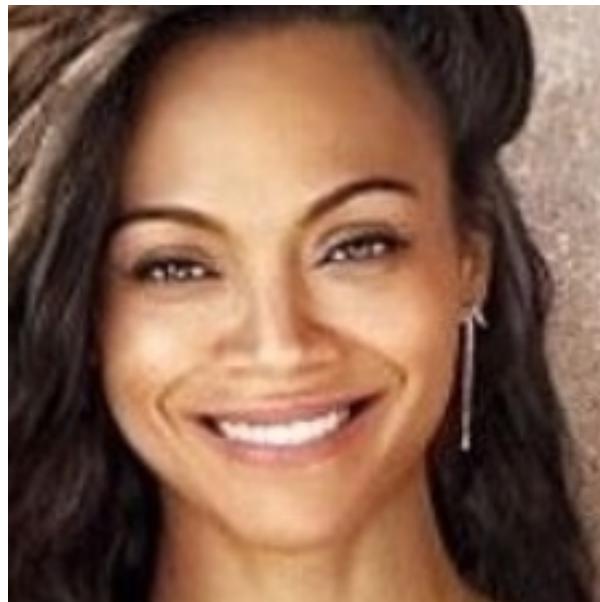
Actual = Stephen Amell Predicted = Stephen Amell



Actual = Zoe Saldana Predicted = Zoe Saldana



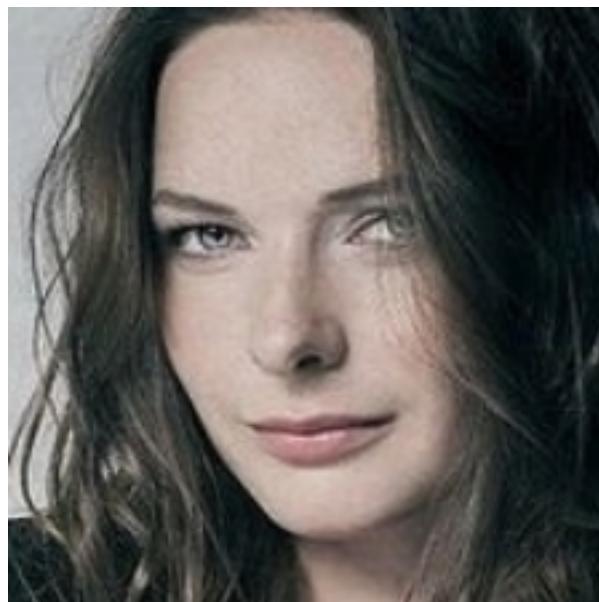
Actual = amber heard Predicted = amber heard



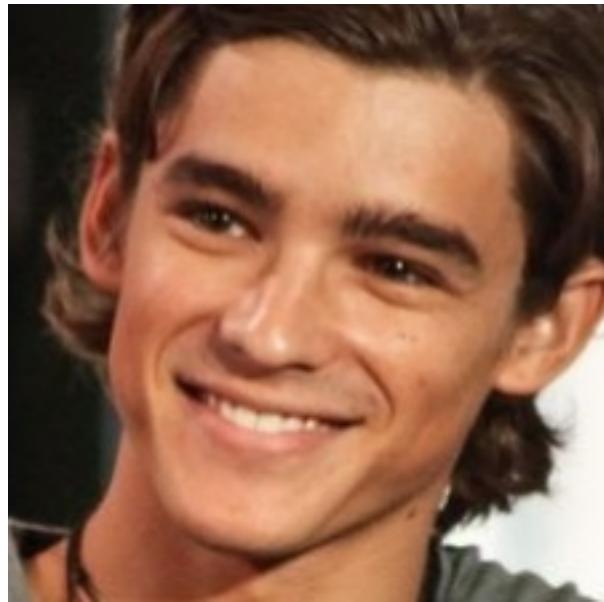
Actual = Zoe Saldana Predicted = Zoe Saldana



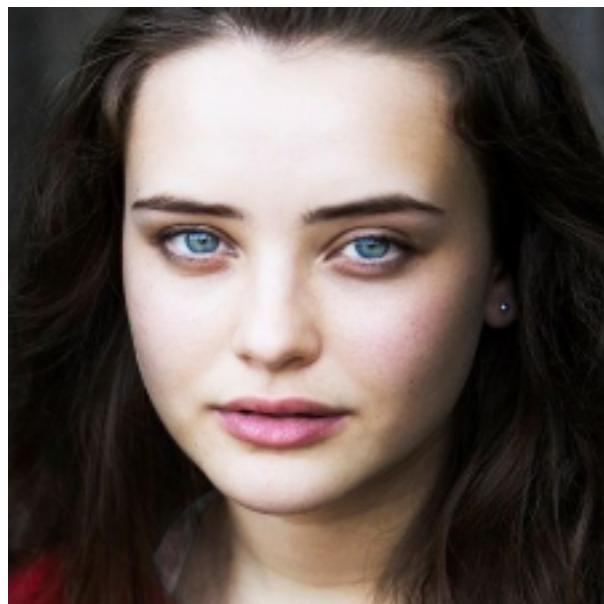
Actual = Alexandra Daddario Predicted = Alexandra Daddario



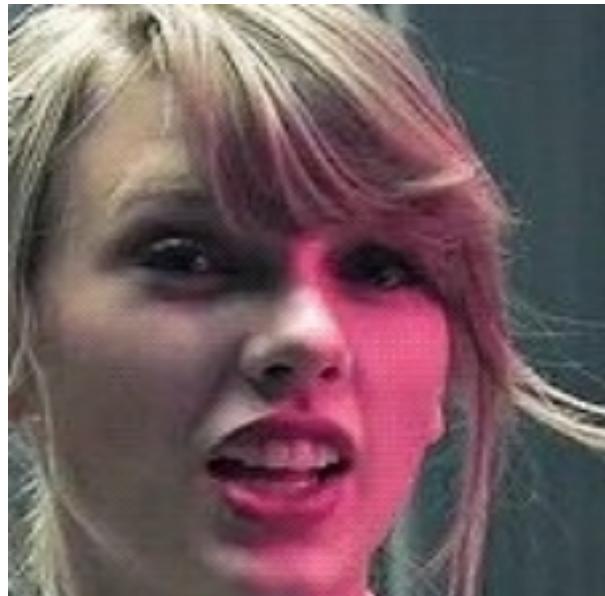
Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Katherine Langford Predicted = Katherine Langford



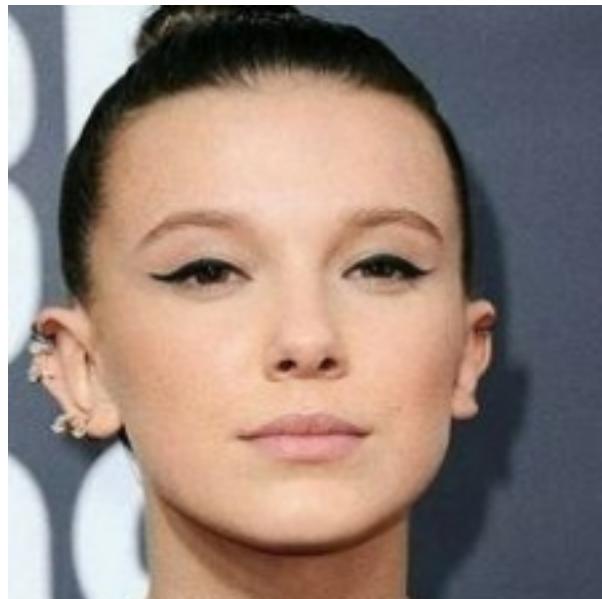
Actual = Taylor Swift Predicted = Taylor Swift



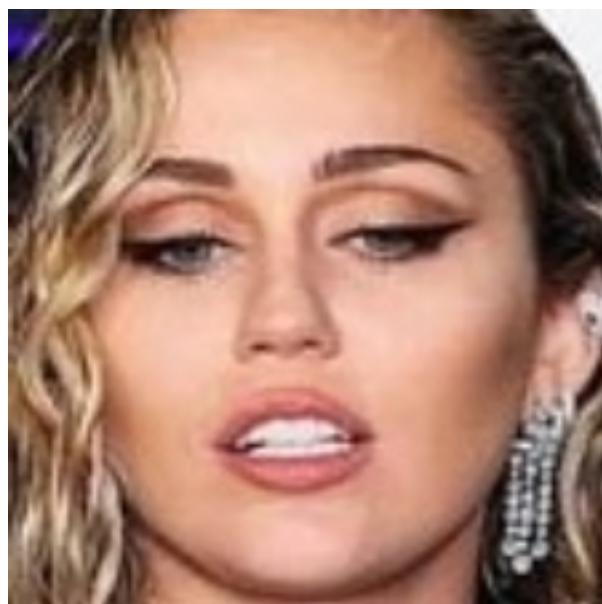
Actual = Bill Gates Predicted = Bill Gates



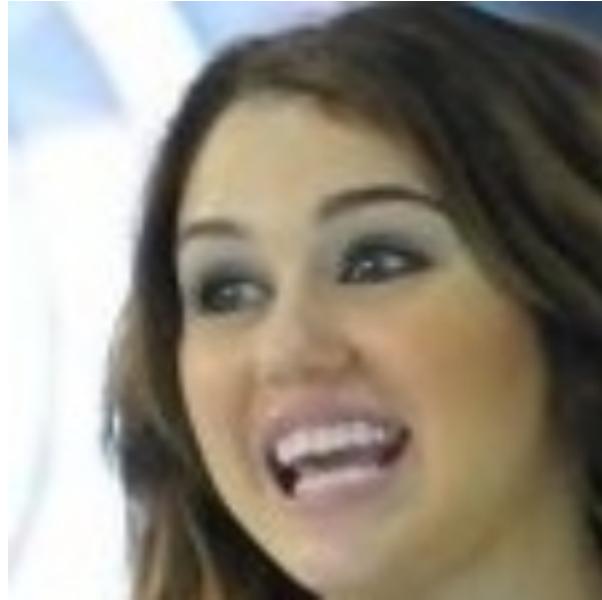
Actual = Emilia Clarke Predicted = Emilia Clarke



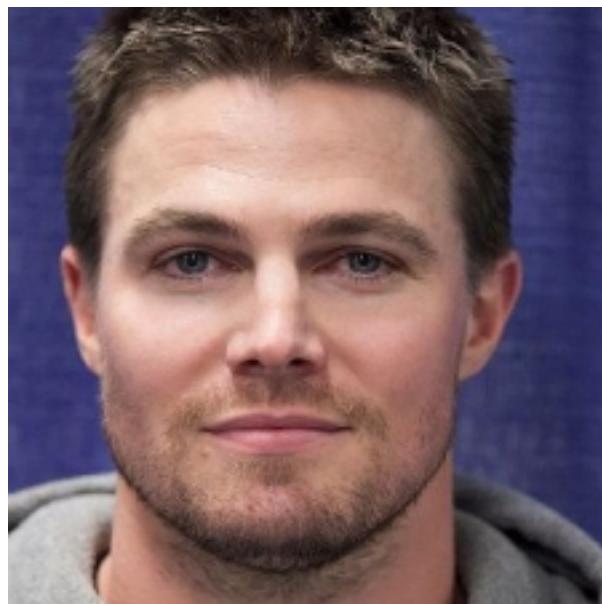
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



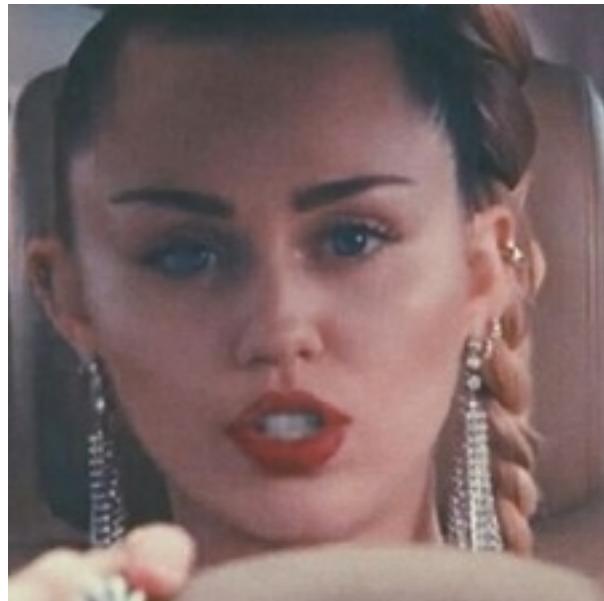
Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = Stephen Amell Predicted = Stephen Amell



Actual = Miley Cyrus Predicted = Miley Cyrus



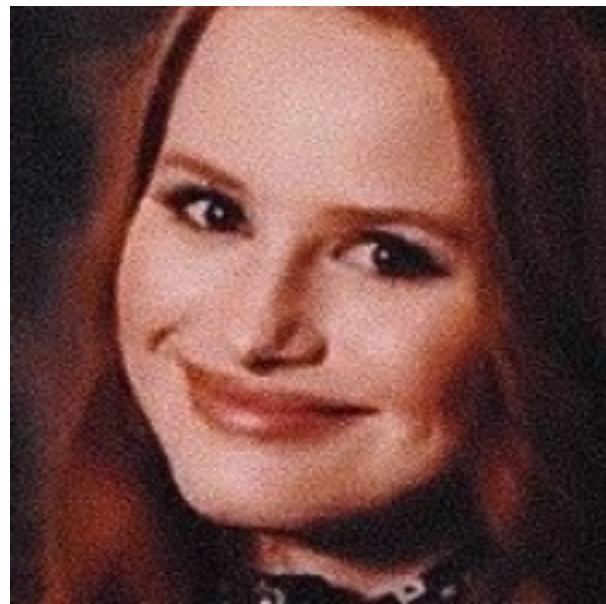
Actual = amber heard Predicted = amber heard



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Jennifer Lawrence Predicted = grant gustin



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Alexandra Daddario Predicted = Alexandra Daddario



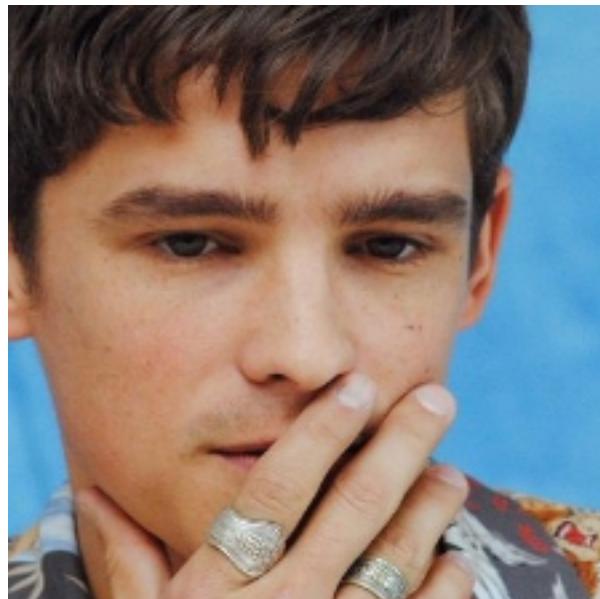
Actual = Katherine Langford Predicted = Katherine Langford



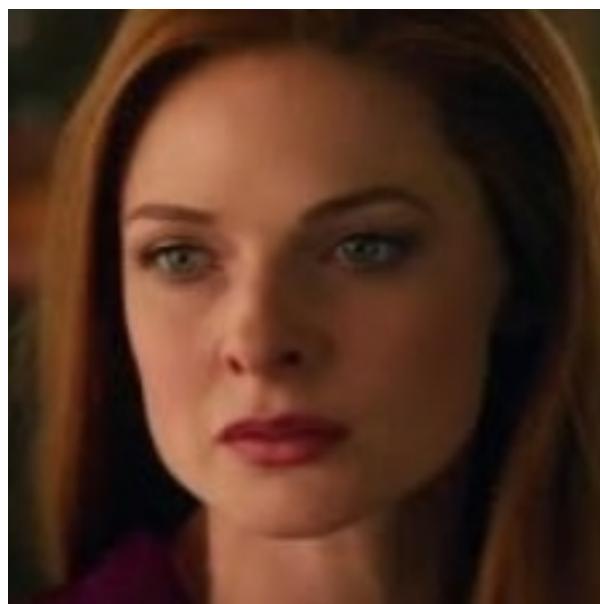
Actual = Bill Gates Predicted = Bill Gates



Actual = amber heard Predicted = amber heard



Actual = Brenton Thwaites Predicted = Brenton Thwaites



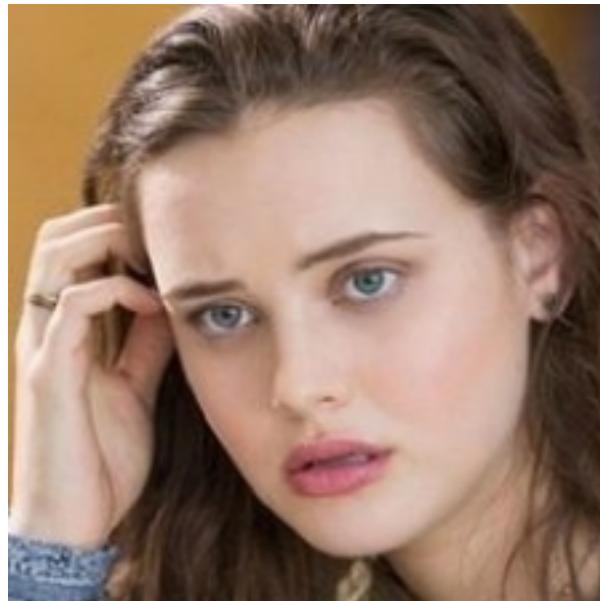
Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



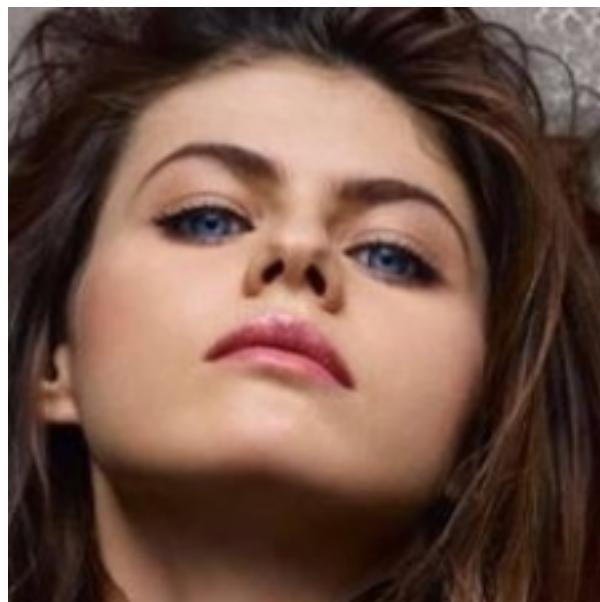
Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Katherine Langford Predicted = Katherine Langford



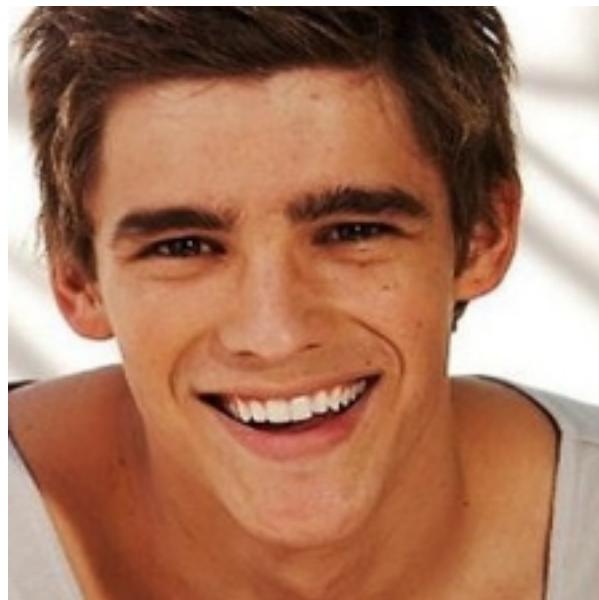
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Zoe Saldana Predicted = Katherine Langford



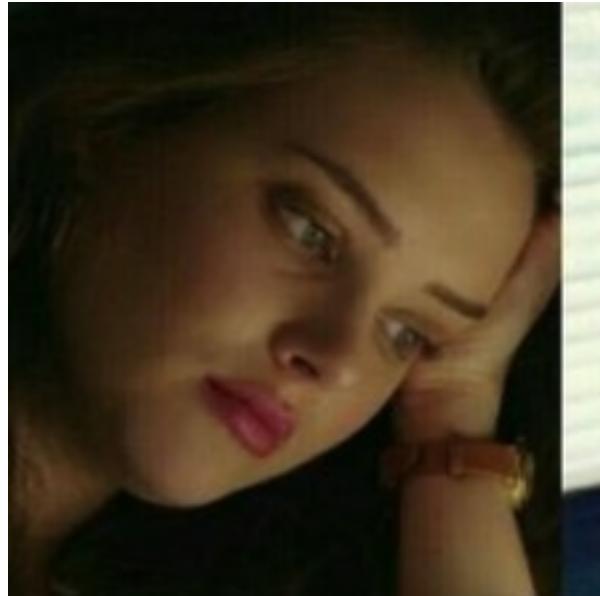
Actual = Stephen Amell Predicted = Stephen Amell



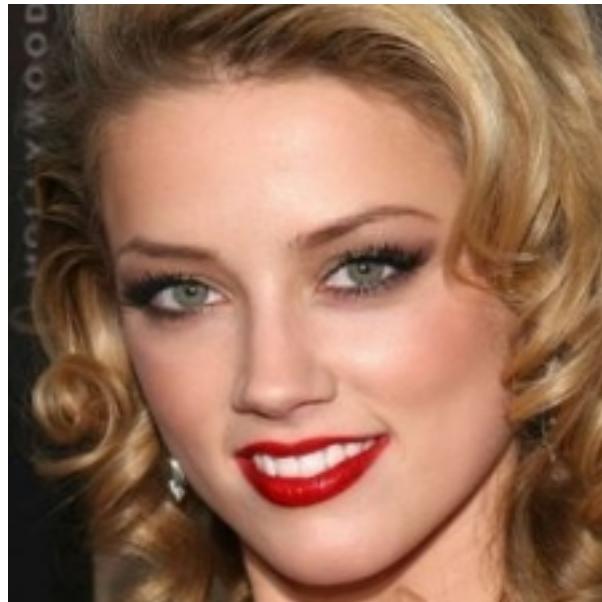
Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Bill Gates Predicted = Bill Gates



Actual = Katherine Langford Predicted = Katherine Langford



Actual = amber heard Predicted = amber heard



Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = Miley Cyrus Predicted = amber heard



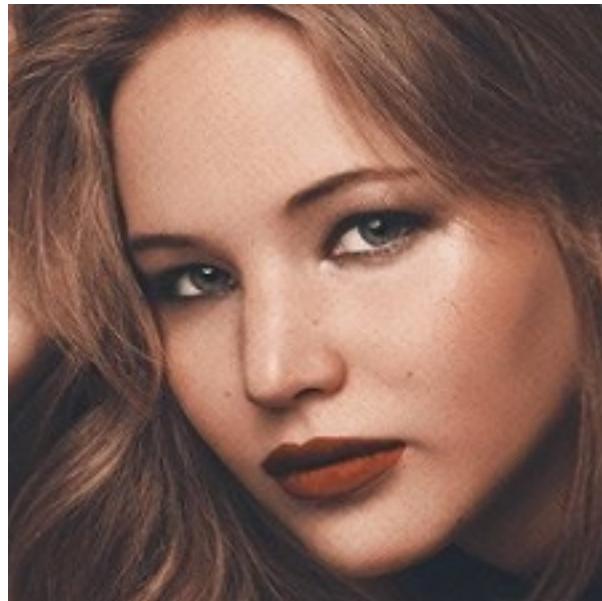
Actual = Taylor Swift Predicted = Taylor Swift



Actual = Anne Hathaway Predicted = Madelaine Petsch



Actual = Bill Gates Predicted = Bill Gates



Actual = Jennifer Lawrence Predicted = Taylor Swift



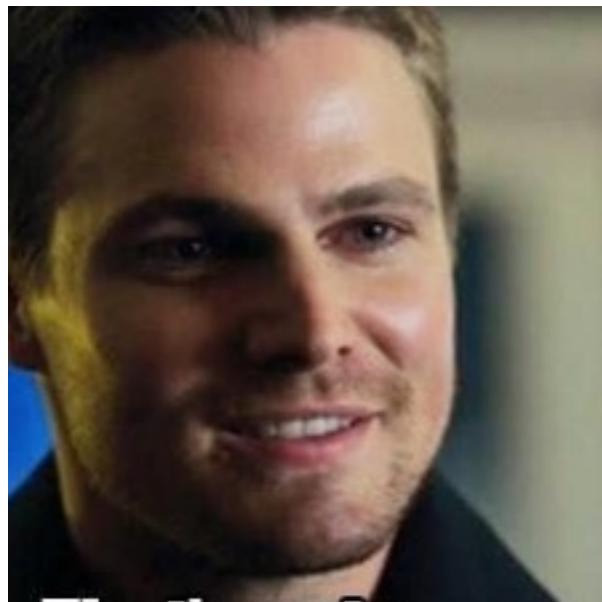
Actual = amber heard Predicted = amber heard



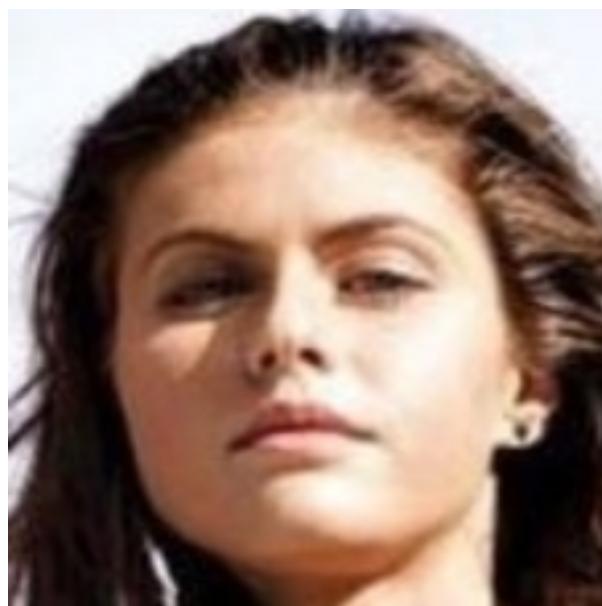
Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = Zoe Saldana Predicted = Zoe Saldana



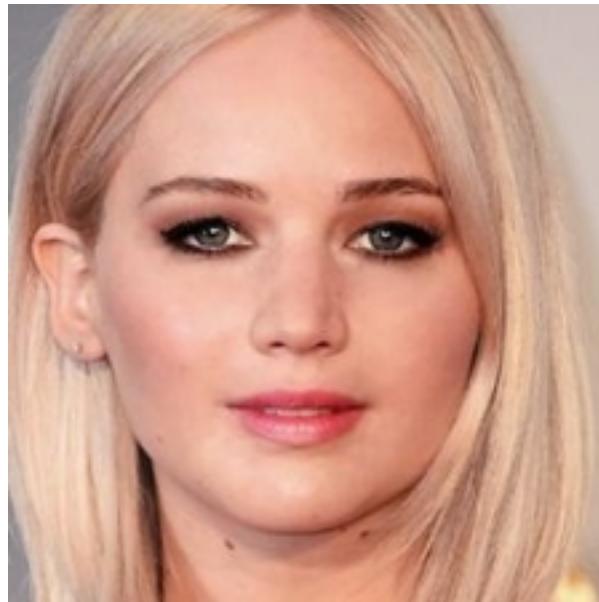
Actual = Stephen Amell Predicted = Stephen Amell



Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



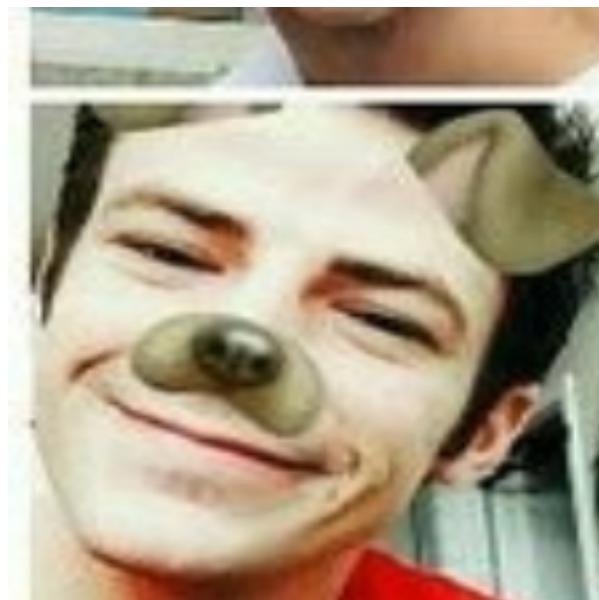
Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Katherine Langford Predicted = Katherine Langford



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



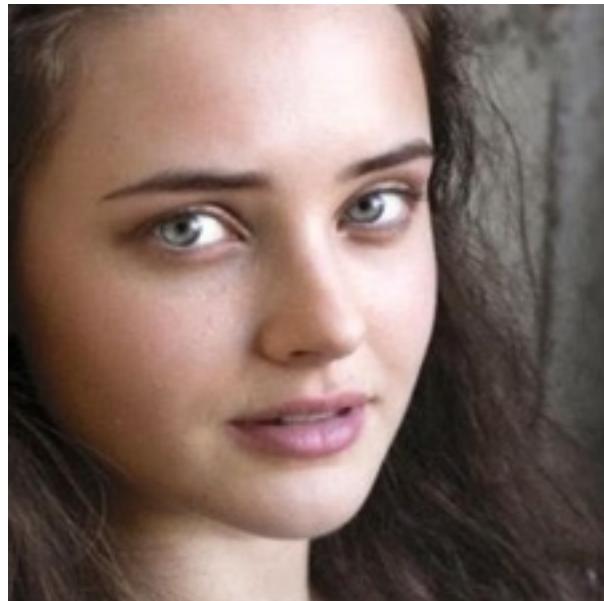
Actual = grant gustin Predicted = grant gustin



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



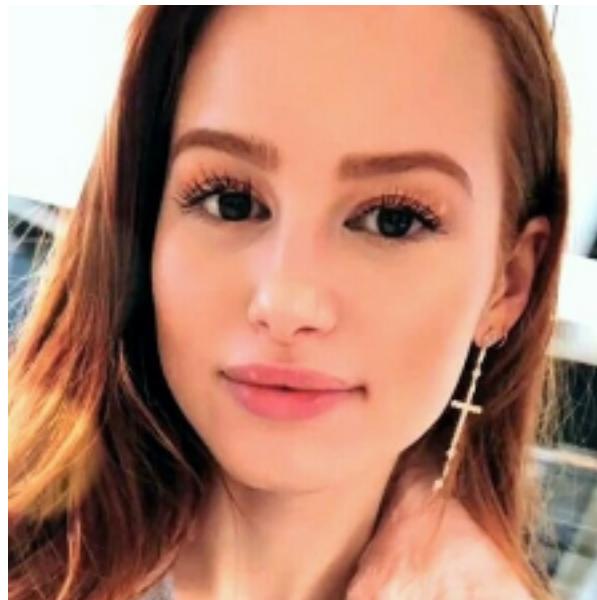
Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = Katherine Langford Predicted = Katherine Langford



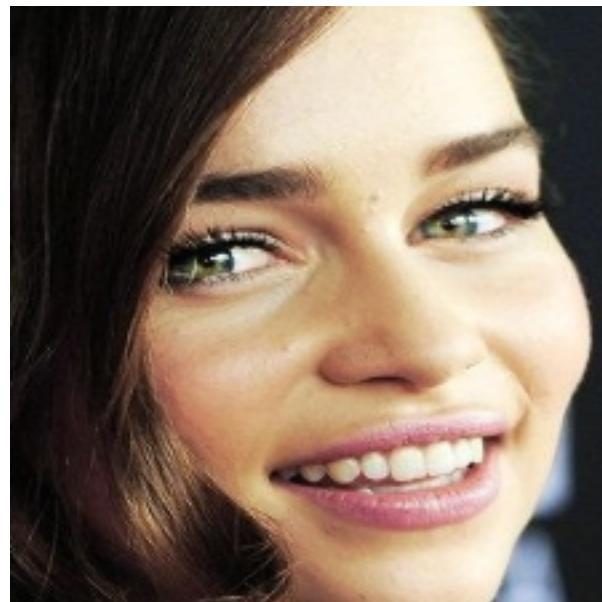
Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = Madelaine Petsch Predicted = Madelaine Petsch



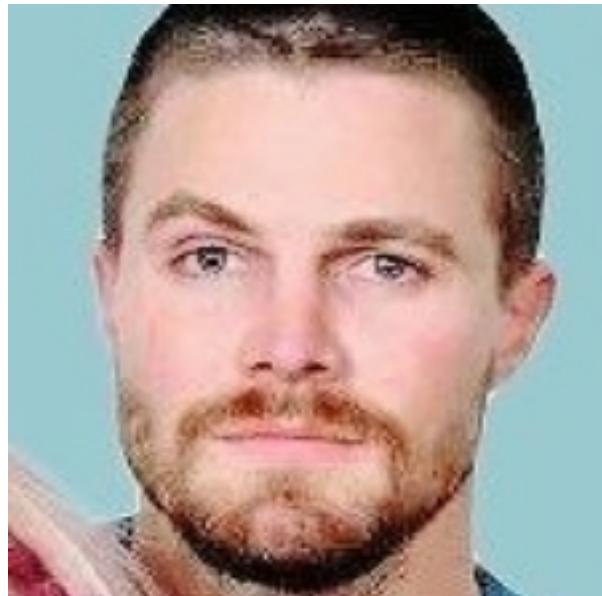
Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



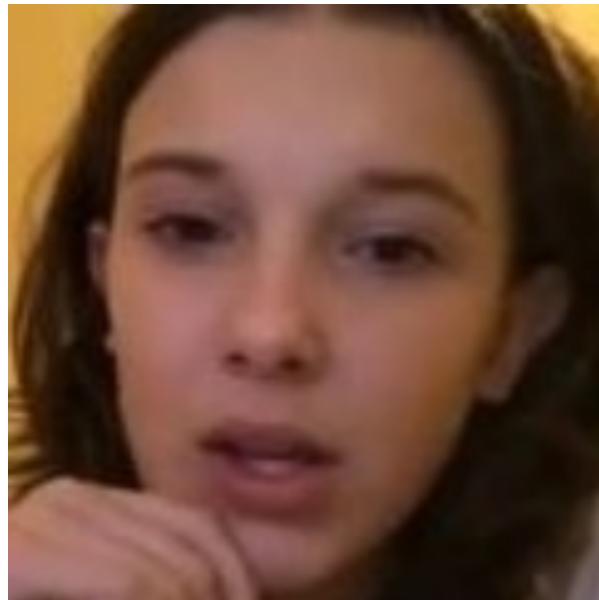
Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



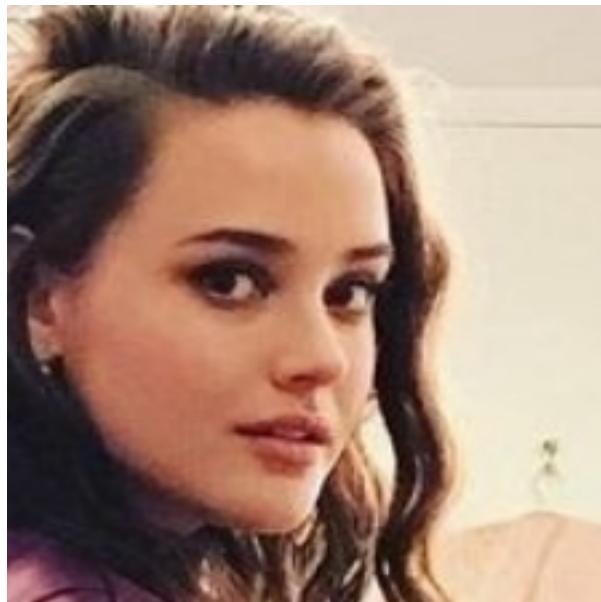
Actual = Stephen Amell Predicted = Stephen Amell



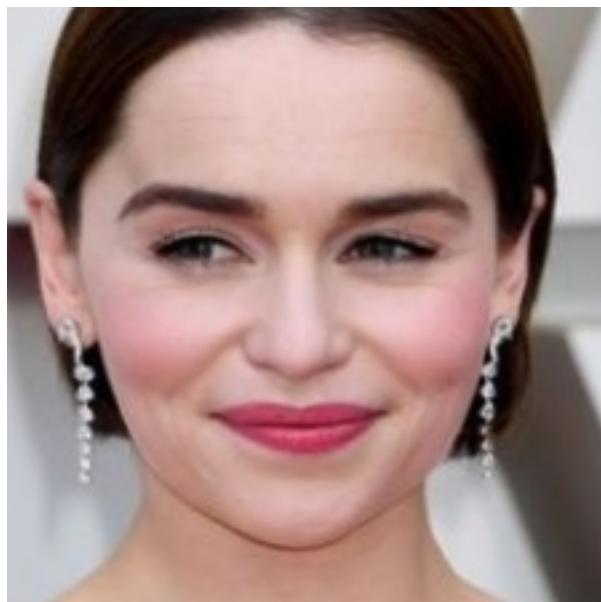
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Jeremy Renner Predicted = Jeremy Renner



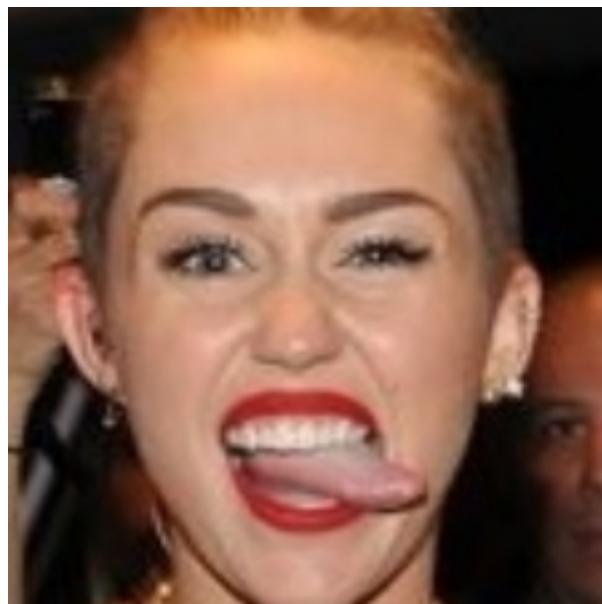
Actual = Katherine Langford Predicted = Katherine Langford



Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = Anne Hathaway Predicted = Anne Hathaway



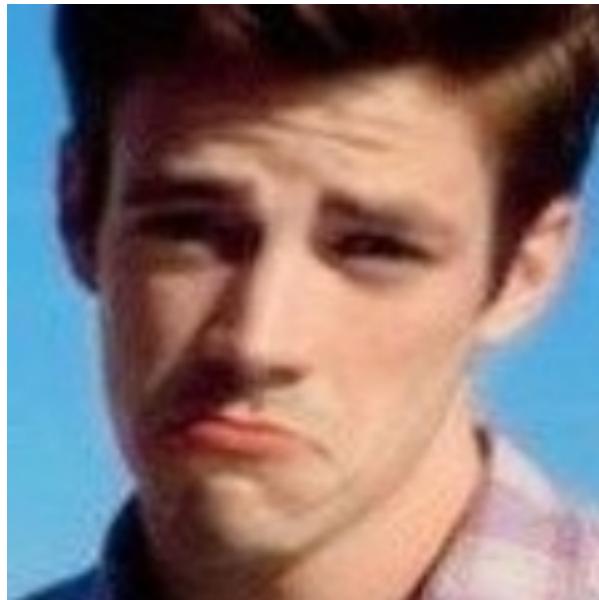
Actual = Krysten Ritter Predicted = Krysten Ritter



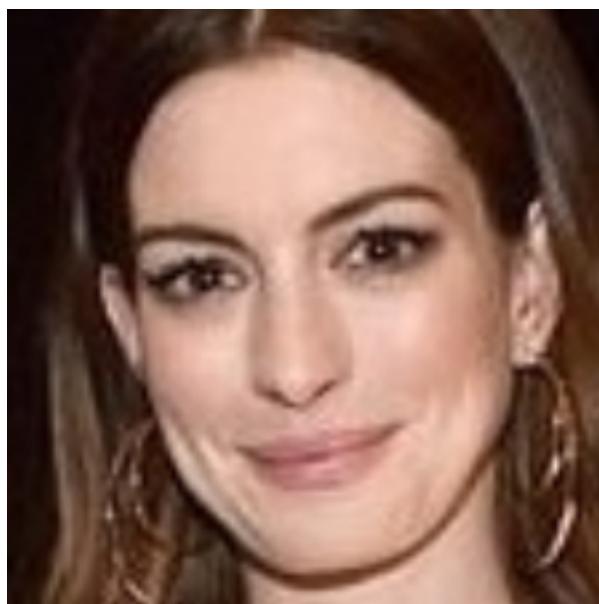
Actual = amber heard Predicted = Millie Bobby Brown



Actual = Katherine Langford Predicted = Katherine Langford



Actual = grant gustin Predicted = grant gustin



Actual = Anne Hathaway Predicted = Anne Hathaway



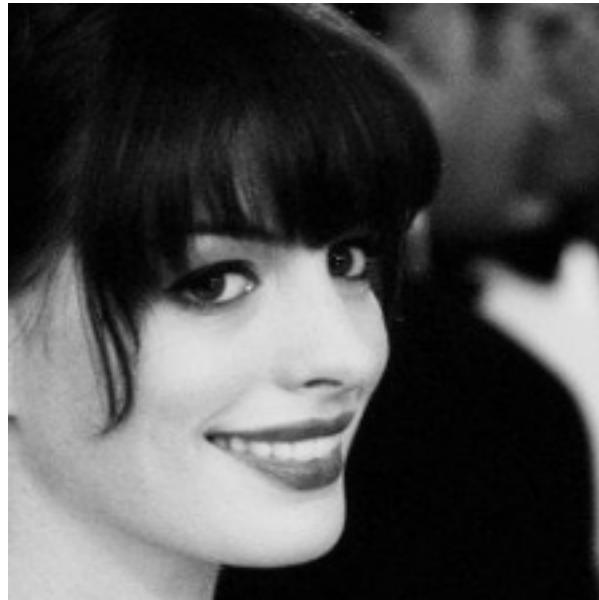
Actual = Alexandra Daddario Predicted = Alexandra Daddario



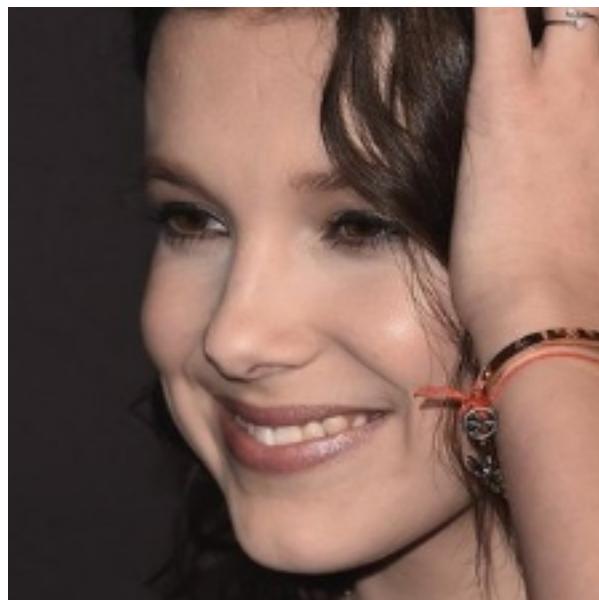
Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = Bill Gates Predicted = Bill Gates



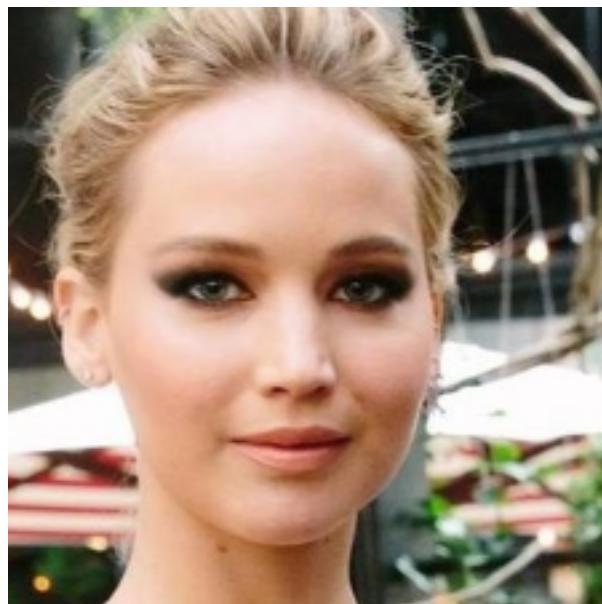
Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



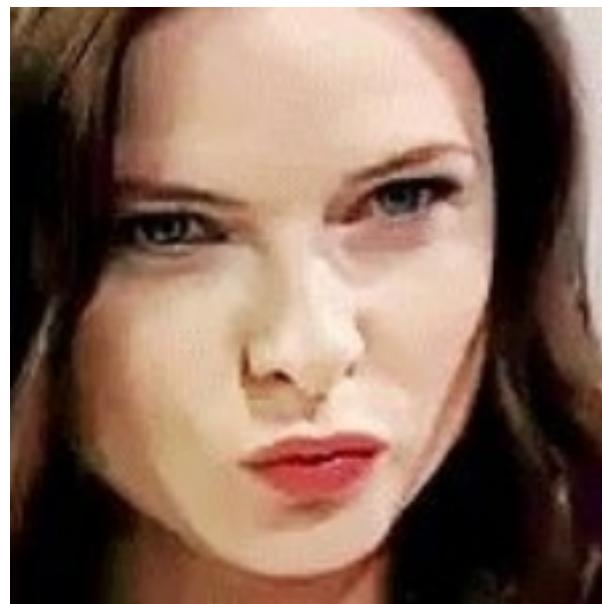
Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Miley Cyrus Predicted = Miley Cyrus



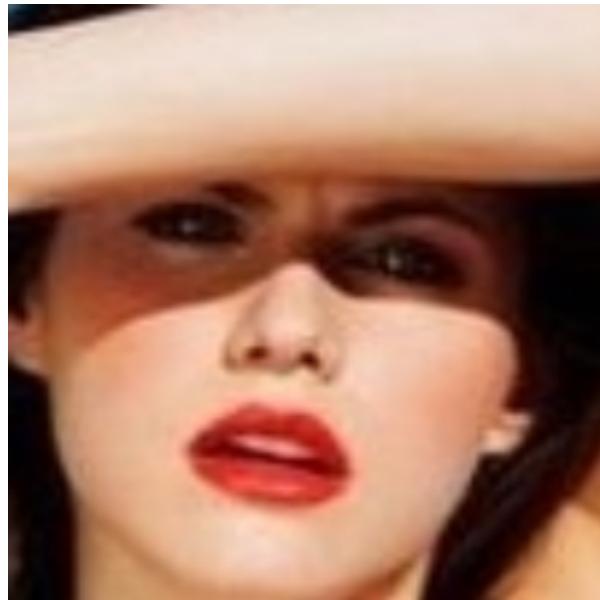
Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Alexandra Daddario Predicted = Millie Bobby Brown



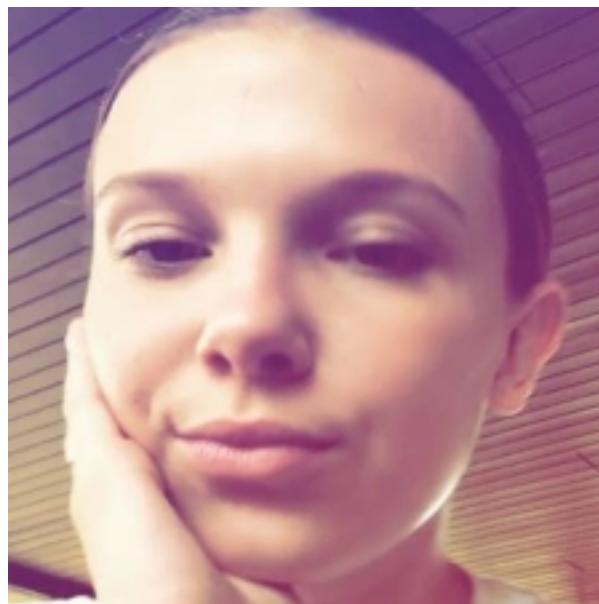
Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = amber heard Predicted = amber heard



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Zoe Saldana Predicted = Zoe Saldana



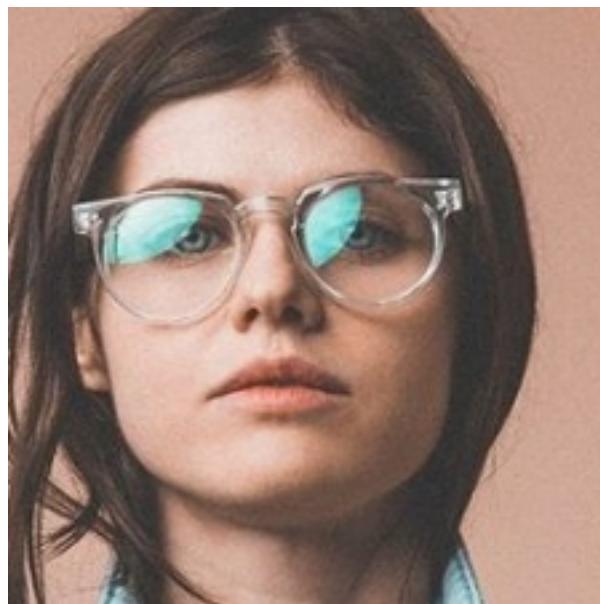
Actual = Stephen Amell Predicted = Stephen Amell



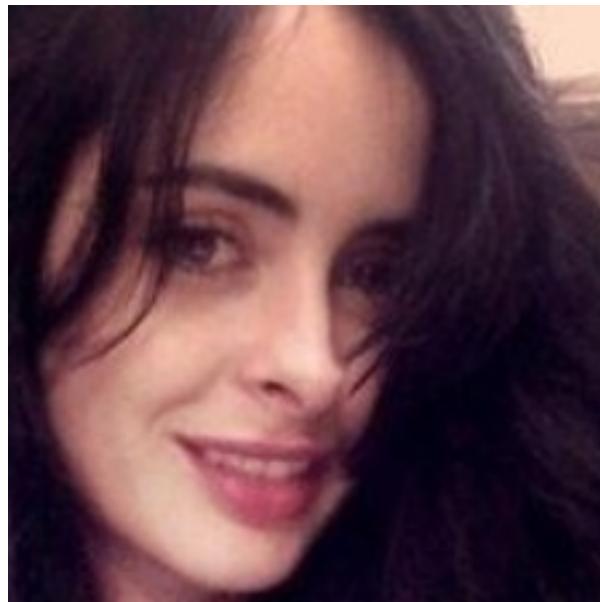
Actual = Bill Gates Predicted = Bill Gates



Actual = Taylor Swift Predicted = Taylor Swift



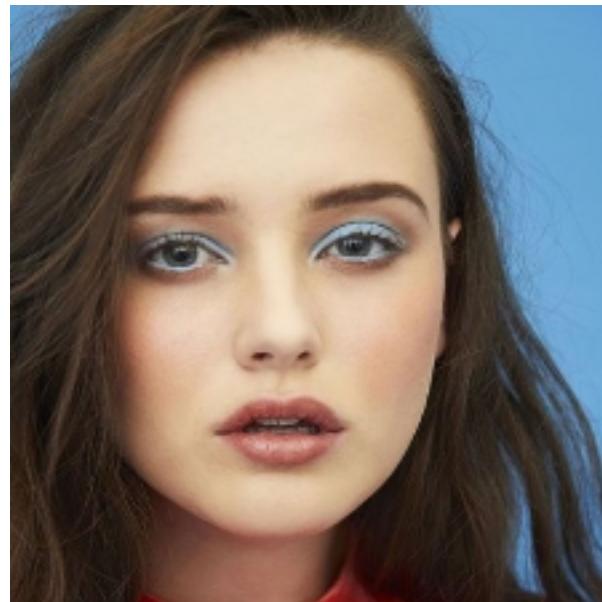
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Miley Cyrus Predicted = Miley Cyrus



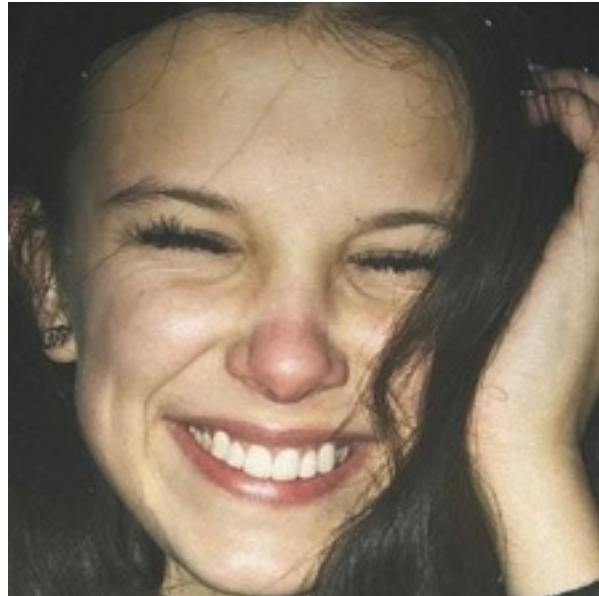
Actual = Katherine Langford Predicted = Katherine Langford



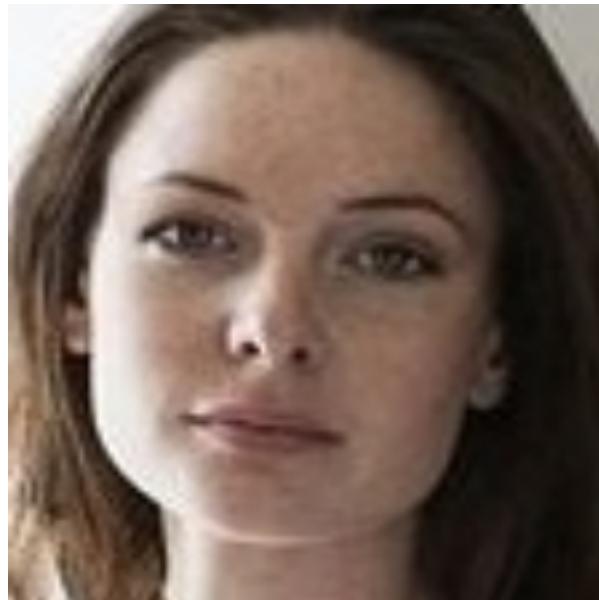
Actual = amber heard Predicted = amber heard



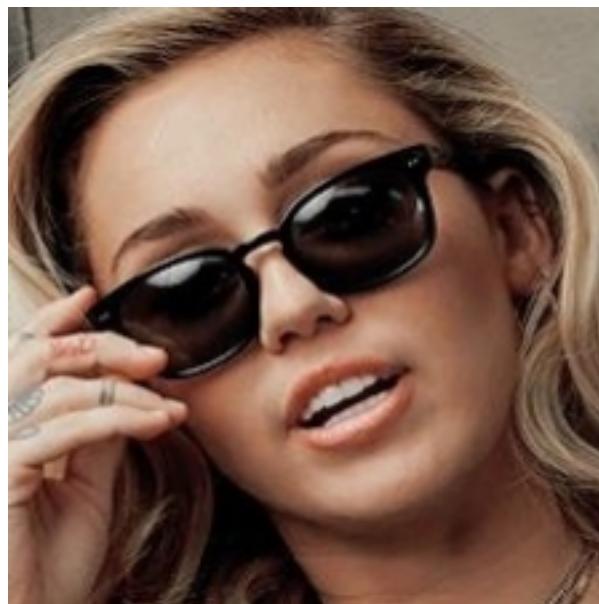
Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



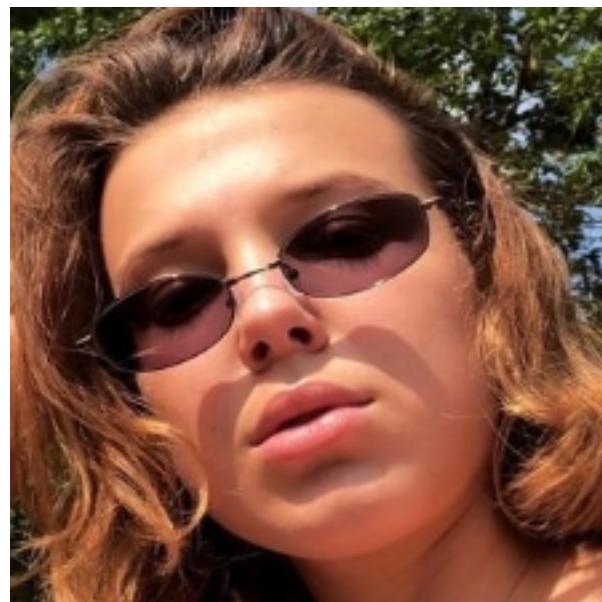
Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



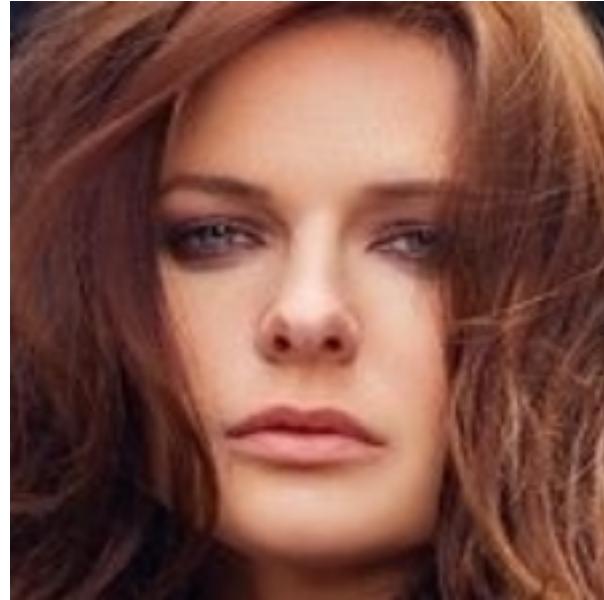
Actual = Miley Cyrus Predicted = Millie Bobby Brown



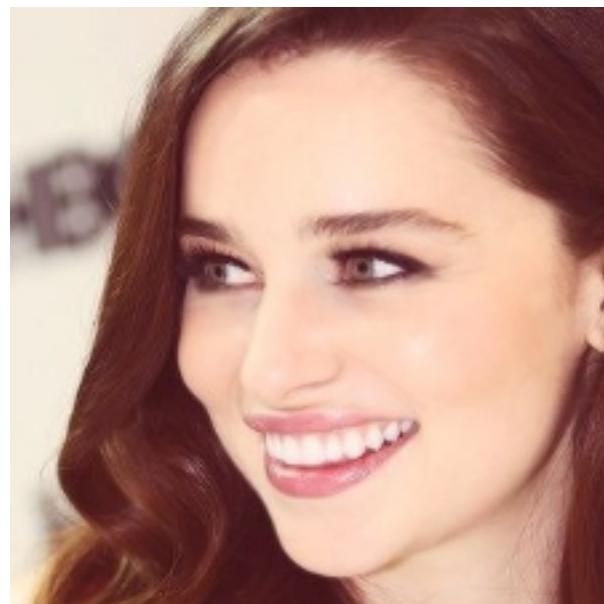
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



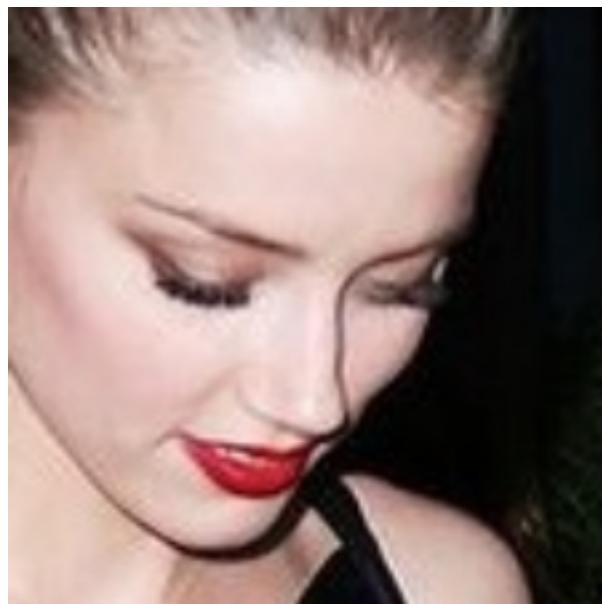
Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Emilia Clarke Predicted = Emilia Clarke



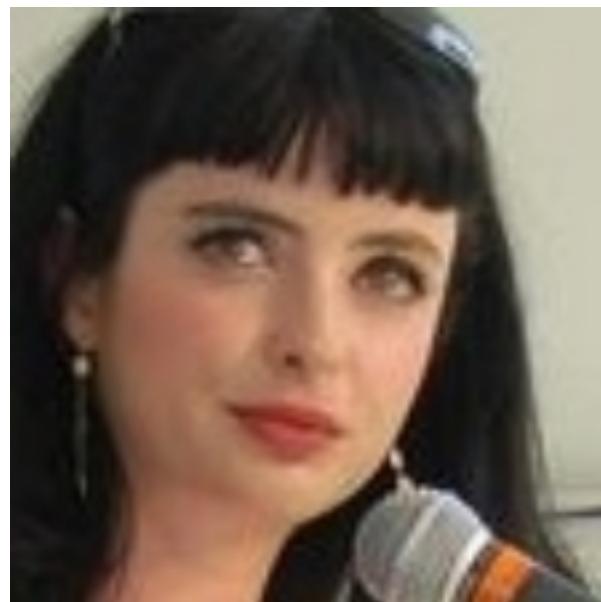
Actual = Madelaine Petsch Predicted = Madelaine Petsch



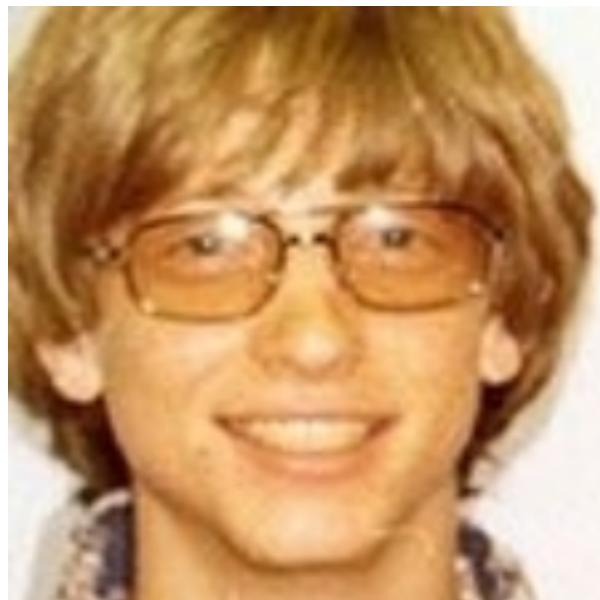
Actual = amber heard Predicted = amber heard



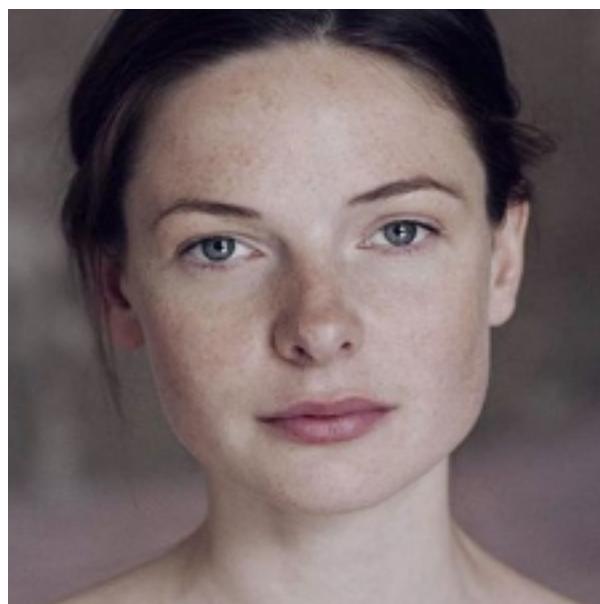
Actual = amber heard Predicted = amber heard



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Bill Gates Predicted = Bill Gates



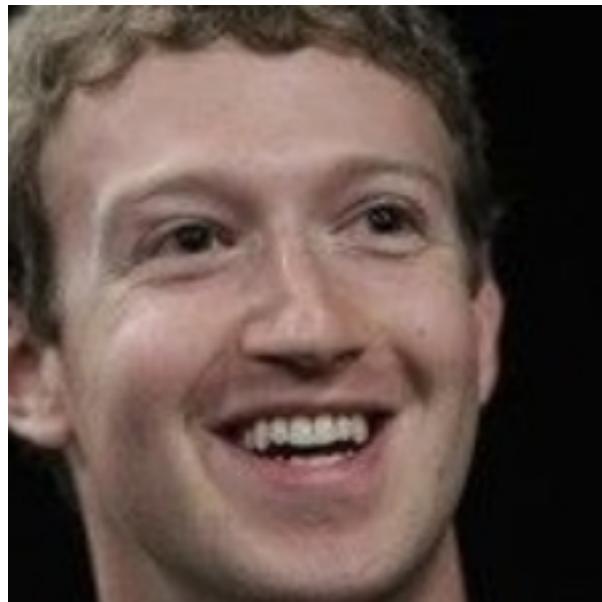
Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Brenton Thwaites Predicted = Brenton Thwaites



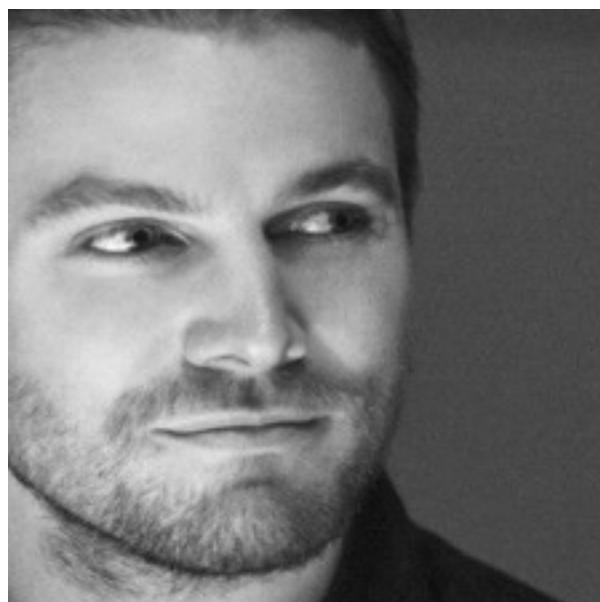
Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



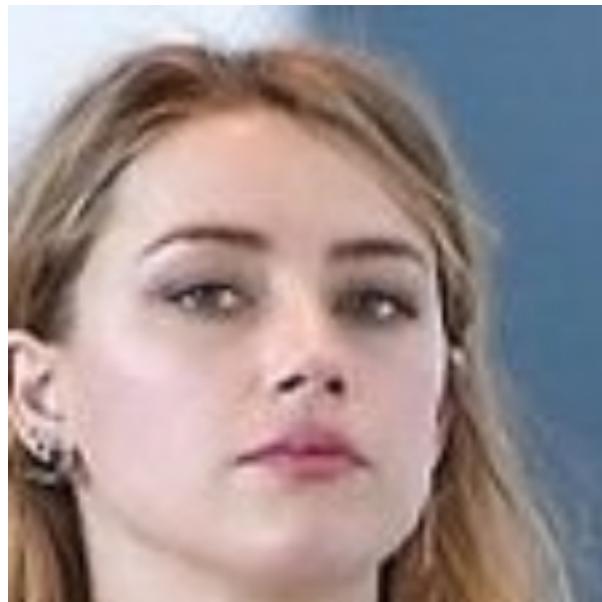
Actual = Jeremy Renner Predicted = Jeremy Renner



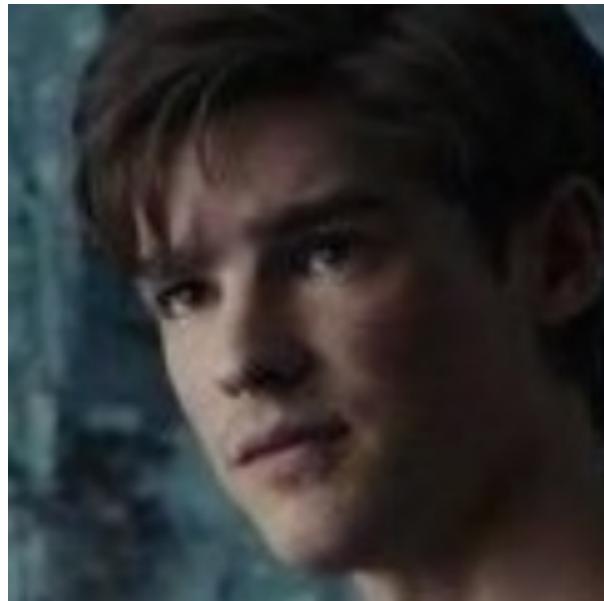
Actual = Stephen Amell Predicted = Stephen Amell



Actual = Jeremy Renner Predicted = Jeremy Renner



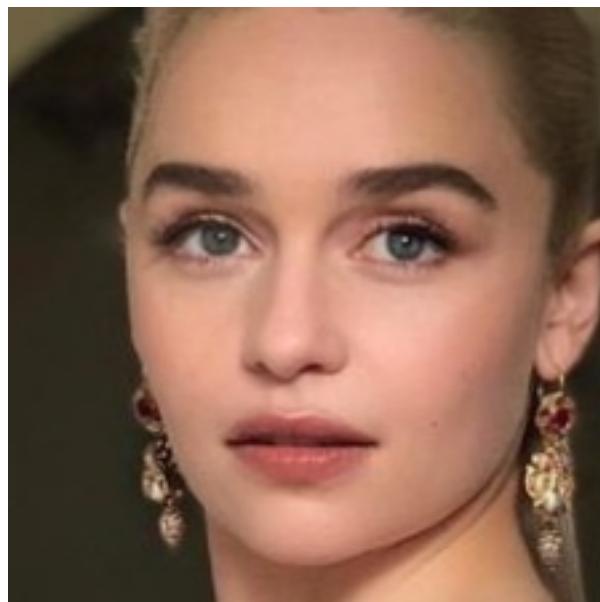
Actual = amber heard Predicted = amber heard



Actual = Brenton Thwaites Predicted = Brenton Thwaites



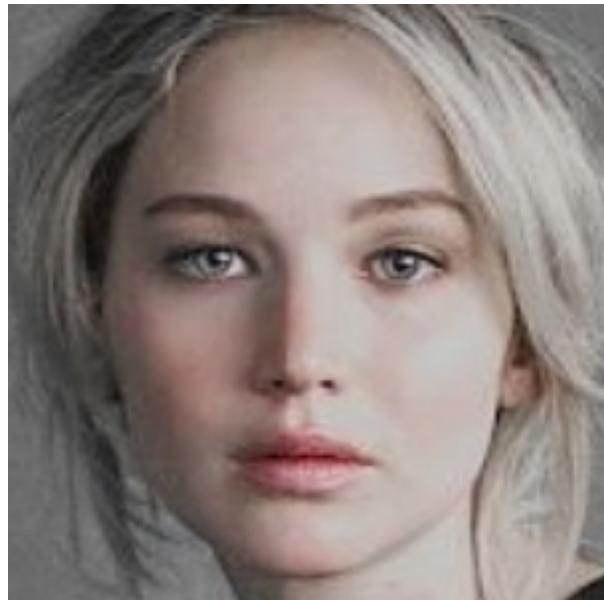
Actual = grant gustin Predicted = grant gustin



Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Taylor Swift Predicted = Taylor Swift



Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Stephen Amell Predicted = Stephen Amell



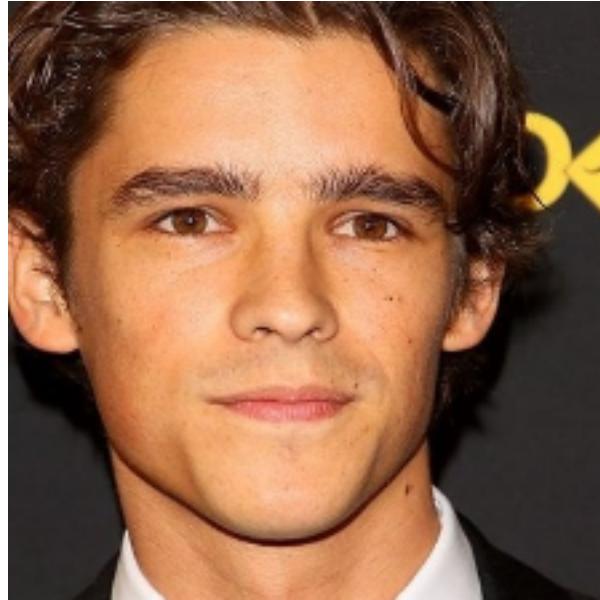
Actual = Emilia Clarke Predicted = Emilia Clarke



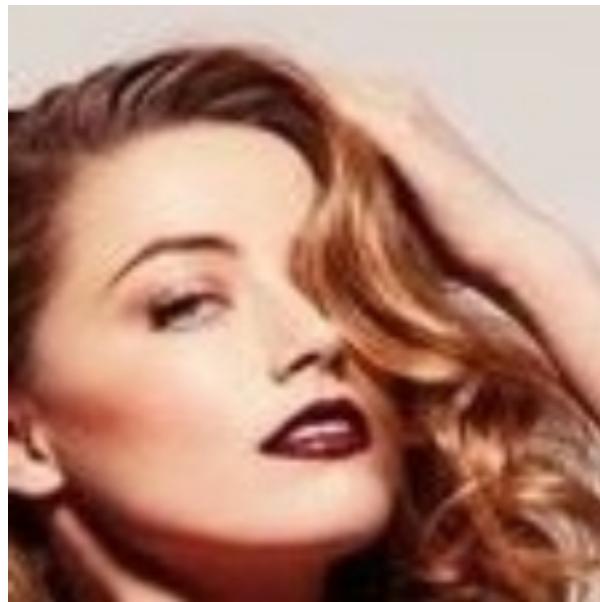
Actual = Jeremy Renner Predicted = grant gustin



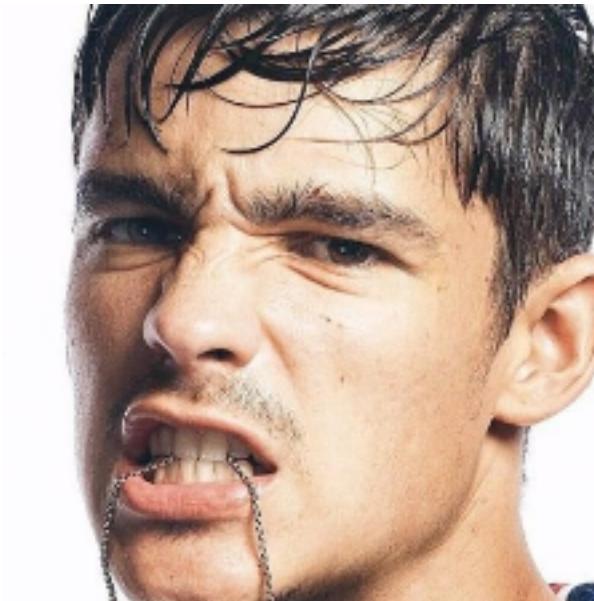
Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = amber heard Predicted = Taylor Swift



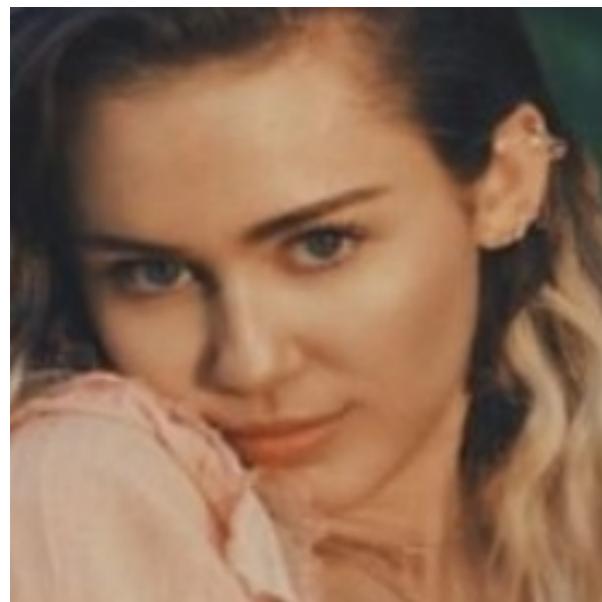
Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



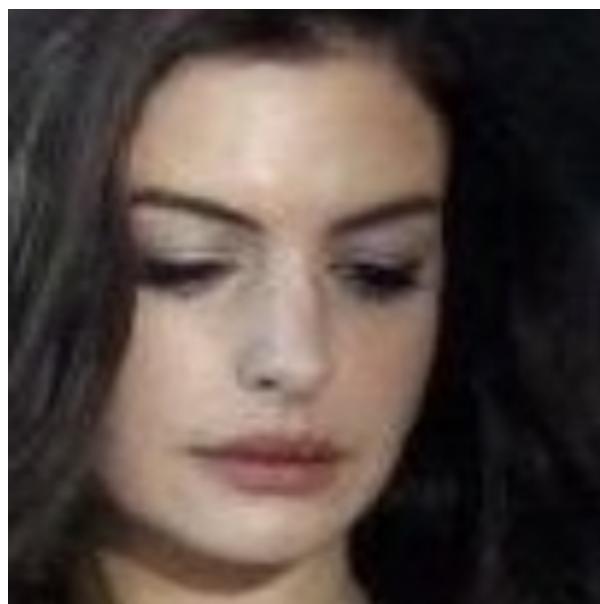
Actual = Stephen Amell Predicted = Stephen Amell



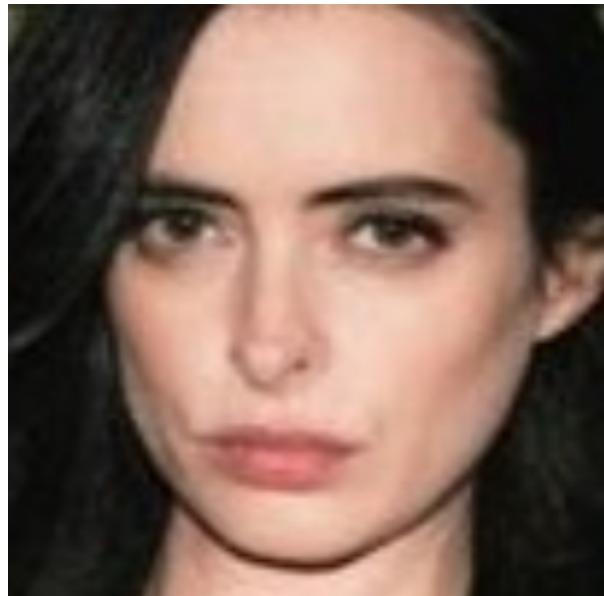
Actual = Miley Cyrus Predicted = Miley Cyrus



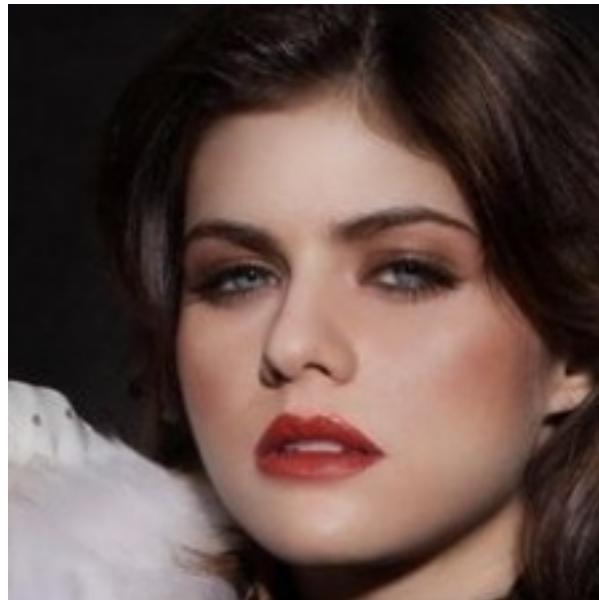
Actual = Bill Gates Predicted = Bill Gates



Actual = Anne Hathaway Predicted = Krysten Ritter



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Alexandra Daddario Predicted = Alexandra Daddario



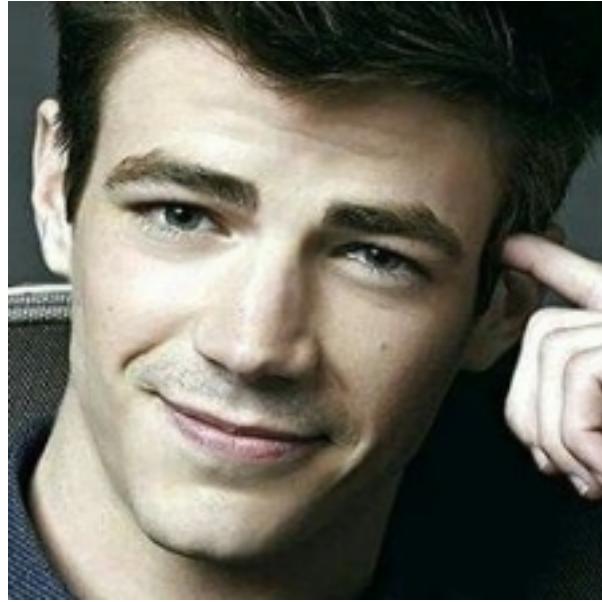
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Jeremy Renner Predicted = Millie Bobby Brown



Actual = amber heard Predicted = amber heard



Actual = grant gustin Predicted = grant gustin



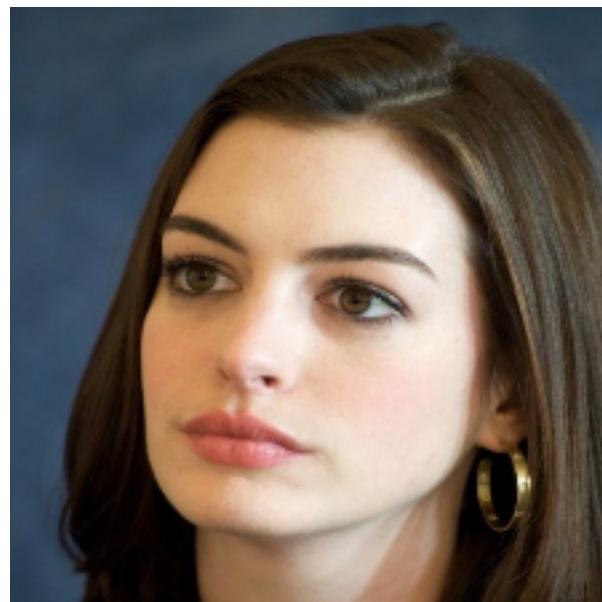
Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = amber heard Predicted = amber heard



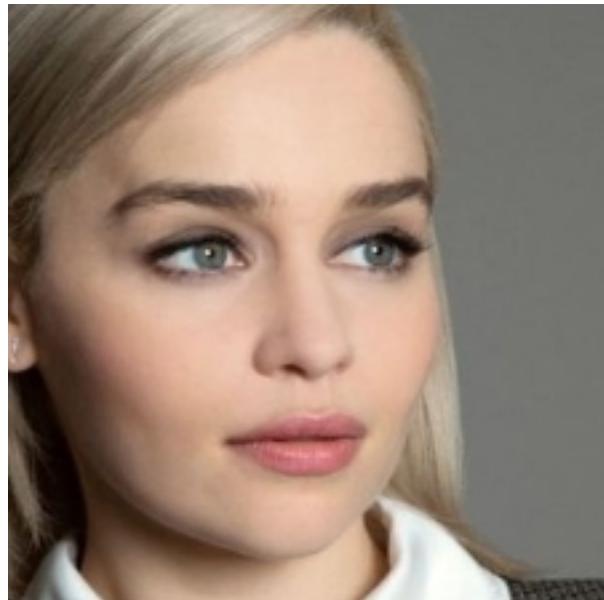
Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



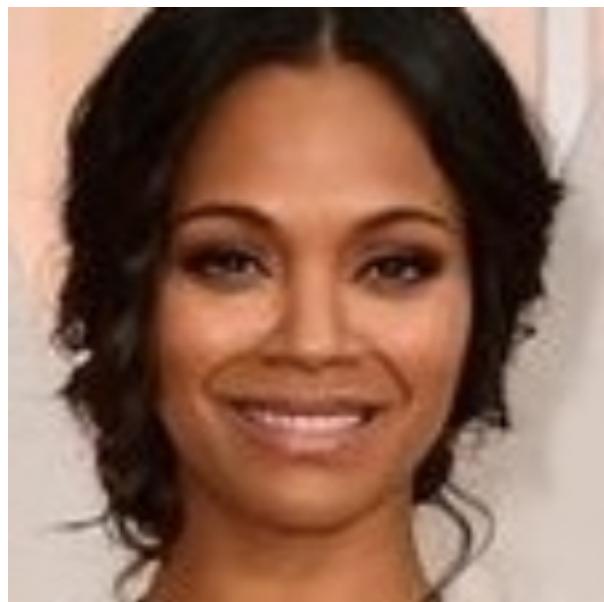
Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Zoe Saldana Predicted = Zoe Saldana



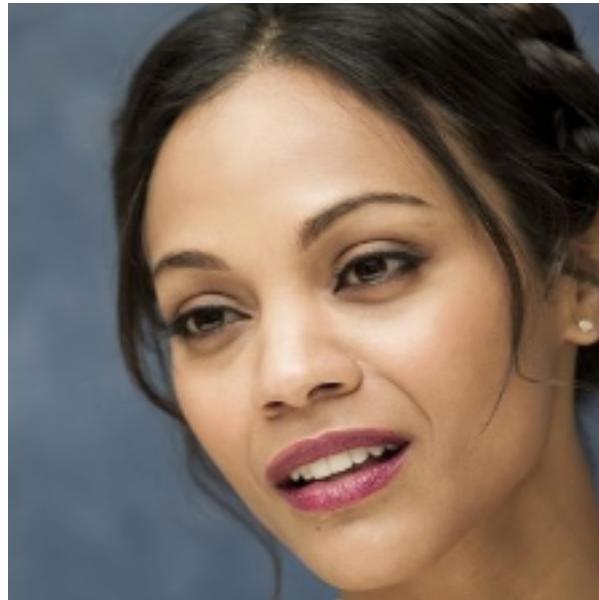
Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



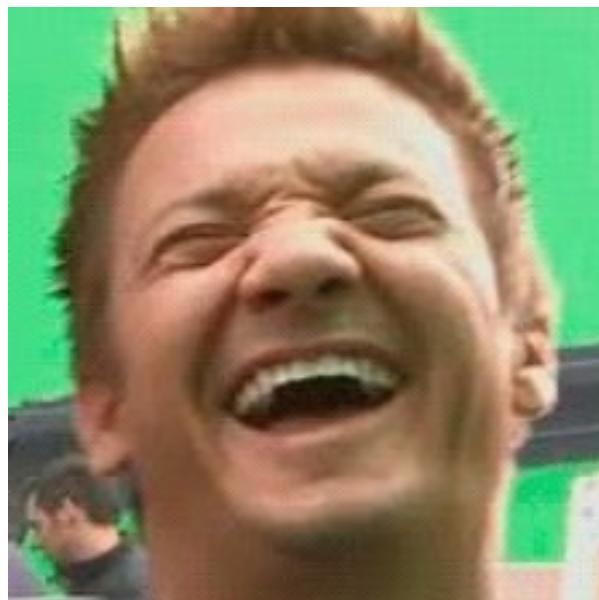
Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Jeremy Renner Predicted = Millie Bobby Brown



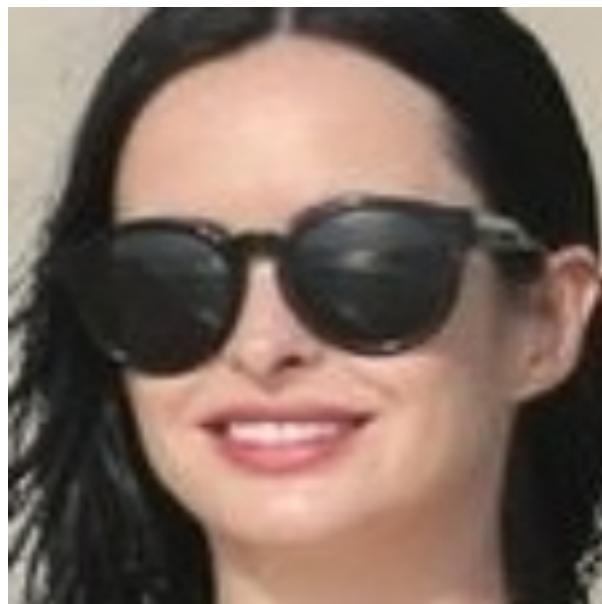
Actual = amber heard Predicted = amber heard



Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Jeremy Renner Predicted = Jeremy Renner



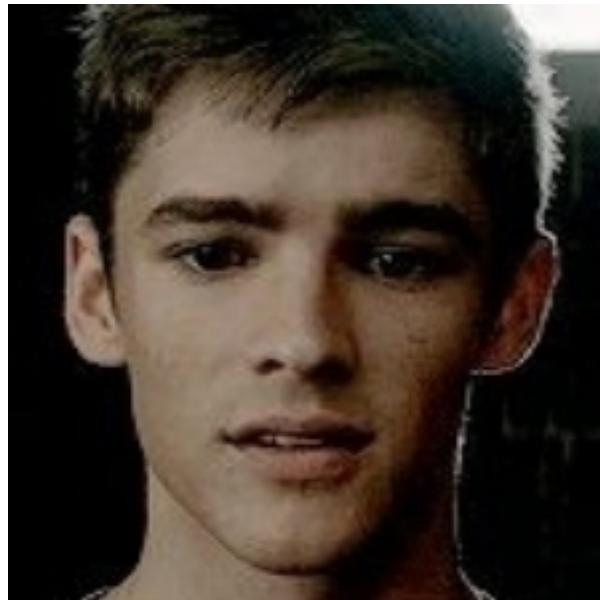
Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = amber heard Predicted = amber heard



Actual = Stephen Amell Predicted = Stephen Amell



Actual = Brenton Thwaites Predicted = Brenton Thwaites



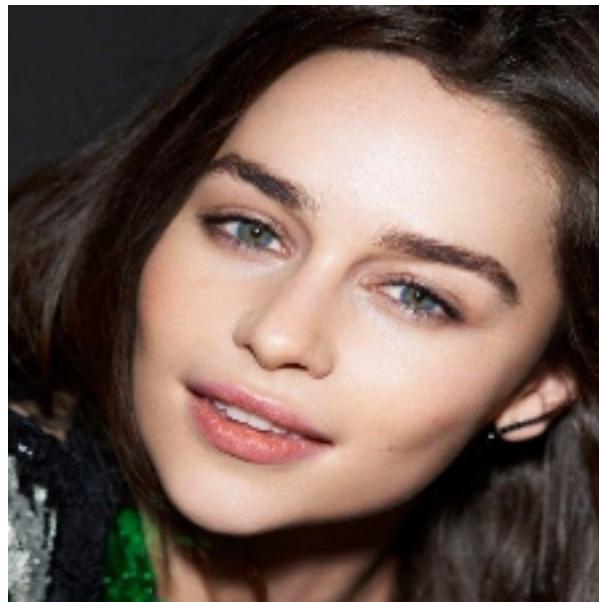
Actual = Zoe Saldana Predicted = Zoe Saldana



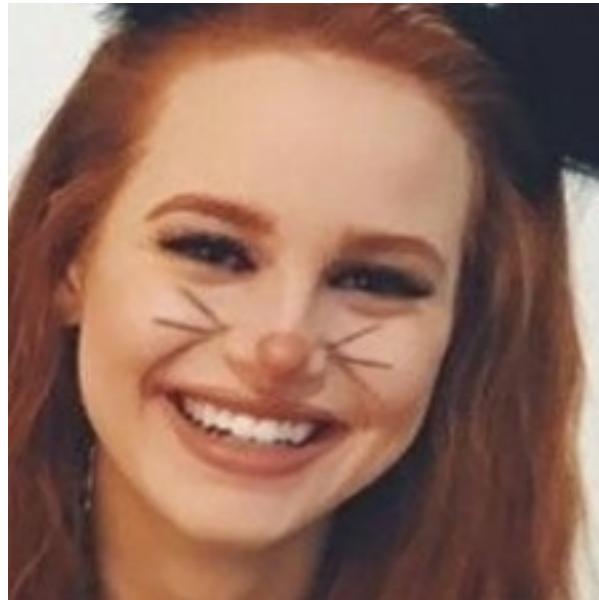
Actual = Stephen Amell Predicted = Stephen Amell



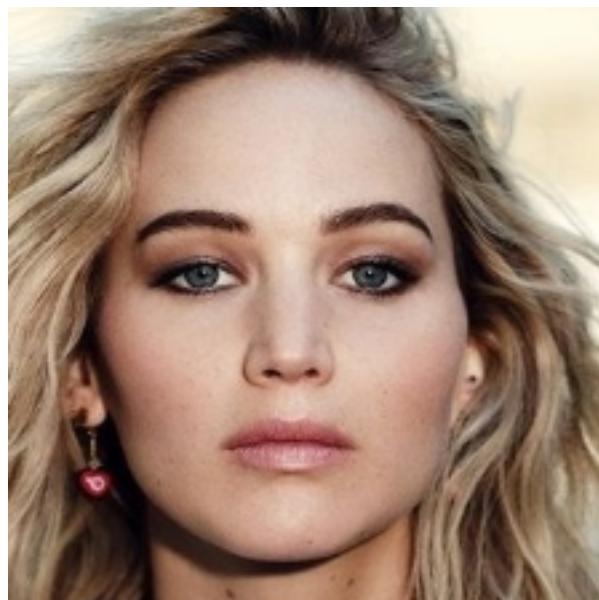
Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Emilia Clarke Predicted = Katherine Langford



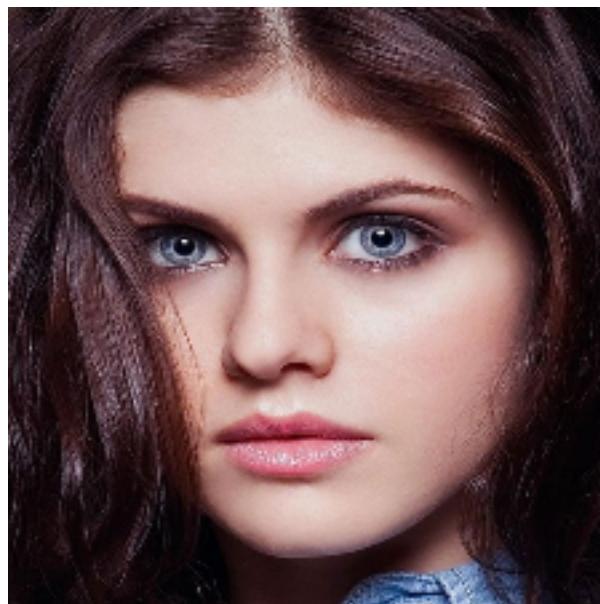
Actual = Madelaine Petsch Predicted = Madelaine Petsch



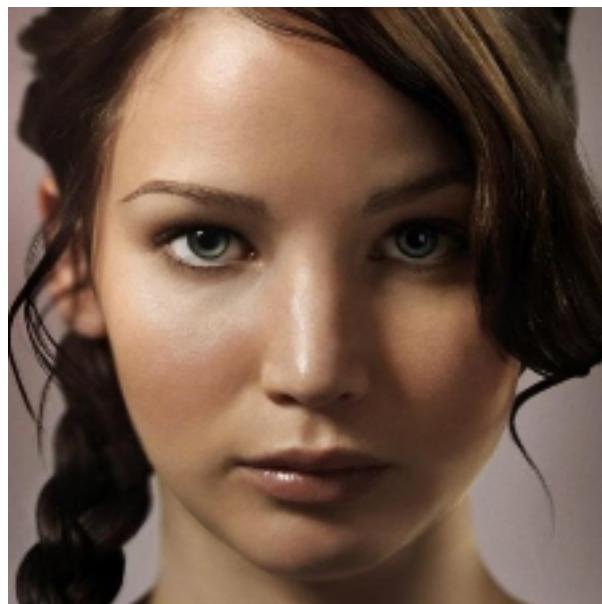
Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Taylor Swift Predicted = Emilia Clarke



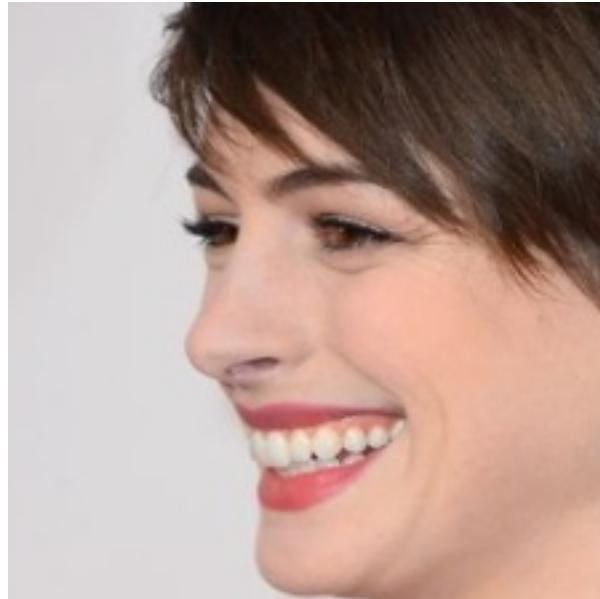
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Anne Hathaway Predicted = Krysten Ritter



Actual = Bill Gates Predicted = Bill Gates



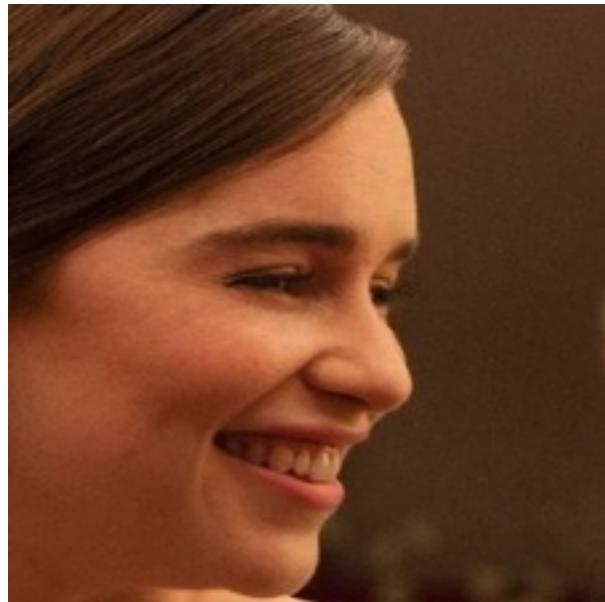
Actual = grant gustin Predicted = grant gustin



Actual = Krysten Ritter Predicted = Krysten Ritter



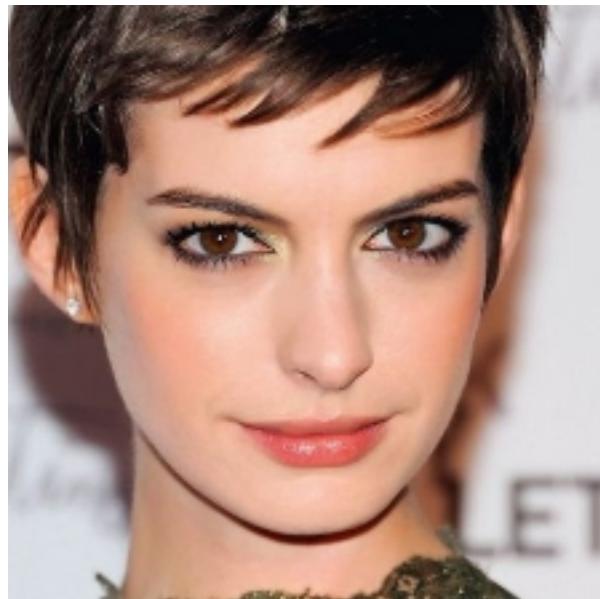
Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Emilia Clarke Predicted = Emilia Clarke



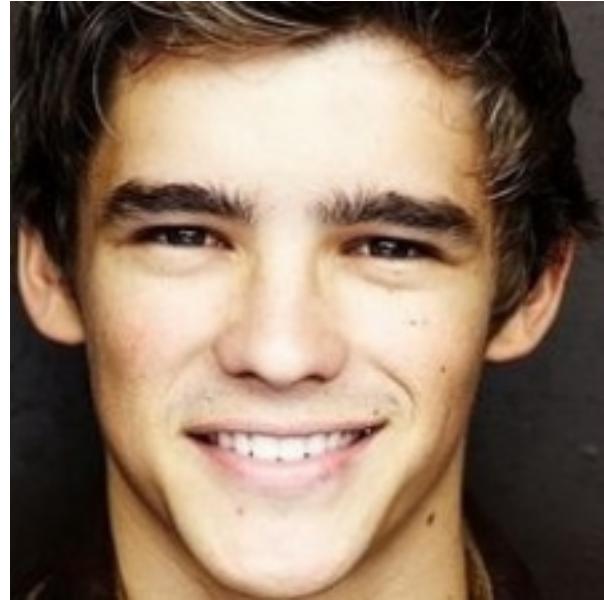
Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = Anne Hathaway Predicted = Krysten Ritter



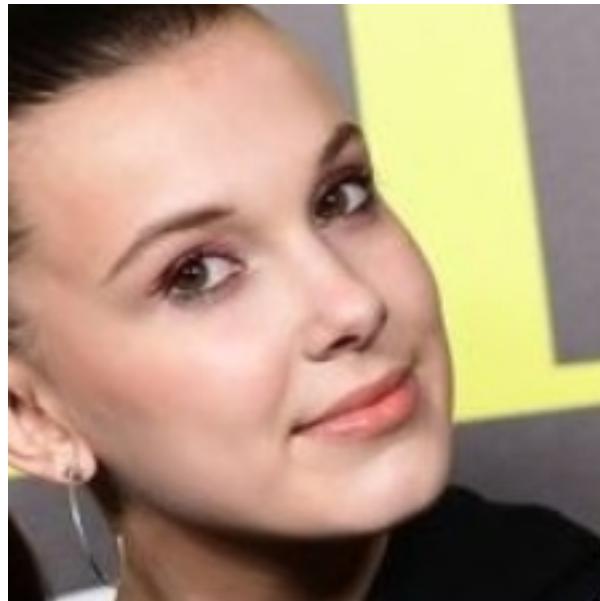
Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



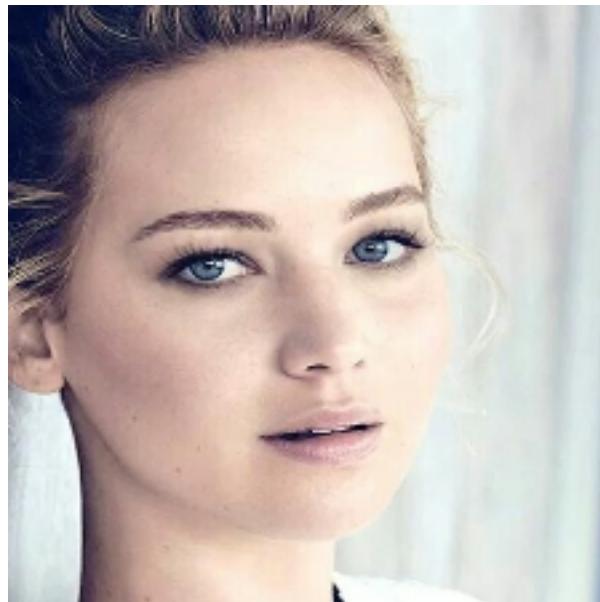
Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = amber heard Predicted = amber heard



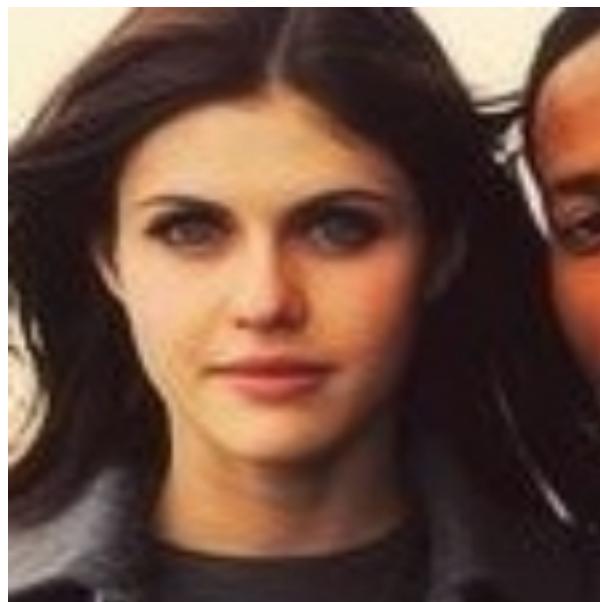
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Katherine Langford Predicted = Katherine Langford



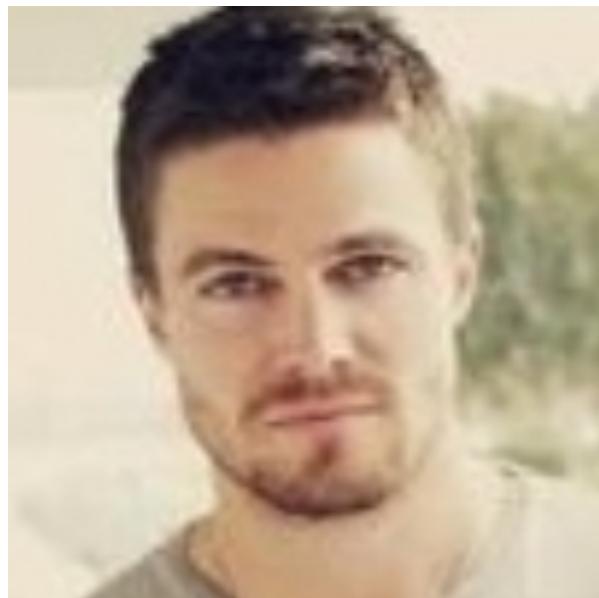
Actual = Alexandra Daddario Predicted = Alexandra Daddario



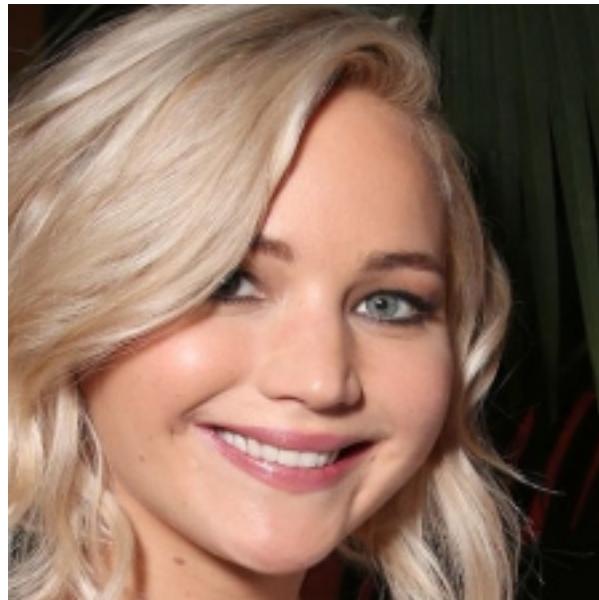
Actual = Stephen Amell Predicted = Stephen Amell



Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



Actual = Stephen Amell Predicted = Stephen Amell



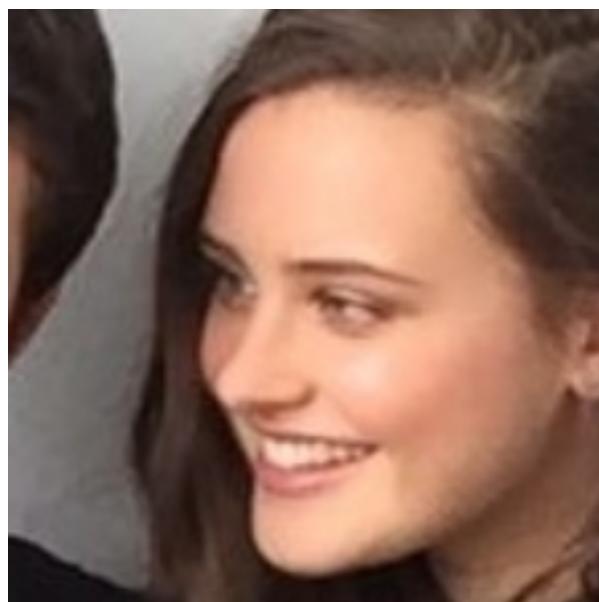
Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Taylor Swift Predicted = Taylor Swift



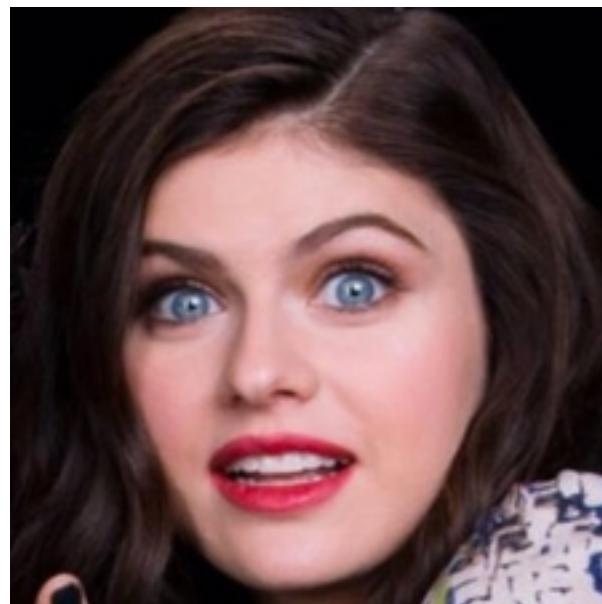
Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Katherine Langford Predicted = Katherine Langford



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



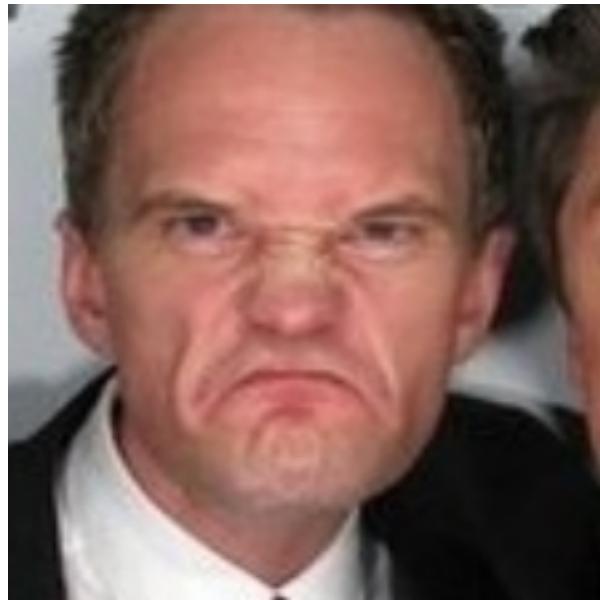
Actual = Brenton Thwaites Predicted = Brenton Thwaites



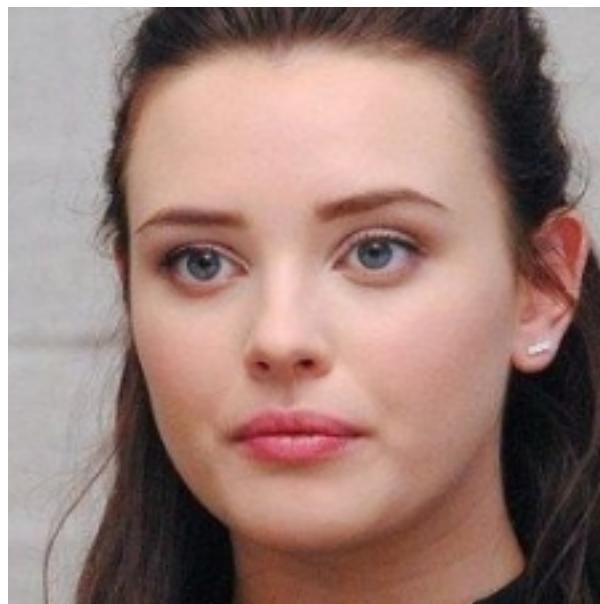
Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



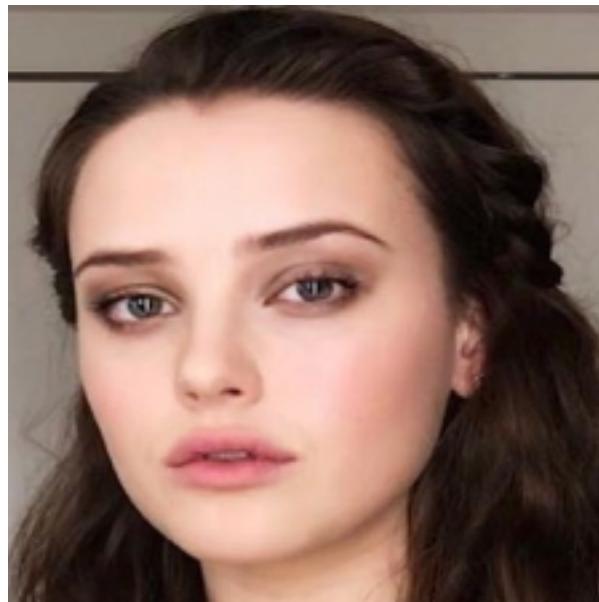
Actual = Katherine Langford Predicted = Katherine Langford



Actual = Bill Gates Predicted = Bill Gates



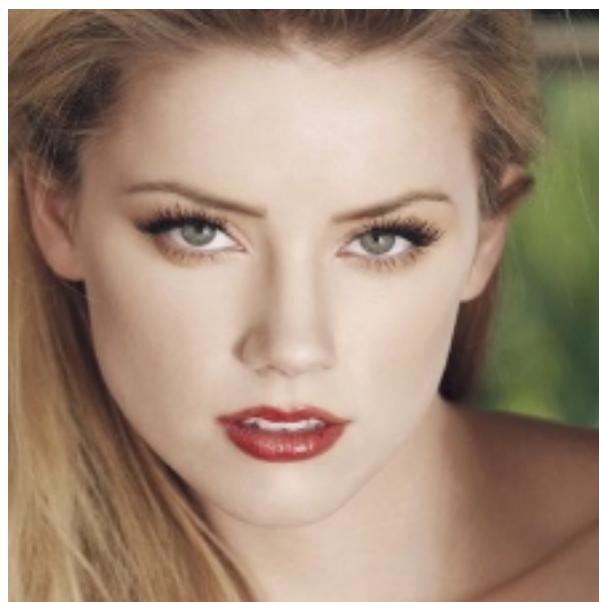
Actual = Mark Zuckerberg Predicted = Millie Bobby Brown



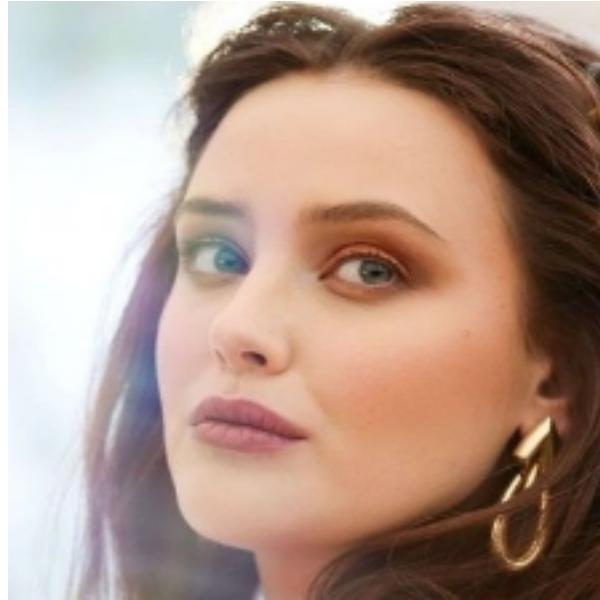
Actual = Katherine Langford Predicted = Katherine Langford



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = amber heard Predicted = amber heard



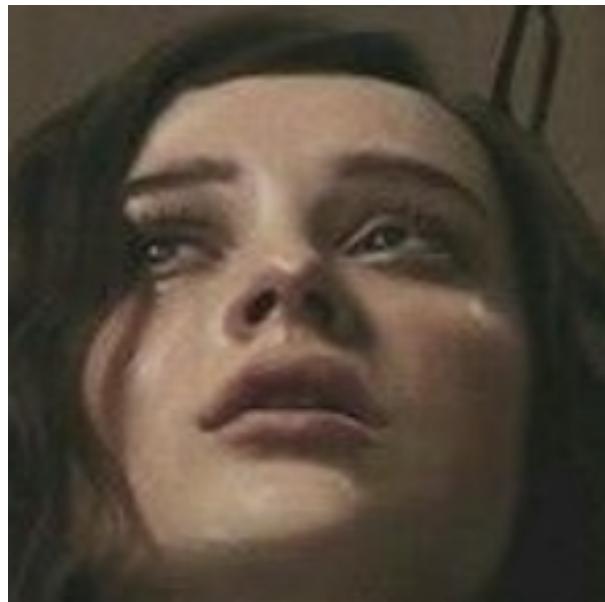
Actual = Katherine Langford Predicted = Katherine Langford



Actual = Jennifer Lawrence Predicted = Miley Cyrus



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Katherine Langford Predicted = Emilia Clarke



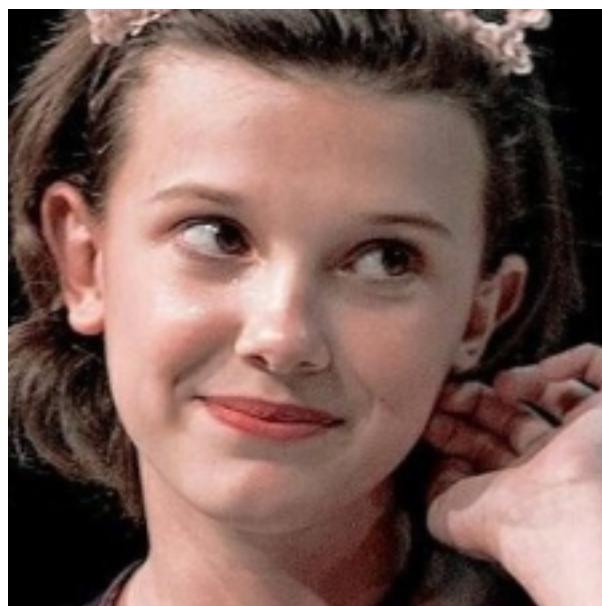
Actual = Miley Cyrus Predicted = Miley Cyrus



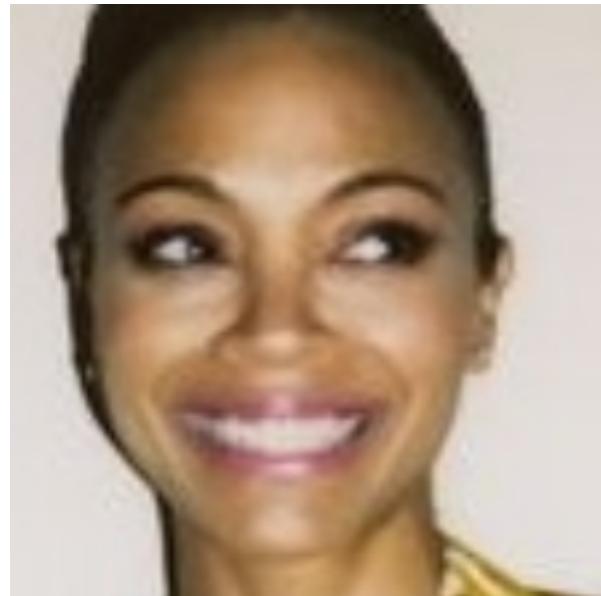
Actual = grant gustin Predicted = grant gustin



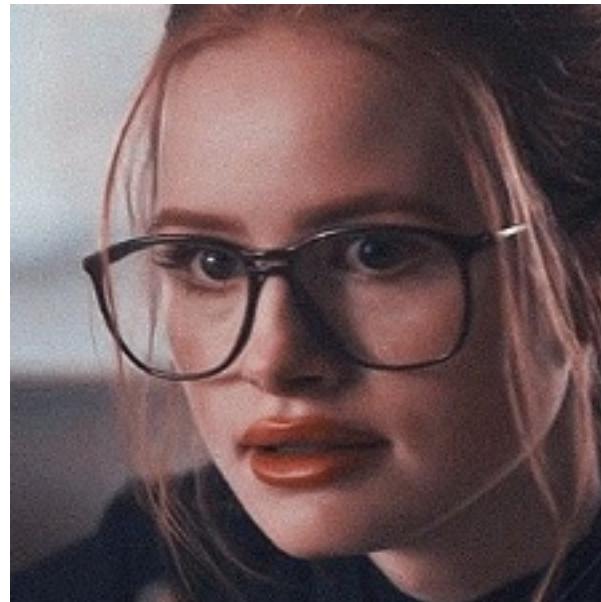
Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



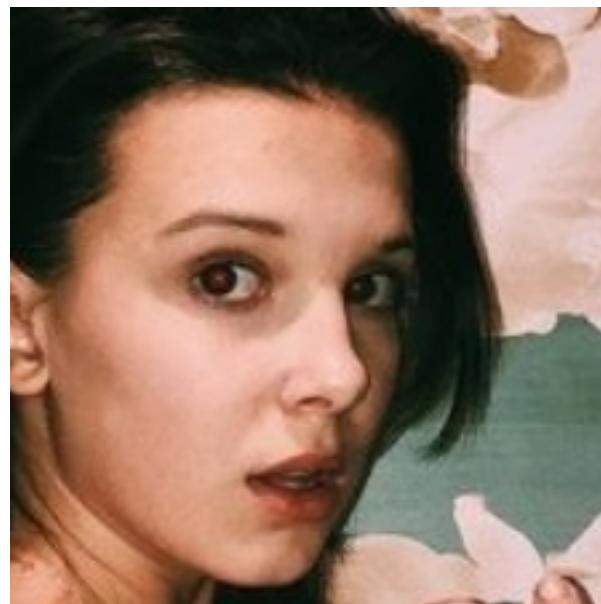
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Zoe Saldana Predicted = Zoe Saldana



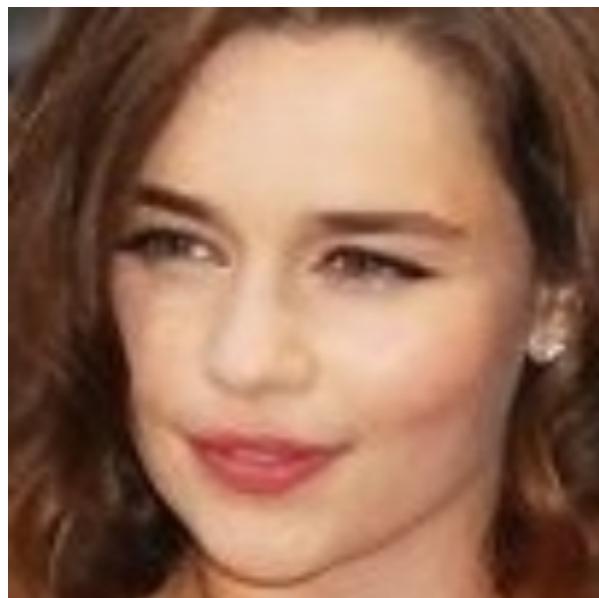
Actual = Madelaine Petsch Predicted = Millie Bobby Brown



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Emilia Clarke Predicted = Emilia Clarke



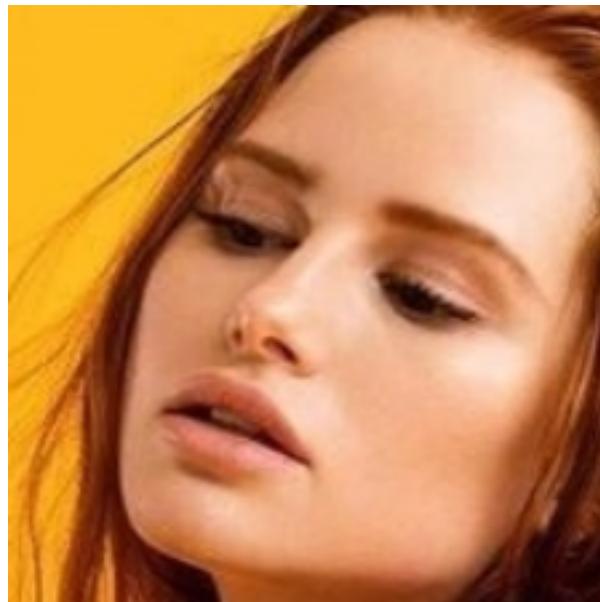
Actual = Miley Cyrus Predicted = Taylor Swift



Actual = Taylor Swift Predicted = Taylor Swift



Actual = Alexandra Daddario Predicted = Alexandra Daddario



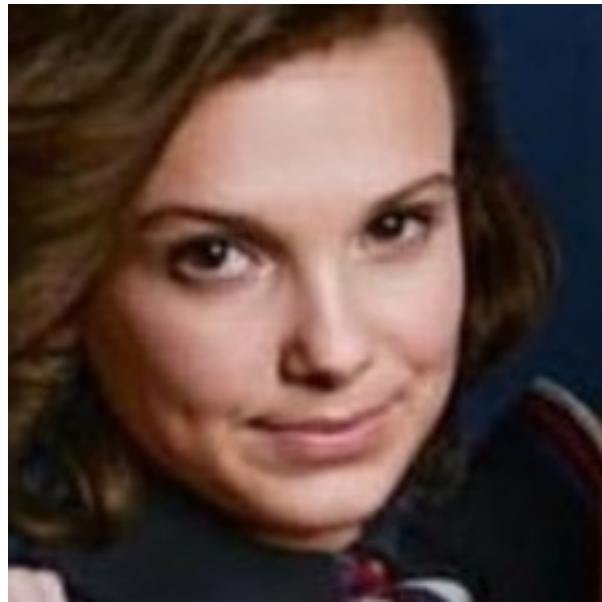
Actual = Madelaine Petsch Predicted = Madelaine Petsch



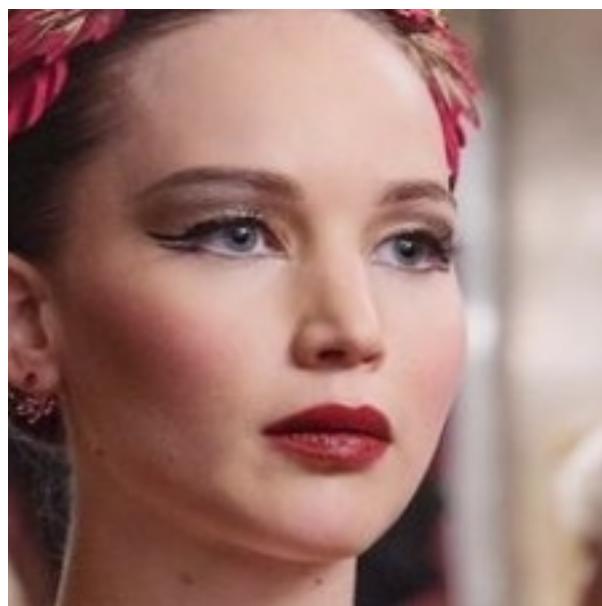
Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Jennifer Lawrence Predicted = Millie Bobby Brown



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = amber heard Predicted = amber heard



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



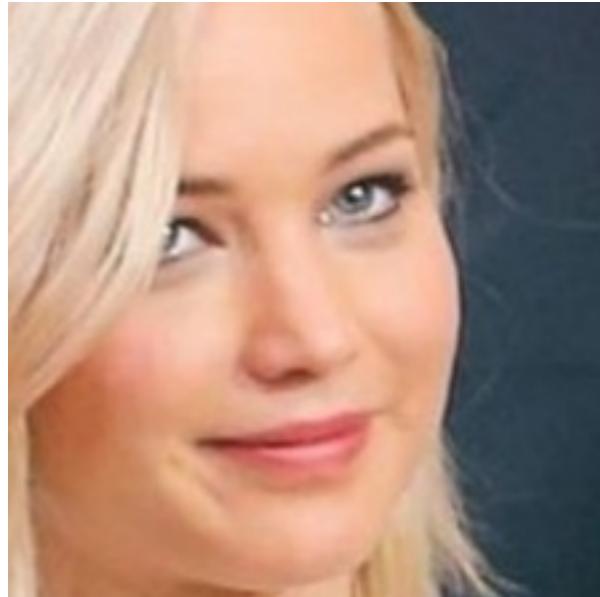
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Stephen Amell Predicted = Stephen Amell



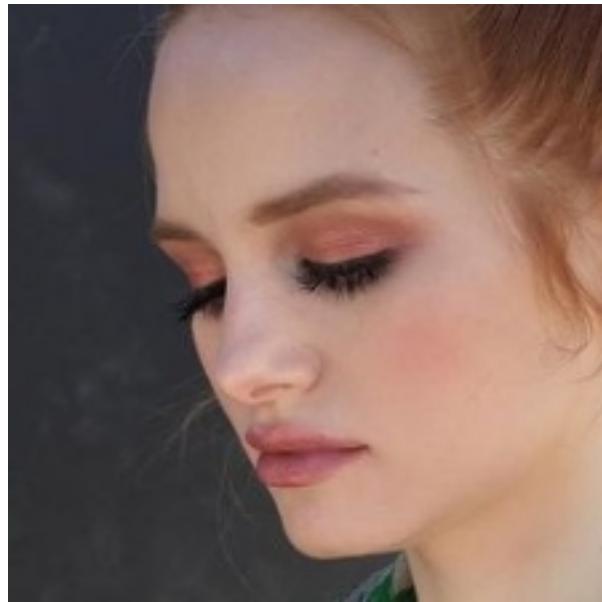
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



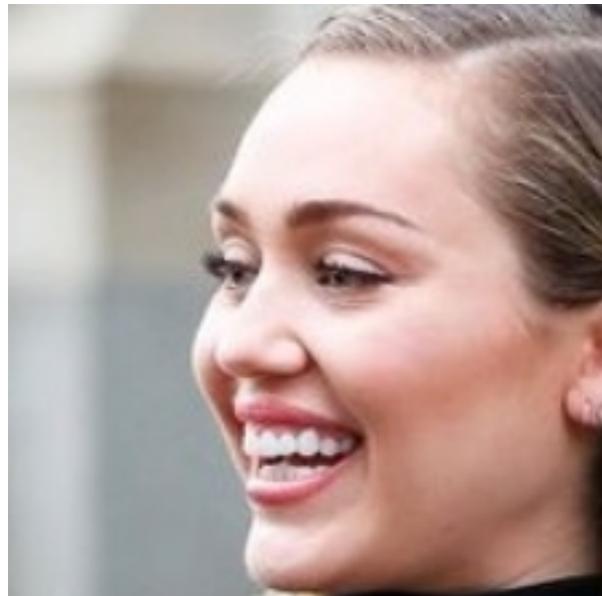
Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Madelaine Petsch Predicted = Madelaine Petsch



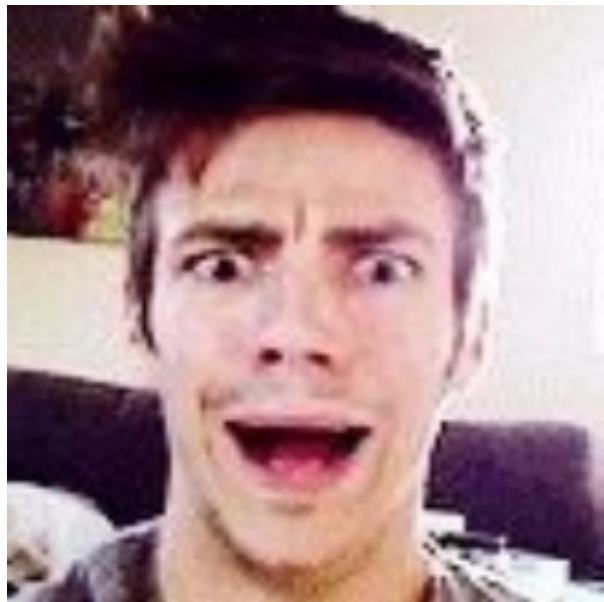
Actual = grant gustin Predicted = grant gustin



Actual = Miley Cyrus Predicted = Millie Bobby Brown



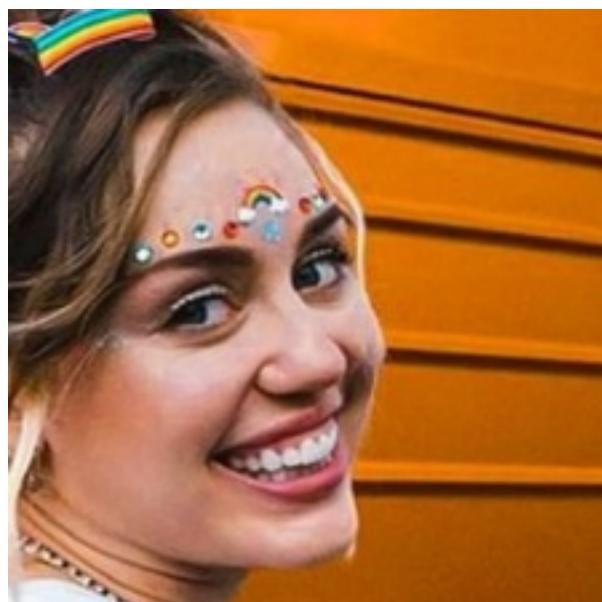
Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = grant gustin Predicted = grant gustin



Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



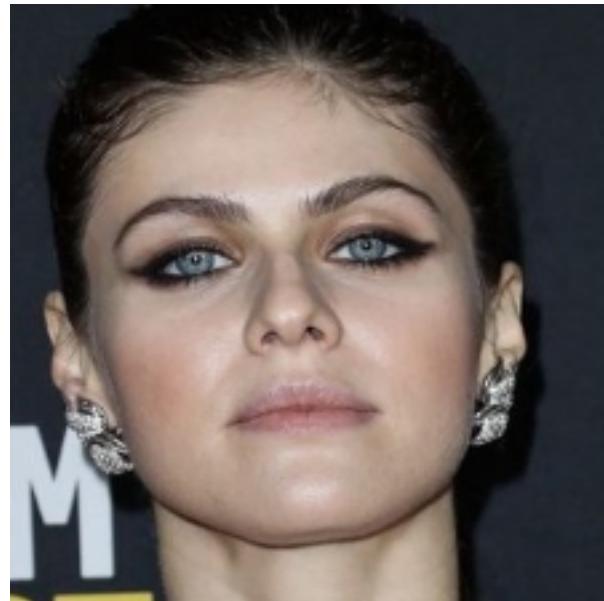
Actual = Miley Cyrus Predicted = Katherine Langford



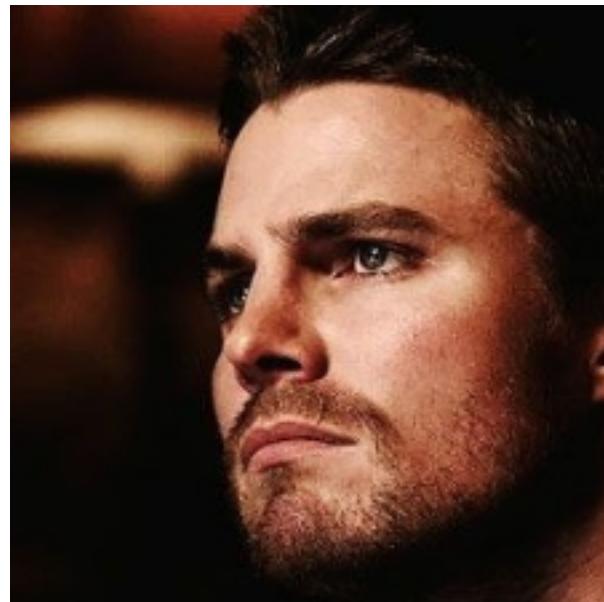
Actual = Brenton Thwaites Predicted = Brenton Thwaites



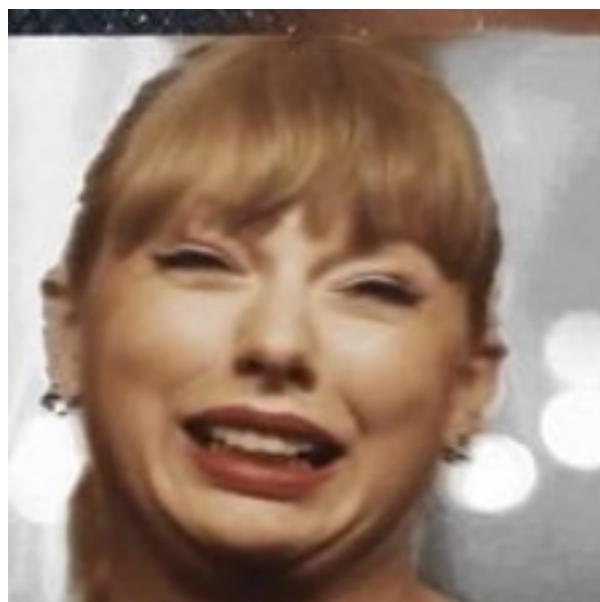
Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Stephen Amell Predicted = Stephen Amell



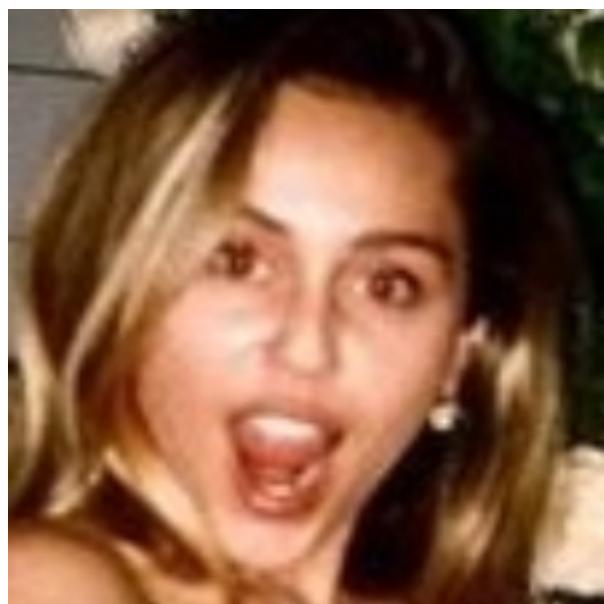
Actual = Taylor Swift Predicted = Taylor Swift



Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = Anne Hathaway Predicted = Miley Cyrus



Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = Anne Hathaway Predicted = Anne Hathaway



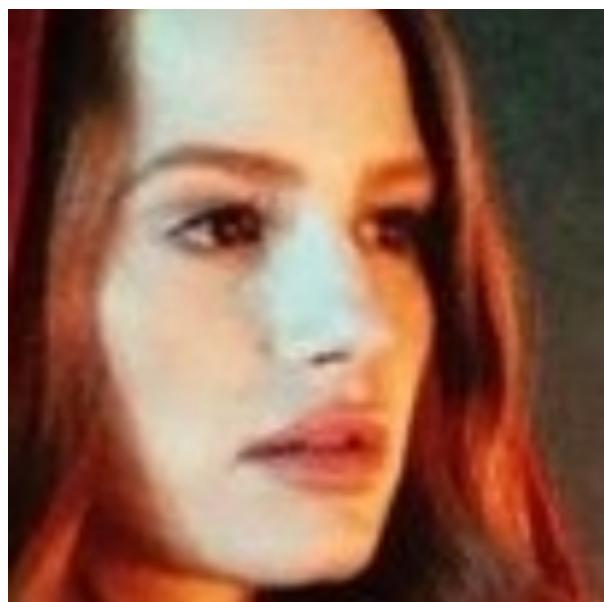
Actual = Jeremy Renner Predicted = Jeremy Renner



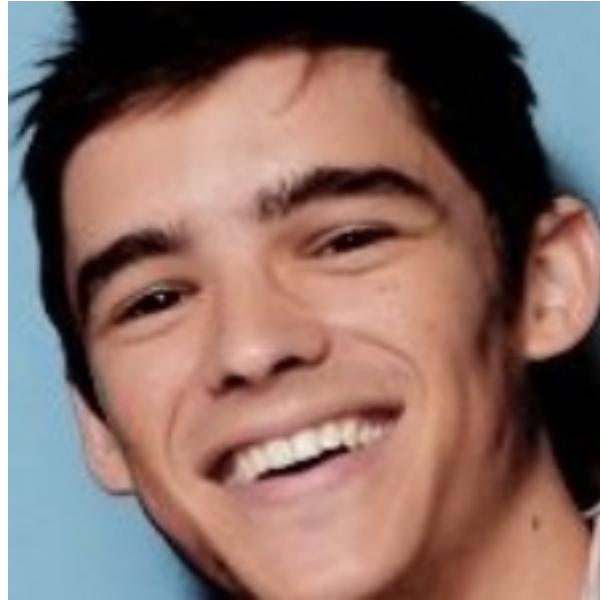
Actual = Bill Gates Predicted = Bill Gates



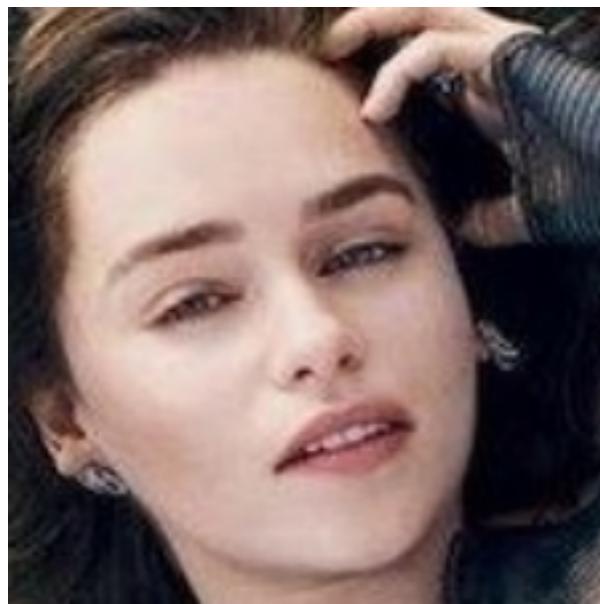
Actual = Jeremy Renner Predicted = Jeremy Renner



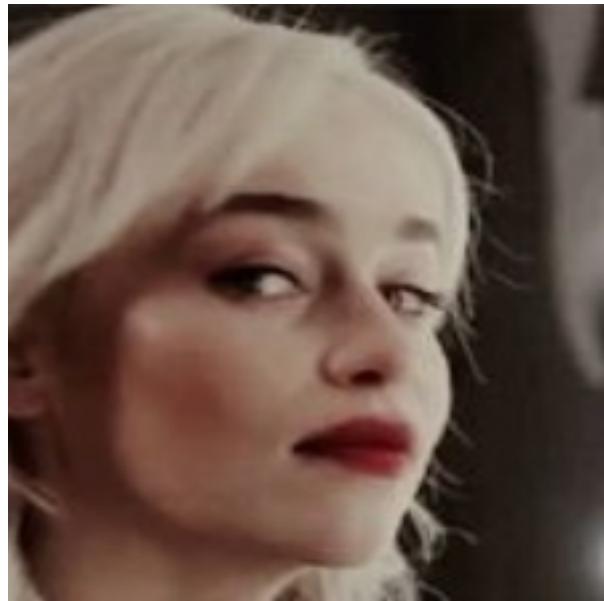
Actual = Madelaine Petsch Predicted = Madelaine Petsch



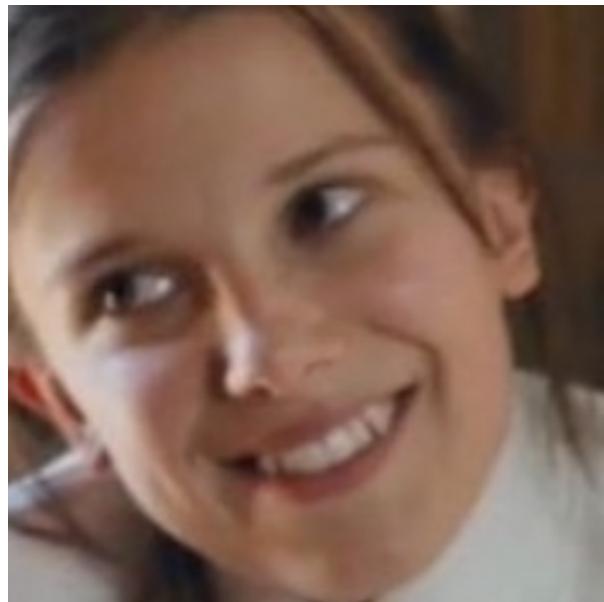
Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Emilia Clarke Predicted = Emilia Clarke



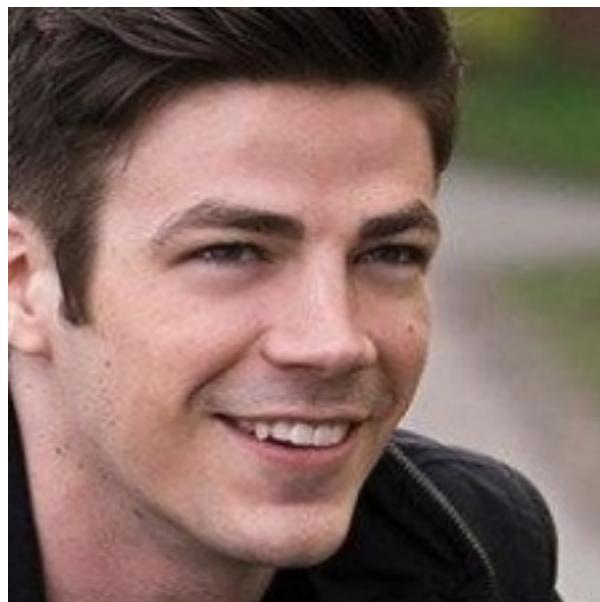
Actual = Emilia Clarke Predicted = Emilia Clarke



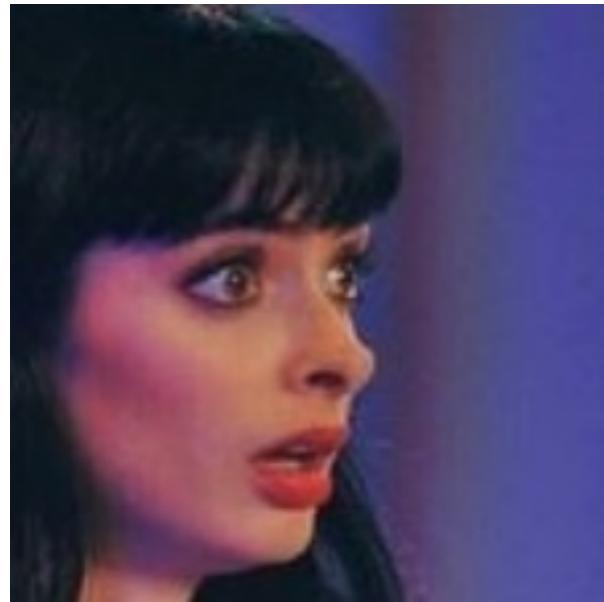
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Zoe Saldana Predicted = Zoe Saldana



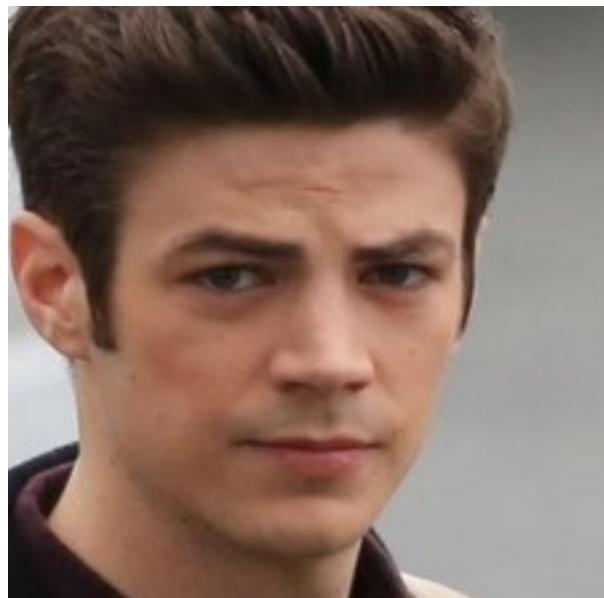
Actual = grant gustin Predicted = grant gustin



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = grant gustin Predicted = grant gustin



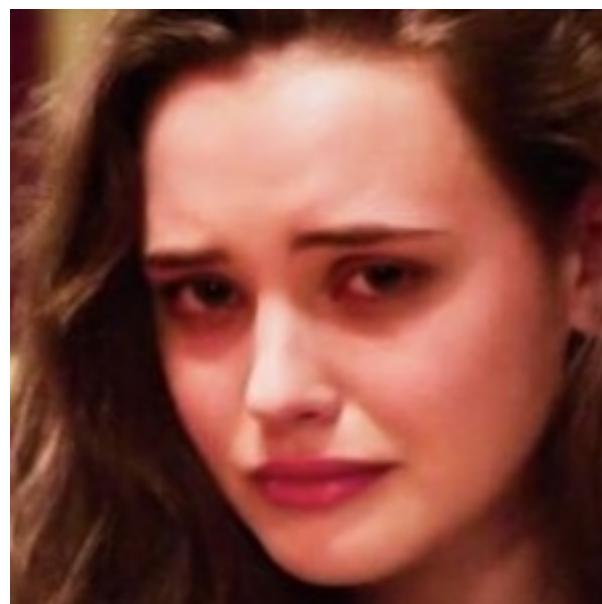
Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = Bill Gates Predicted = Bill Gates



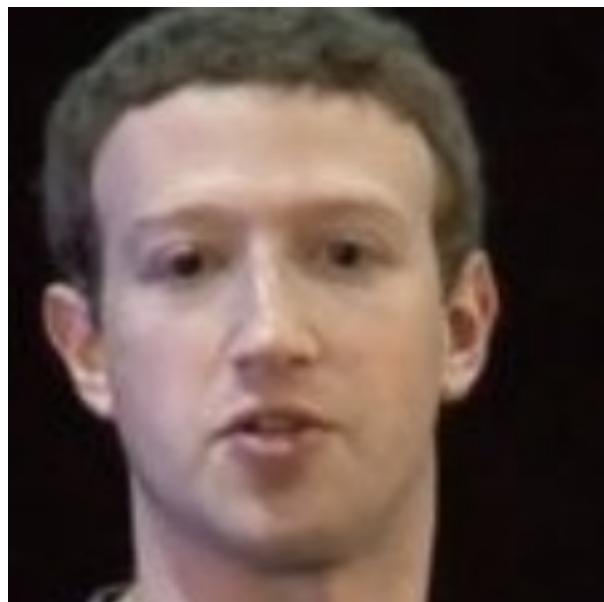
Actual = Bill Gates Predicted = Bill Gates



Actual = Katherine Langford Predicted = Katherine Langford



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



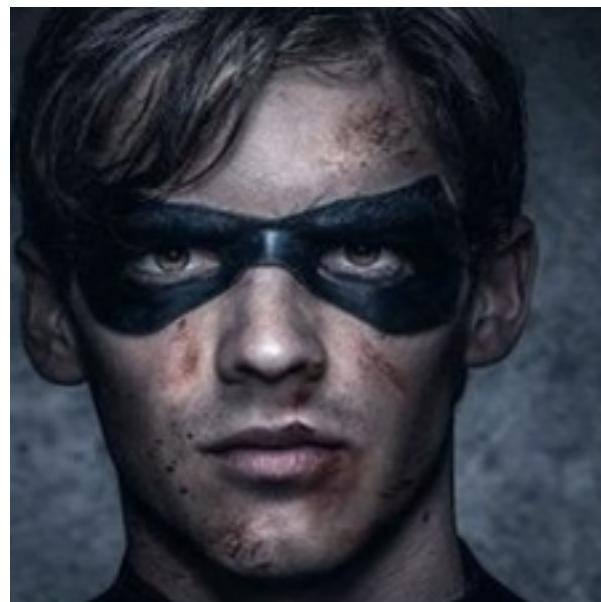
Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



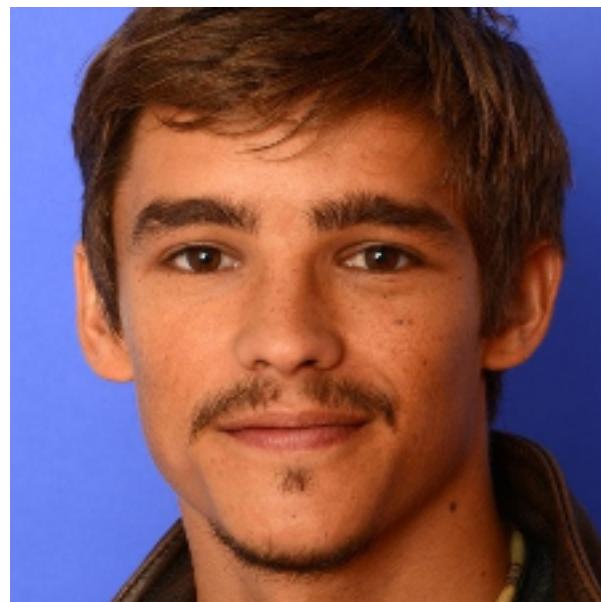
Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = grant gustin Predicted = grant gustin



Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Brenton Thwaites Predicted = Brenton Thwaites



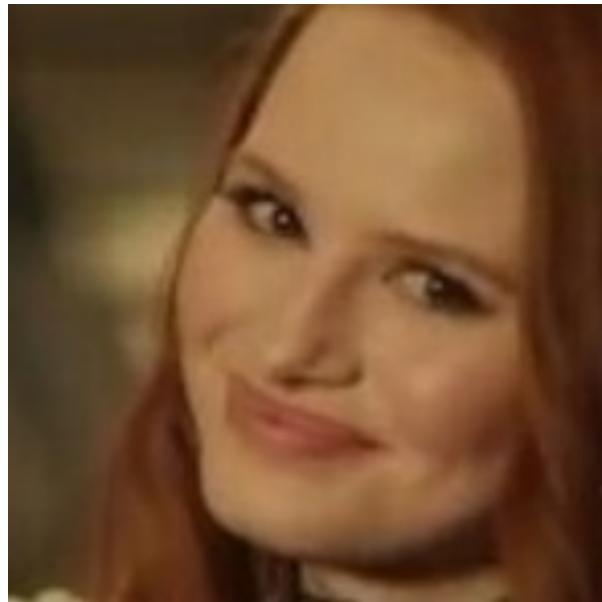
Actual = Bill Gates Predicted = Bill Gates



Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = Stephen Amell Predicted = Stephen Amell



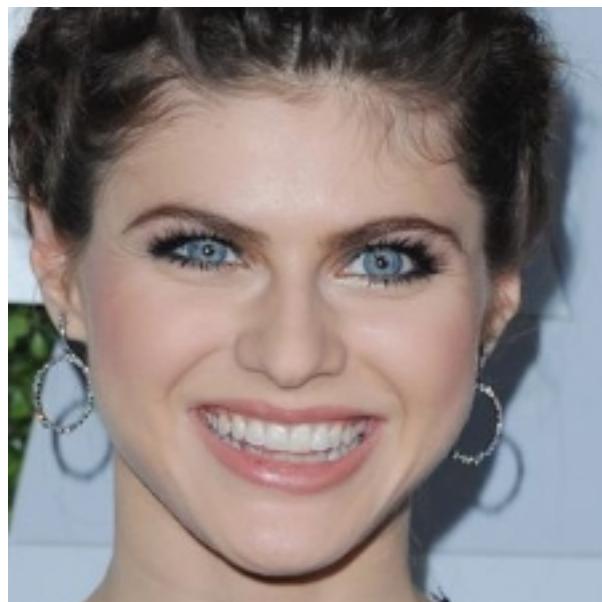
Actual = Madelaine Petsch Predicted = Millie Bobby Brown



Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Anne Hathaway Predicted = Anne Hathaway



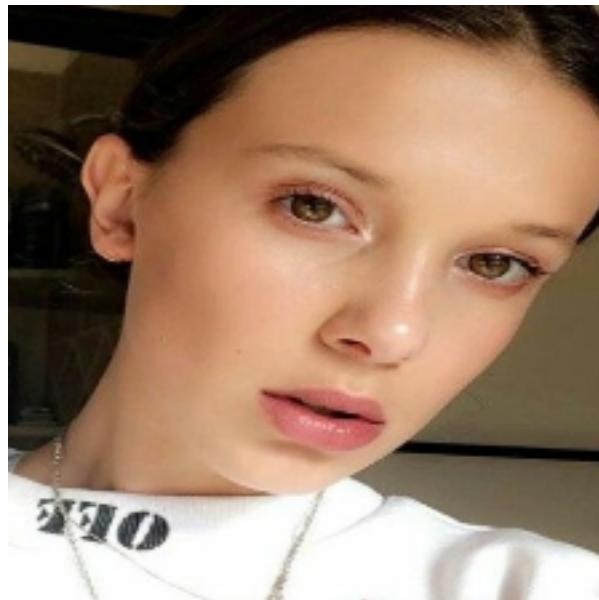
Actual = Miley Cyrus Predicted = Katherine Langford



Actual = Katherine Langford Predicted = Katherine Langford



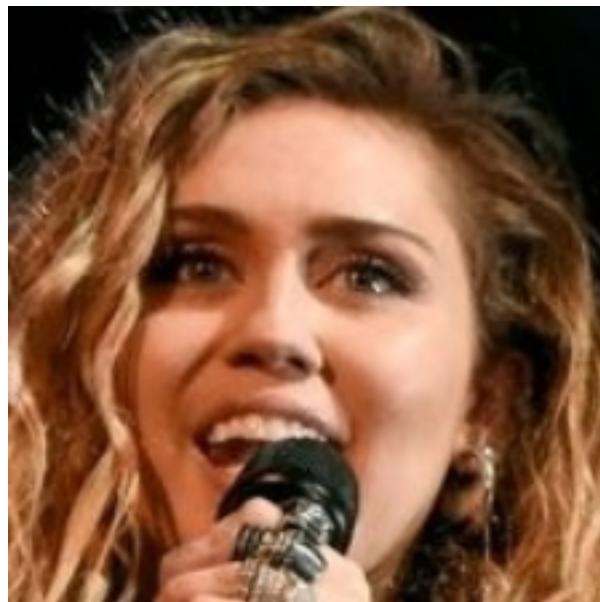
Actual = amber heard Predicted = amber heard



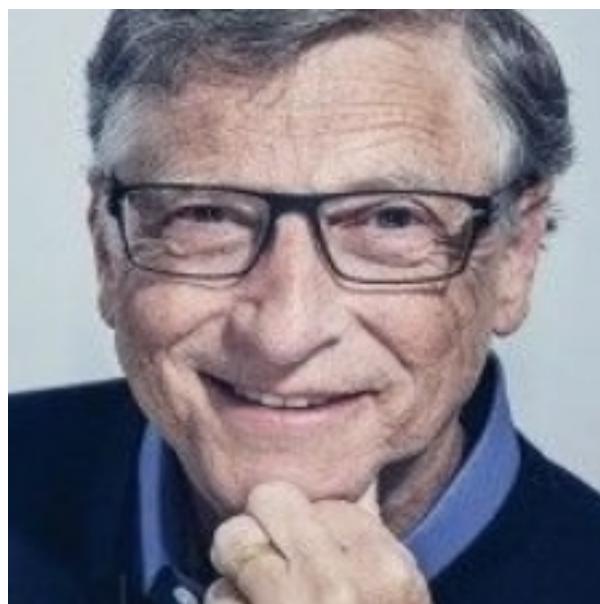
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



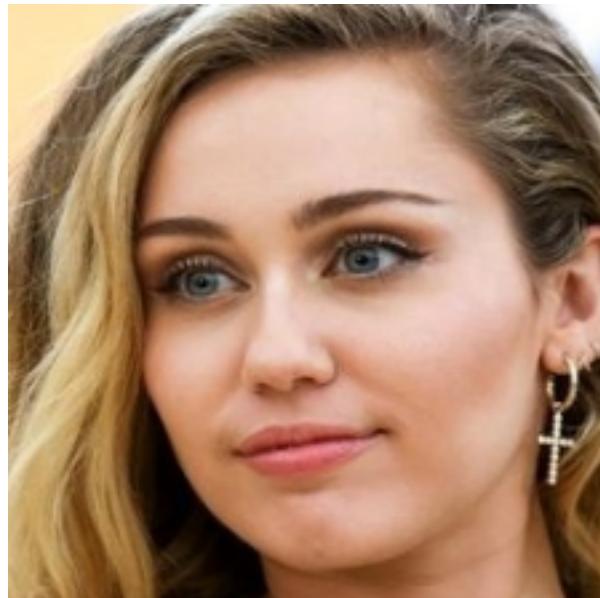
Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = Bill Gates Predicted = Bill Gates



Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = Taylor Swift Predicted = Taylor Swift



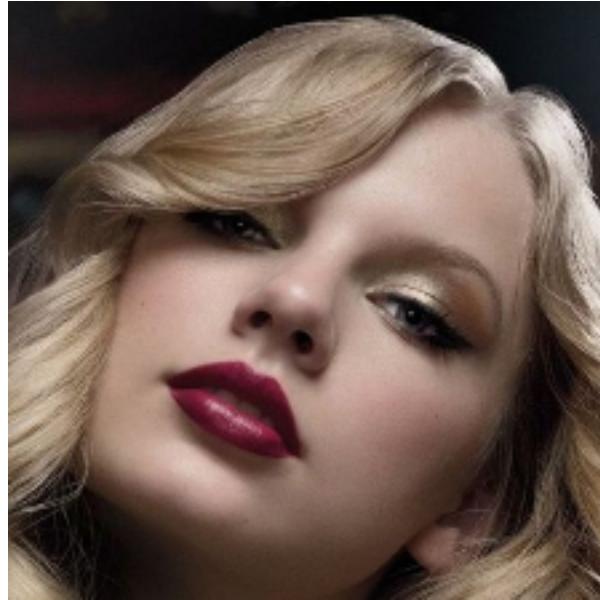
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Rebecca Ferguson Predicted = Millie Bobby Brown



Actual = Madelaine Petsch Predicted = Madelaine Petsch



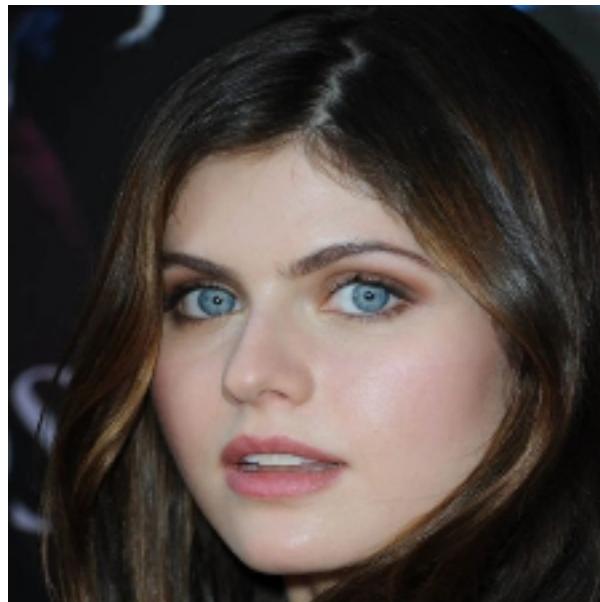
Actual = Taylor Swift Predicted = Taylor Swift



Actual = grant gustin Predicted = grant gustin



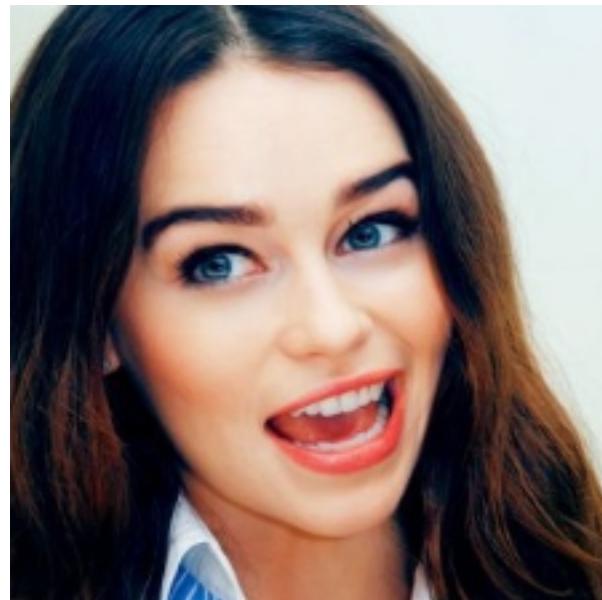
Actual = Brenton Thwaites Predicted = Brenton Thwaites



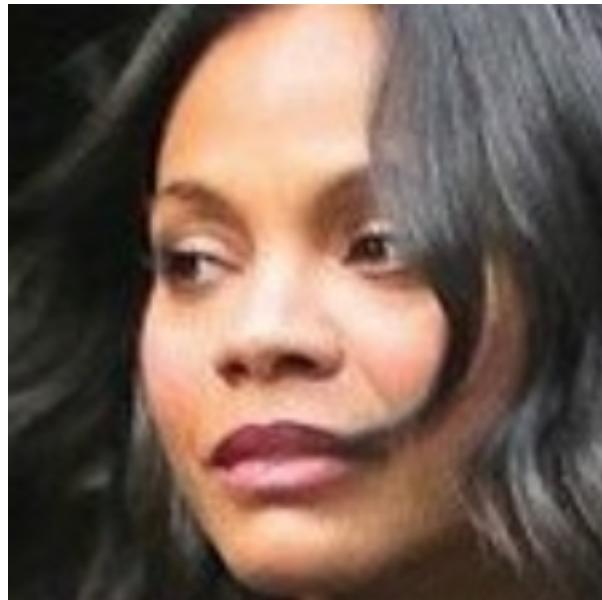
Actual = Alexandra Daddario Predicted = Alexandra Daddario



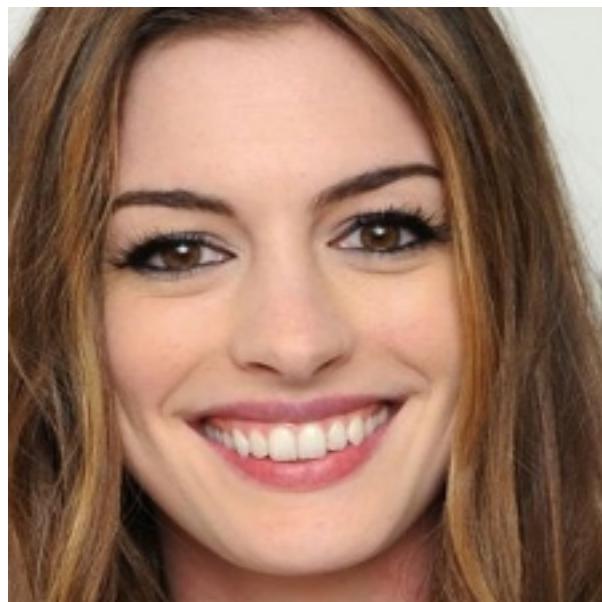
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Zoe Saldana Predicted = Zoe Saldana



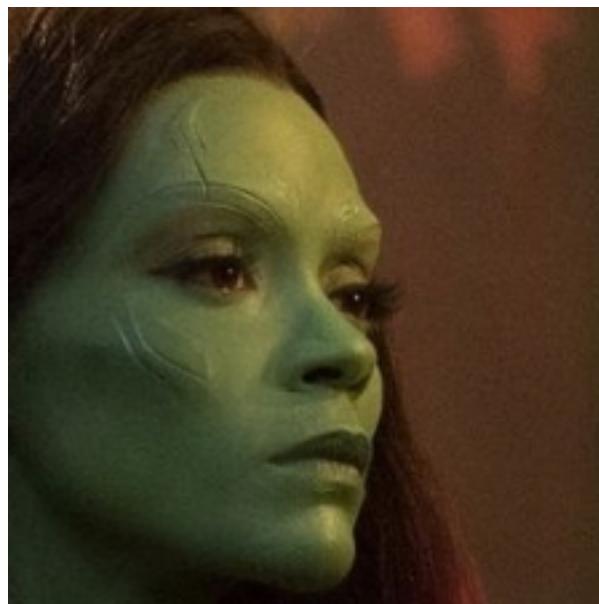
Actual = Anne Hathaway Predicted = Anne Hathaway



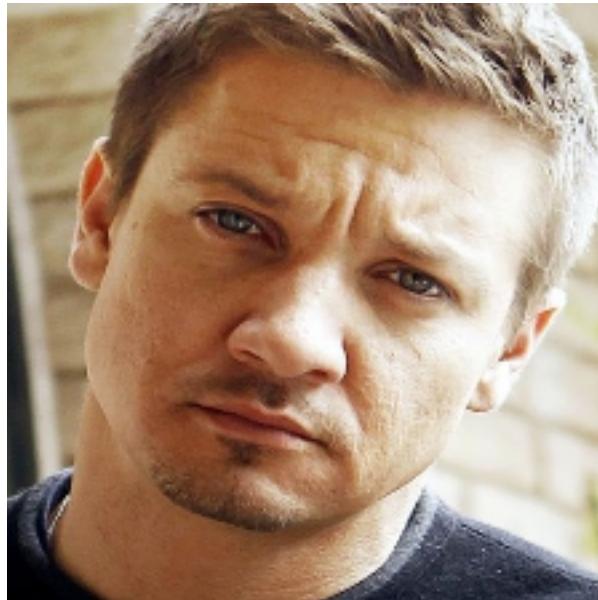
Actual = Taylor Swift Predicted = Taylor Swift



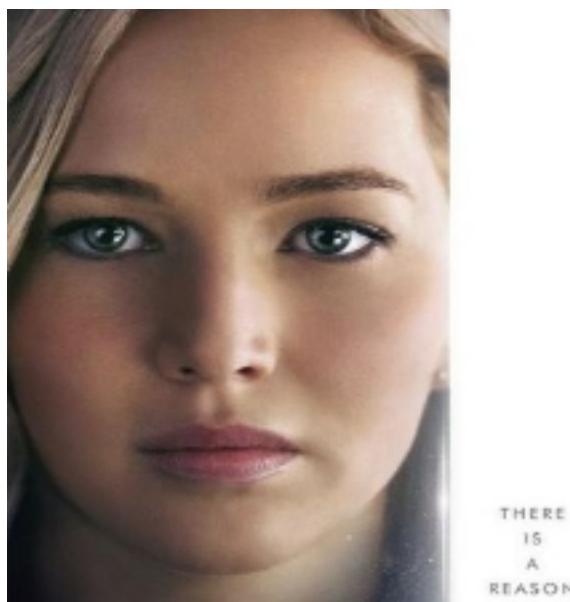
Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = Zoe Saldana Predicted = Zoe Saldana



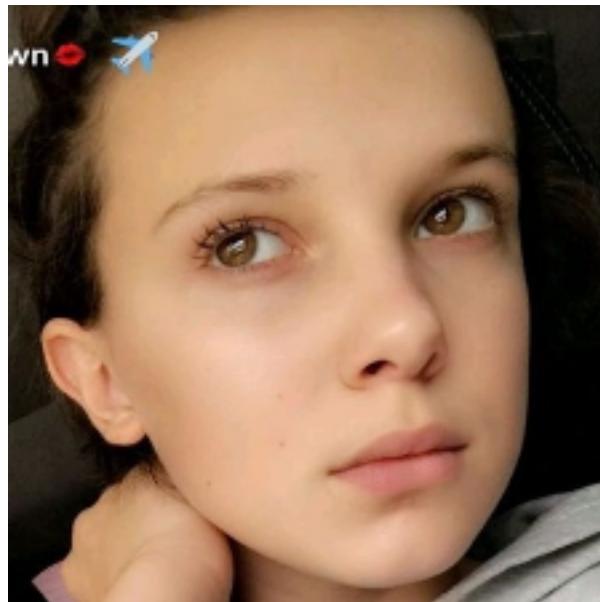
Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = grant gustin Predicted = grant gustin



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Madelaine Petsch Predicted = Millie Bobby Brown



Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = Madelaine Petsch Predicted = Madelaine Petsch



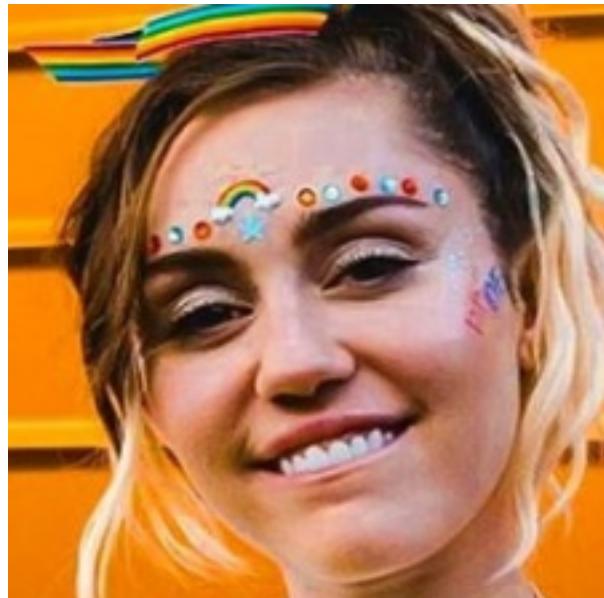
Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = amber heard Predicted = amber heard



Actual = Zoe Saldana Predicted = Zoe Saldana



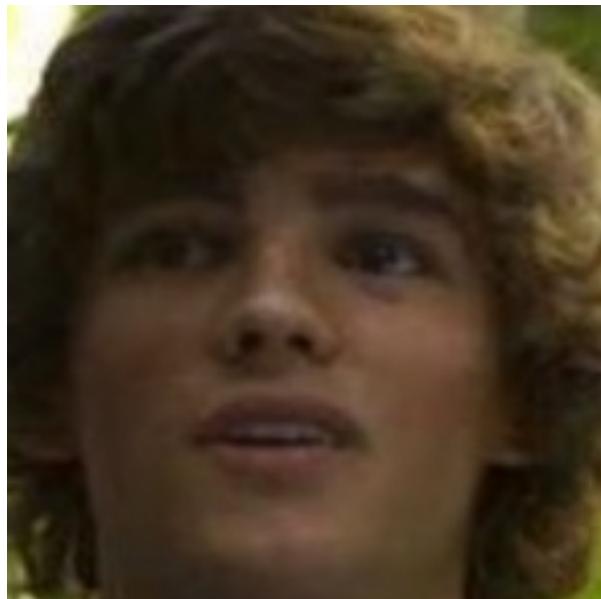
Actual = Miley Cyrus Predicted = Katherine Langford



Actual = Madelaine Petsch Predicted = Katherine Langford



Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Jeremy Renner Predicted = Jeremy Renner



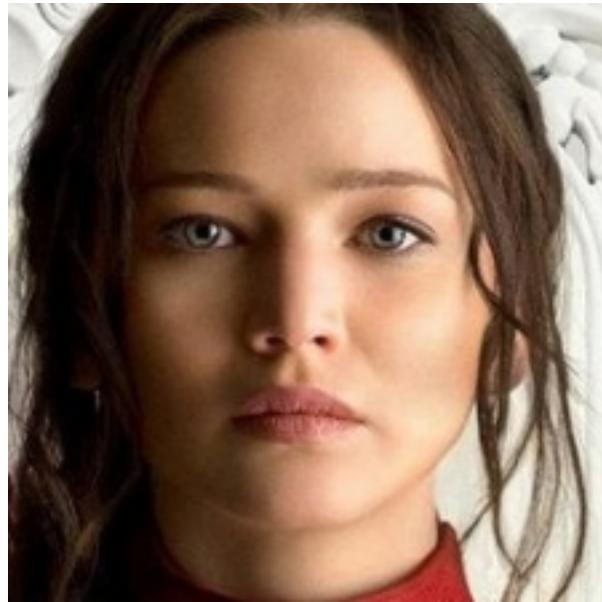
Actual = amber heard Predicted = Taylor Swift



Actual = Taylor Swift Predicted = Taylor Swift



Actual = Katherine Langford Predicted = Katherine Langford



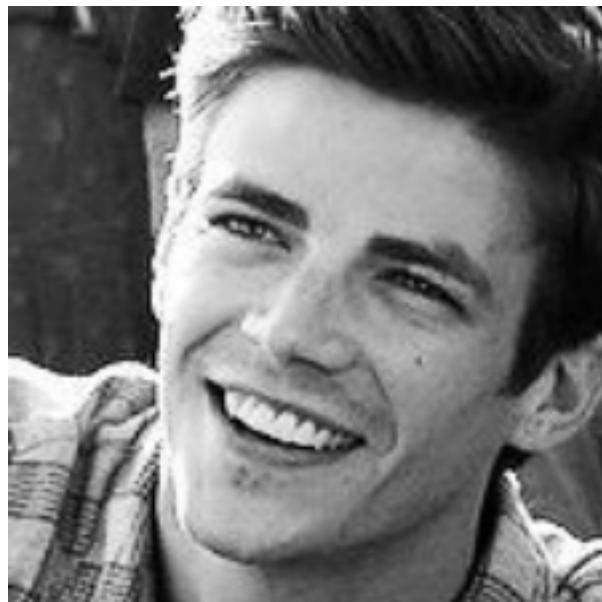
Actual = Jennifer Lawrence Predicted = Katherine Langford



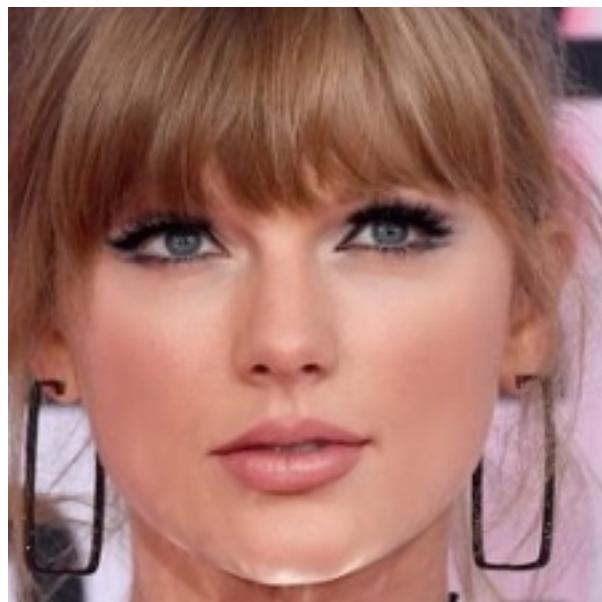
Actual = Alexandra Daddario Predicted = Alexandra Daddario



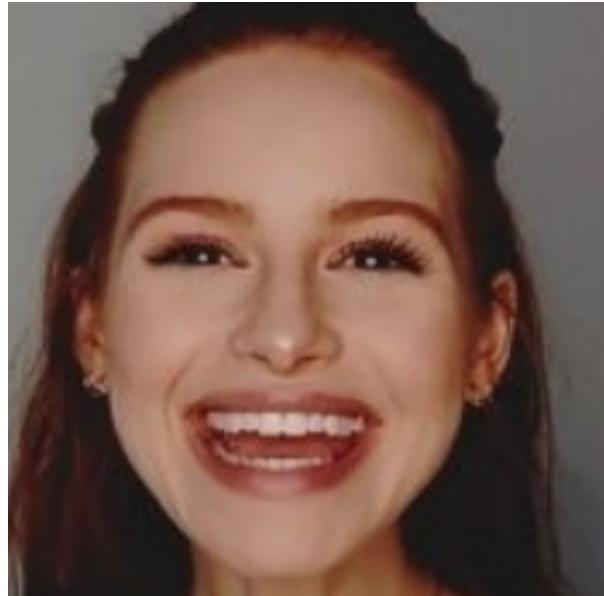
Actual = amber heard Predicted = amber heard



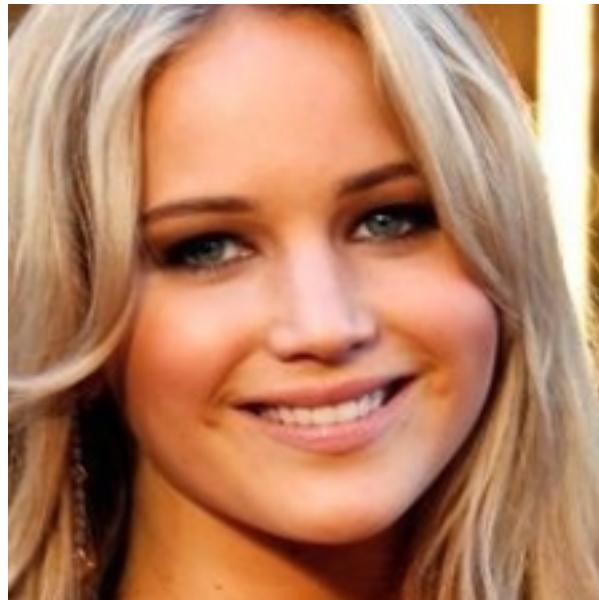
Actual = grant gustin Predicted = grant gustin



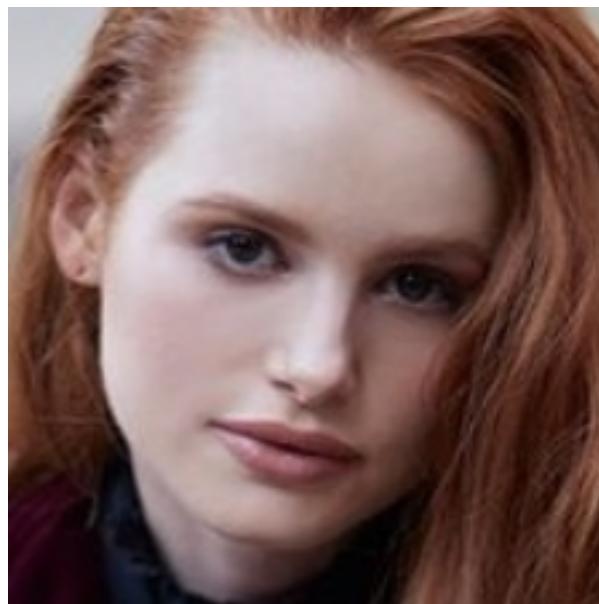
Actual = Taylor Swift Predicted = Taylor Swift



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = Jeremy Renner Predicted = Jeremy Renner



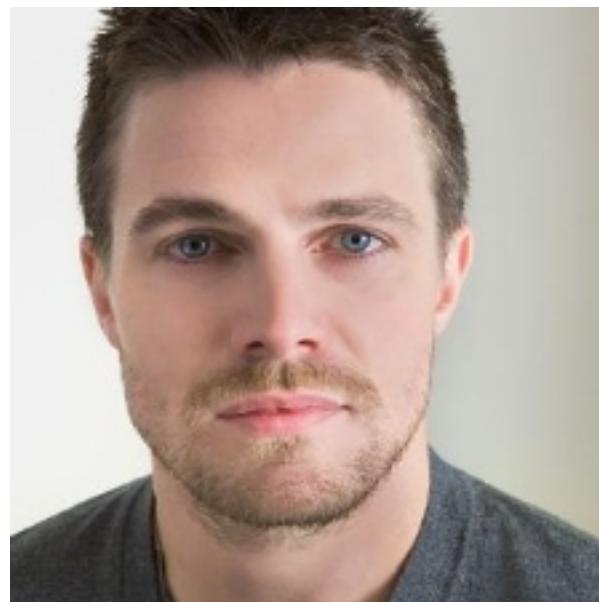
Actual = Brenton Thwaites Predicted = Brenton Thwaites



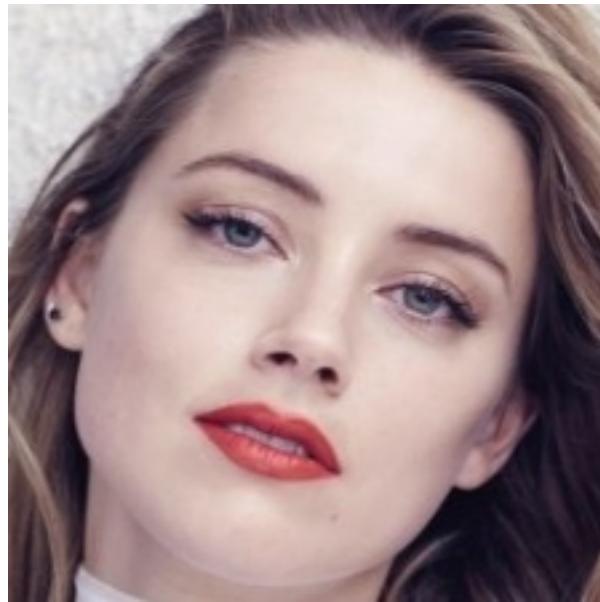
Actual = Bill Gates Predicted = Bill Gates



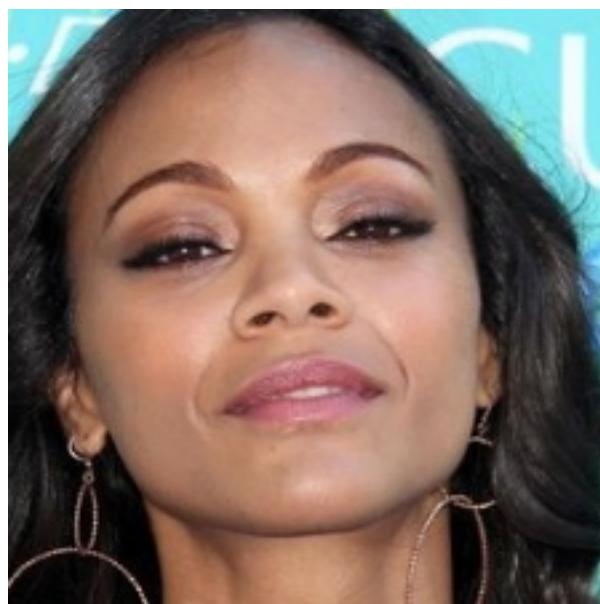
Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Stephen Amell Predicted = Stephen Amell



Actual = amber heard Predicted = amber heard



Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = grant gustin Predicted = grant gustin



Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Madelaine Petsch Predicted = Madelaine Petsch



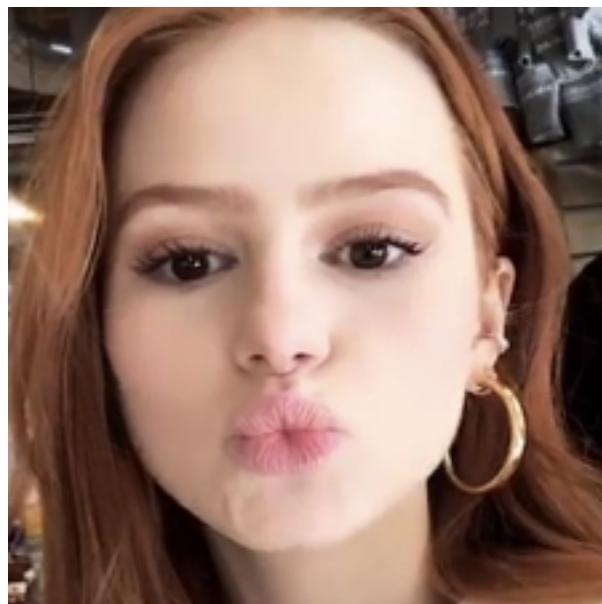
Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



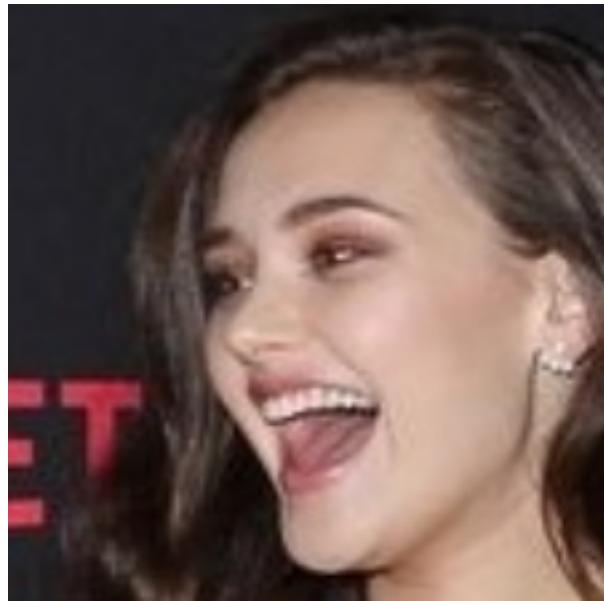
Actual = Taylor Swift Predicted = Taylor Swift



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



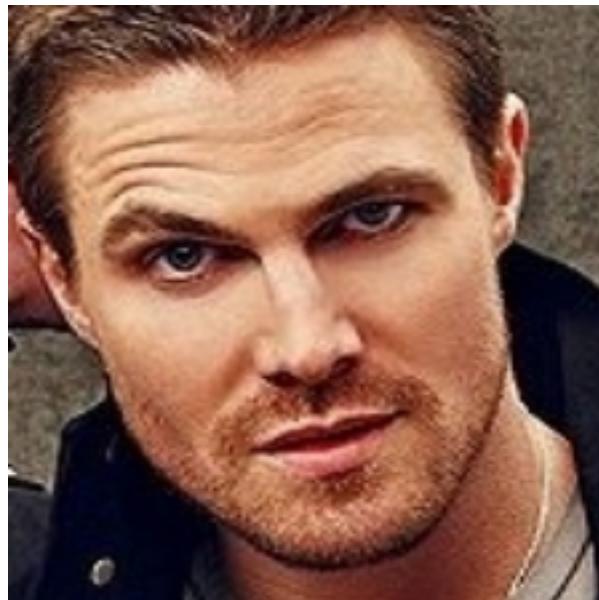
Actual = Madelaine Petsch Predicted = Katherine Langford



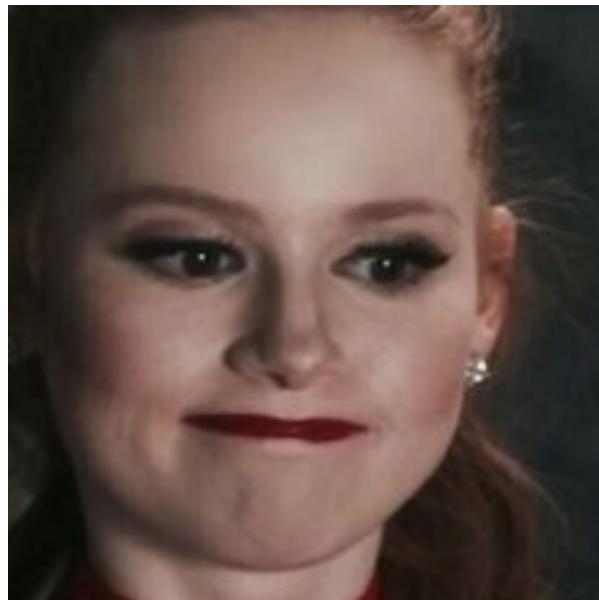
Actual = Katherine Langford Predicted = Millie Bobby Brown



Actual = Zoe Saldana Predicted = Zoe Saldana



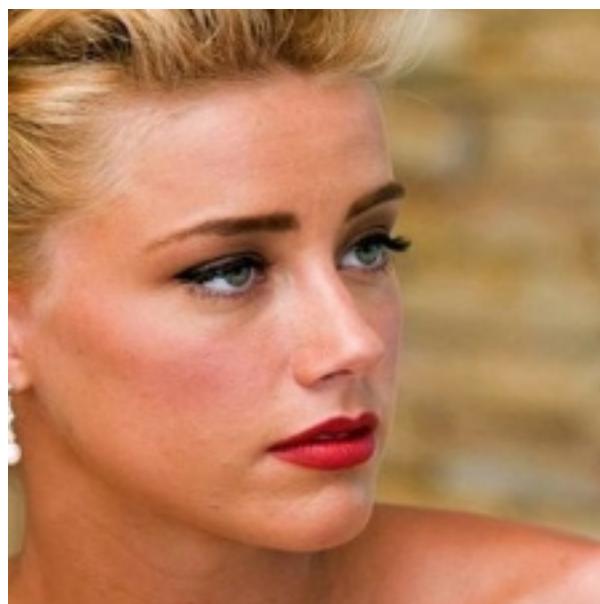
Actual = Stephen Amell Predicted = Stephen Amell



Actual = Madelaine Petsch Predicted = Madelaine Petsch



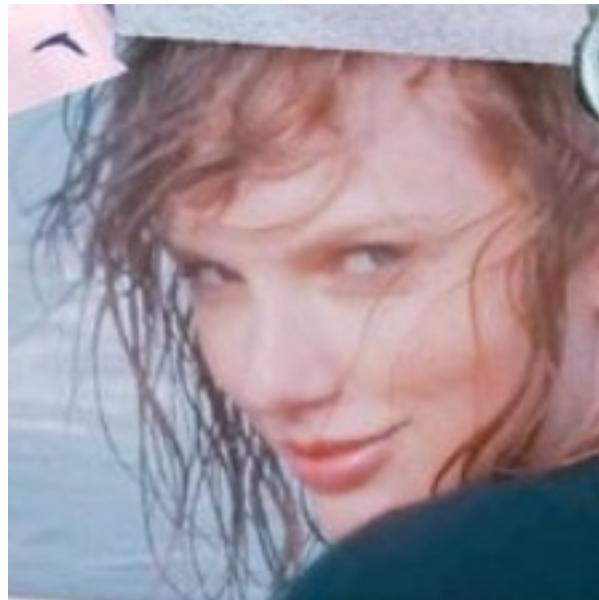
Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



Actual = amber heard Predicted = amber heard



Actual = Katherine Langford Predicted = Katherine Langford



Actual = Taylor Swift Predicted = Taylor Swift



Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



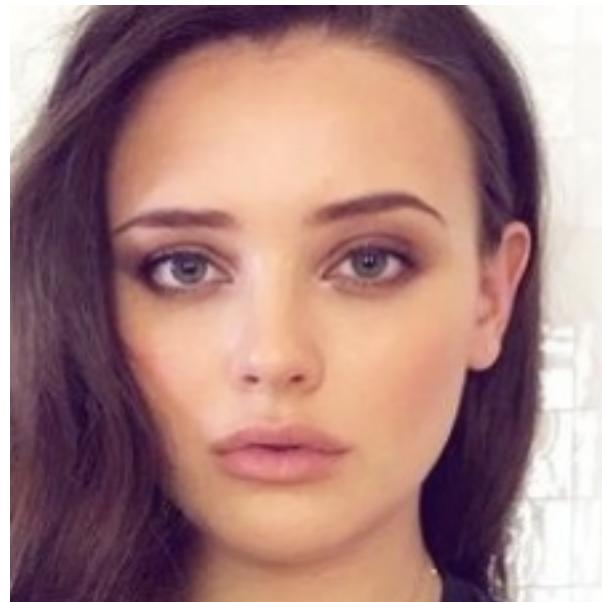
Actual = amber heard Predicted = amber heard



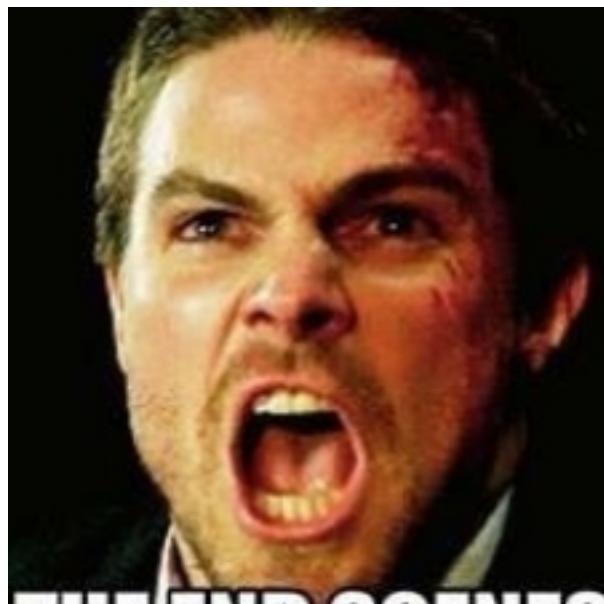
Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = Stephen Amell Predicted = Stephen Amell



Actual = Katherine Langford Predicted = Katherine Langford



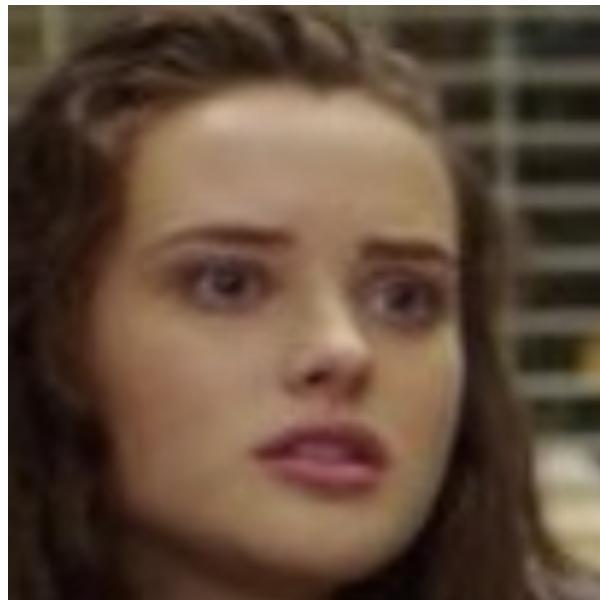
Actual = Stephen Amell Predicted = grant gustin



Actual = amber heard Predicted = Katherine Langford



Actual = grant gustin Predicted = grant gustin



Actual = Katherine Langford Predicted = Katherine Langford



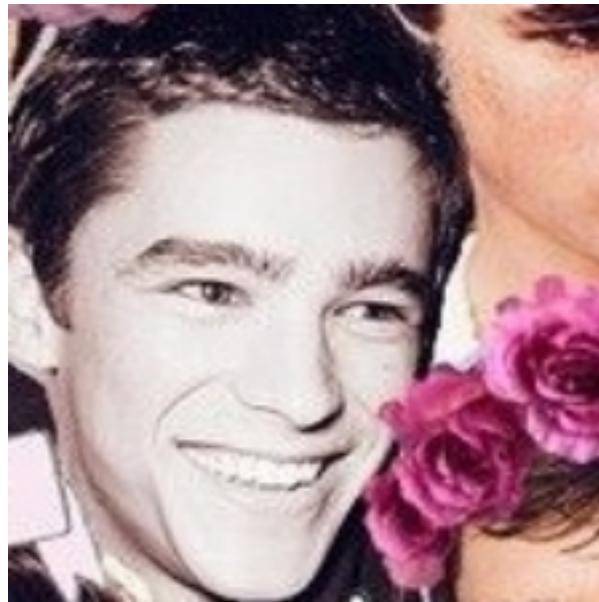
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



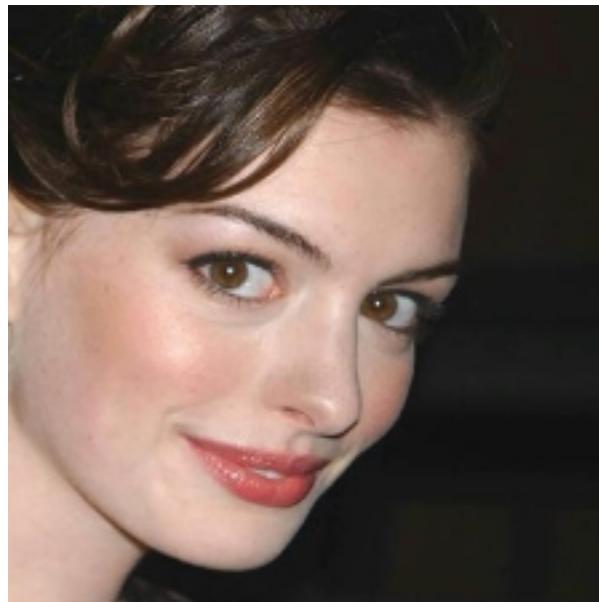
Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Zoe Saldana Predicted = Zoe Saldana



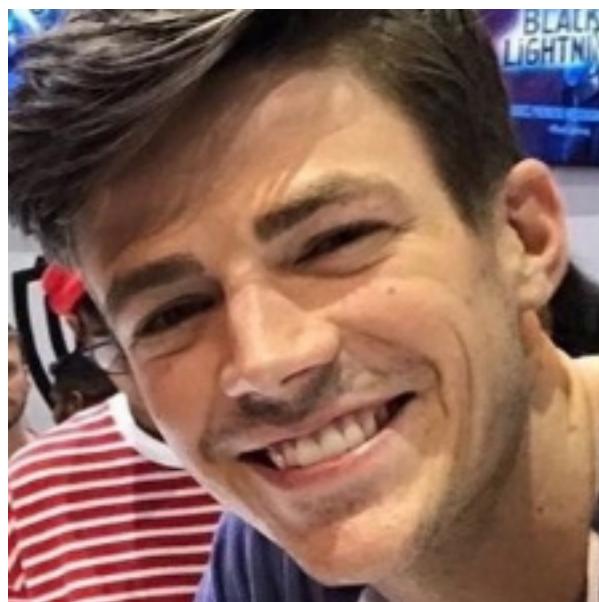
Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Anne Hathaway Predicted = Anne Hathaway



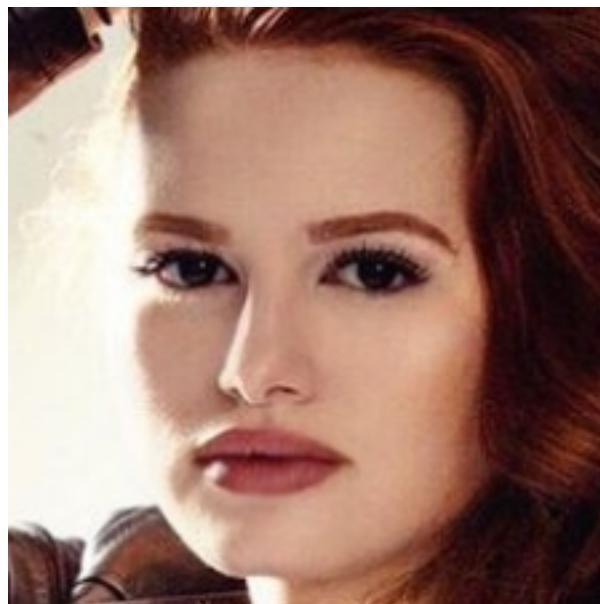
Actual = Emilia Clarke Predicted = amber heard



Actual = grant gustin Predicted = grant gustin



Actual = Krysten Ritter Predicted = Krysten Ritter



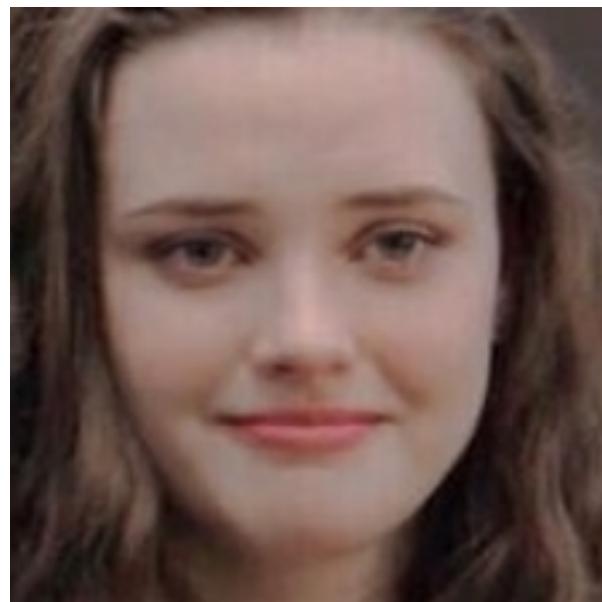
Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = grant gustin Predicted = grant gustin



Actual = Katherine Langford Predicted = Katherine Langford



Actual = Emilia Clarke Predicted = Katherine Langford



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



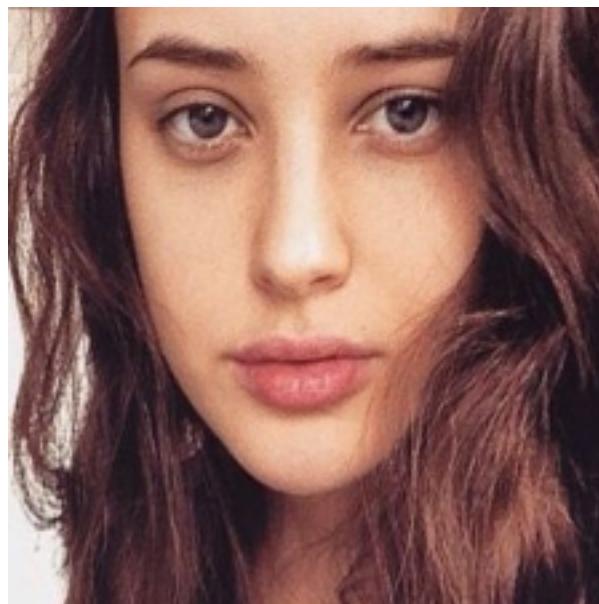
Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Katherine Langford Predicted = Katherine Langford



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = Zoe Saldana Predicted = Zoe Saldana



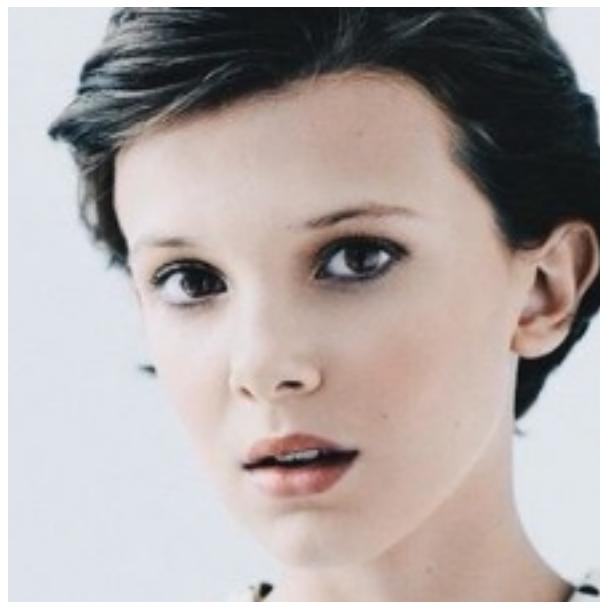
Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



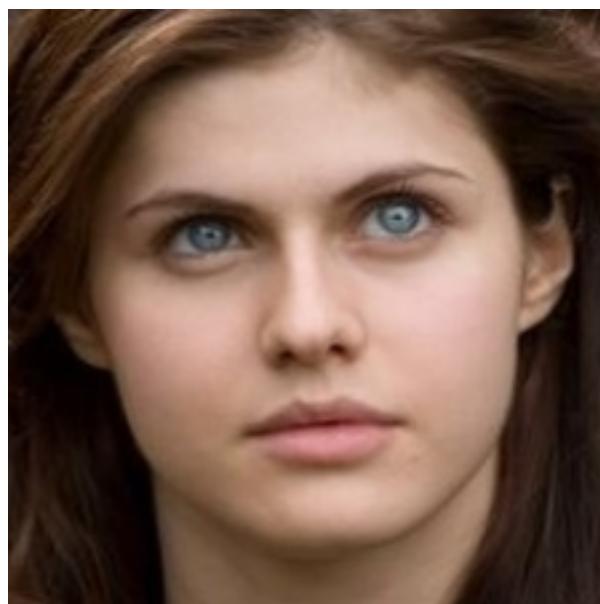
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



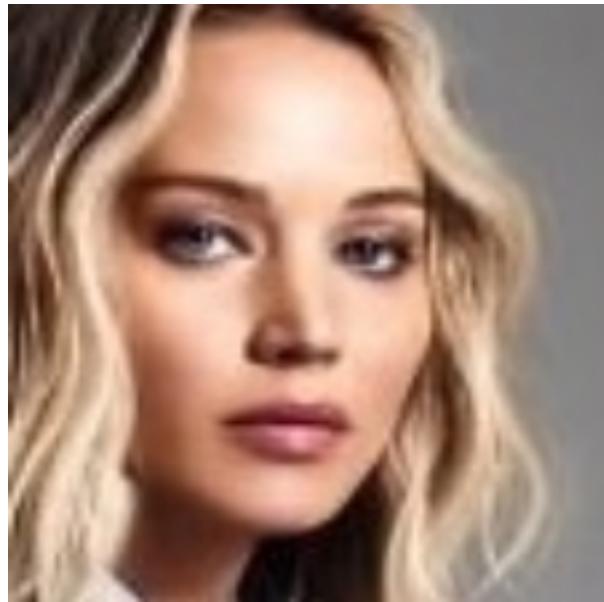
Actual = Taylor Swift Predicted = Taylor Swift



Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Brenton Thwaites Predicted = Brenton Thwaites



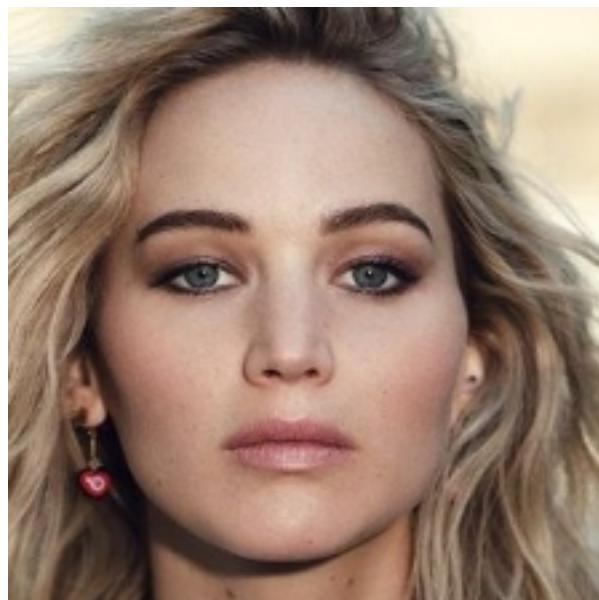
Actual = Jennifer Lawrence Predicted = Miley Cyrus



Actual = Anne Hathaway Predicted = Krysten Ritter



Actual = Katherine Langford Predicted = Katherine Langford



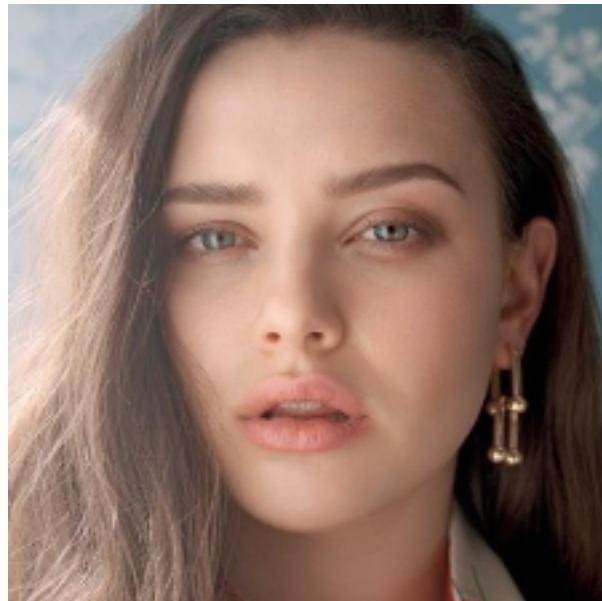
Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Neil Patrick Harris Predicted = Millie Bobby Brown



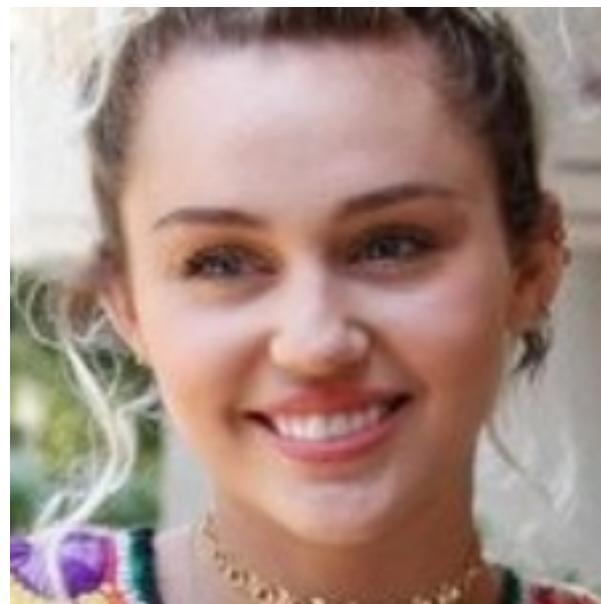
Actual = Katherine Langford Predicted = Katherine Langford



Actual = amber heard Predicted = amber heard



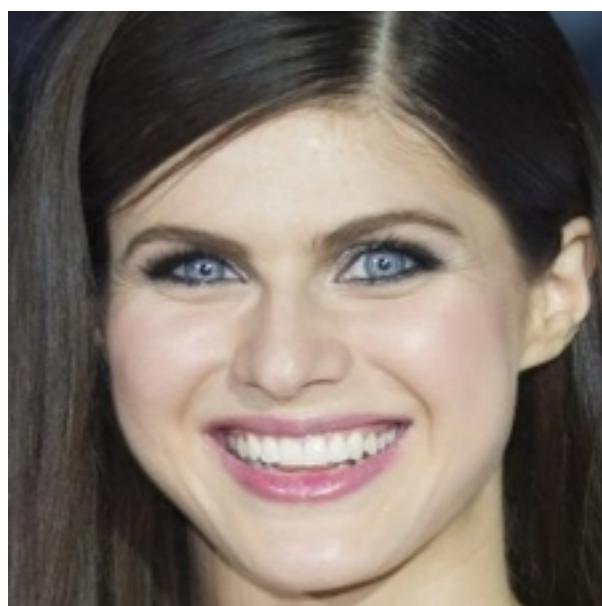
Actual = Taylor Swift Predicted = Taylor Swift



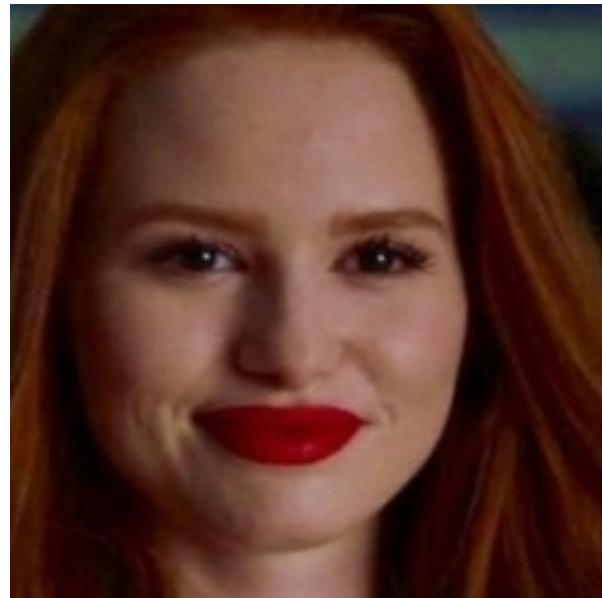
Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = Bill Gates Predicted = Bill Gates



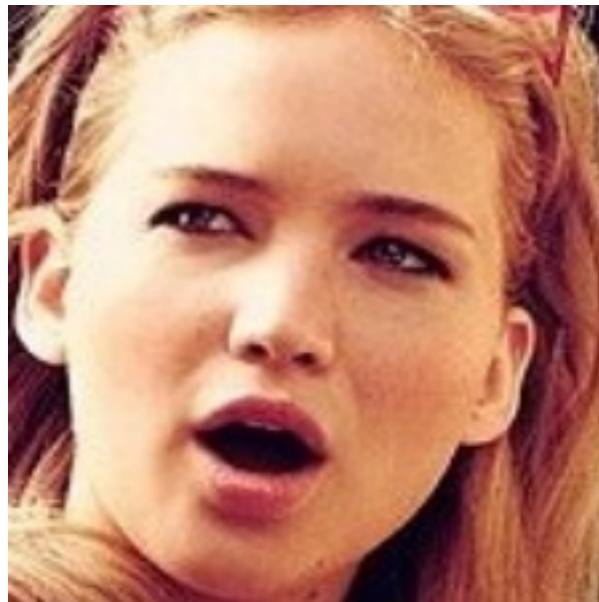
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Katherine Langford Predicted = Katherine Langford



Actual = Jennifer Lawrence Predicted = Rebecca Ferguson



Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Alexandra Daddario Predicted = Alexandra Daddario



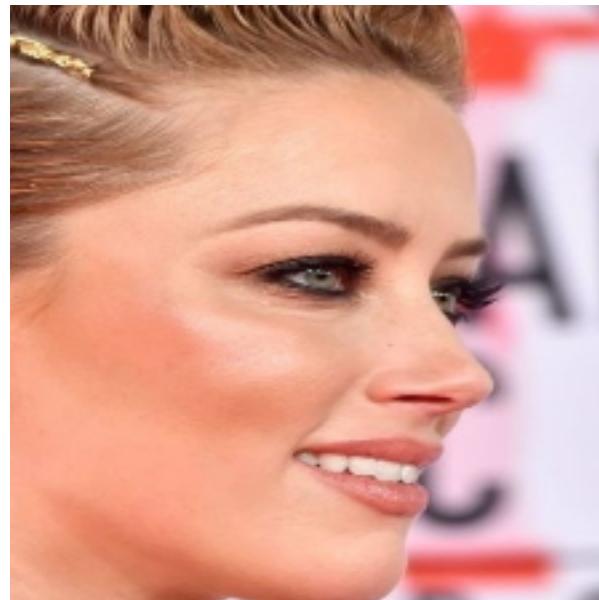
Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Jeremy Renner Predicted = Jeremy Renner



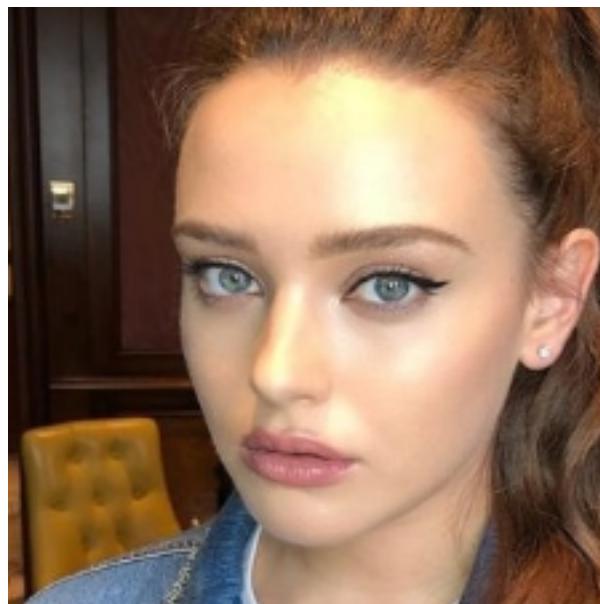
Actual = amber heard Predicted = amber heard



Actual = Katherine Langford Predicted = Katherine Langford



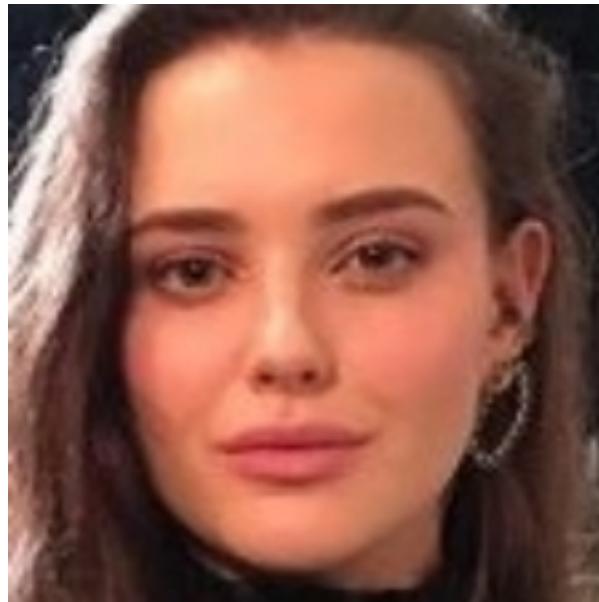
Actual = Brenton Thwaites Predicted = Brenton Thwaites



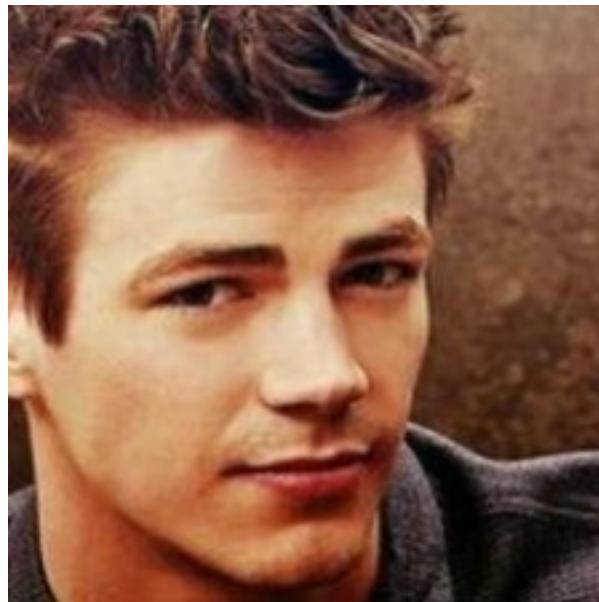
Actual = Katherine Langford Predicted = Katherine Langford



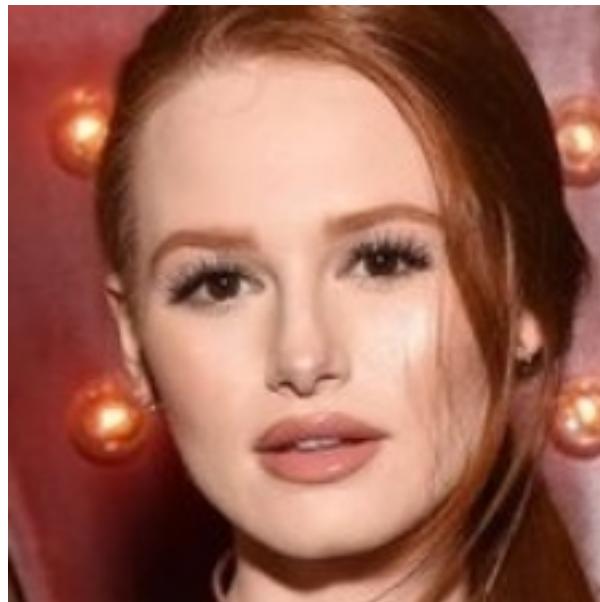
Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Katherine Langford Predicted = Katherine Langford



Actual = grant gustin Predicted = grant gustin



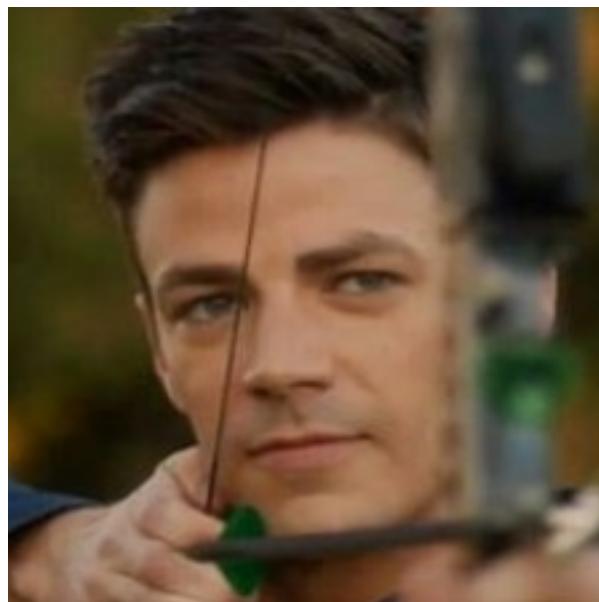
Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



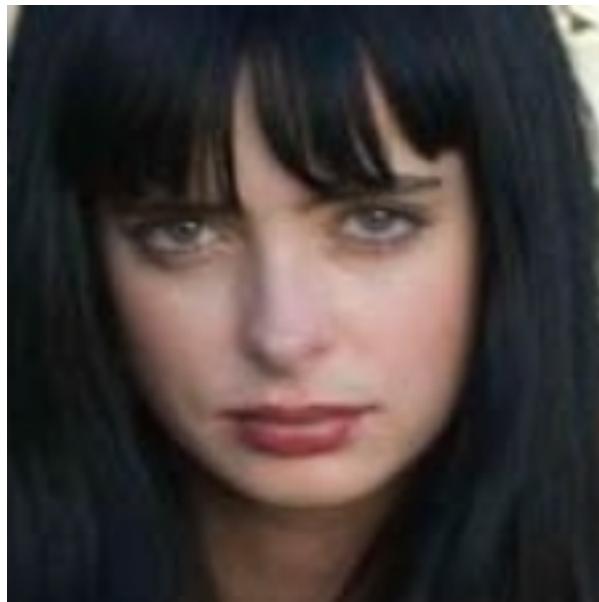
Actual = Stephen Amell Predicted = grant gustin



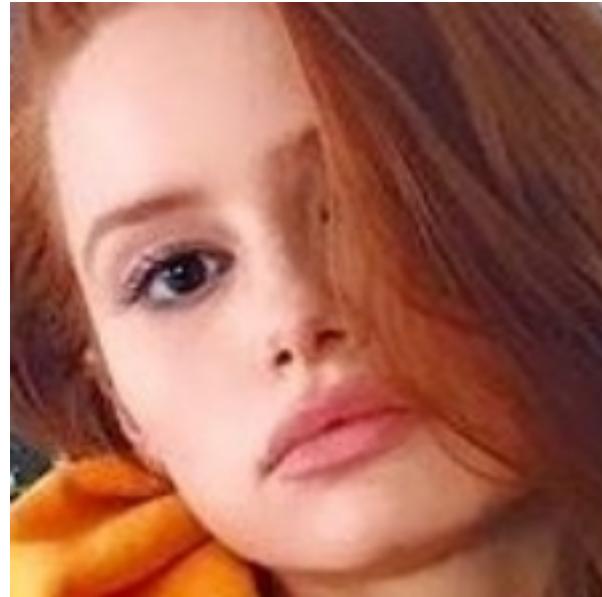
Actual = grant gustin Predicted = grant gustin



Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Alexandra Daddario Predicted = Alexandra Daddario



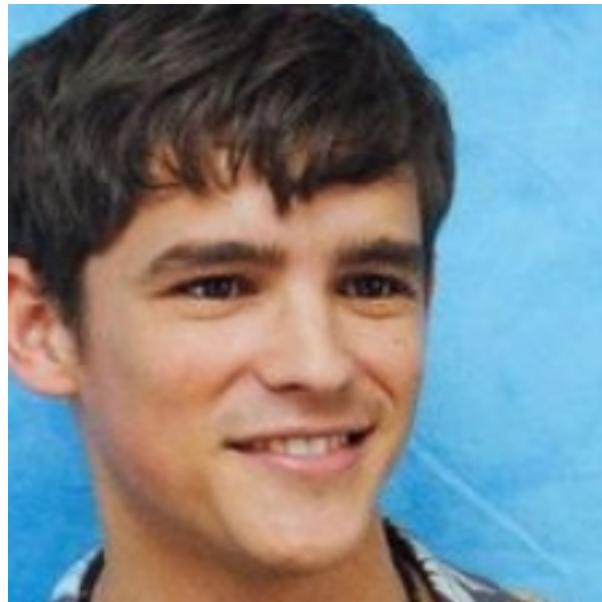
Actual = Katherine Langford Predicted = Katherine Langford



Actual = Alexandra Daddario Predicted = Alexandra Daddario



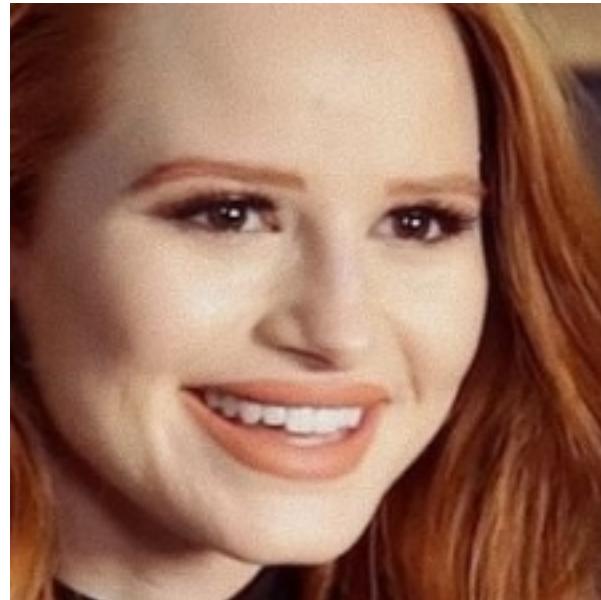
Actual = Krysten Ritter Predicted = Krysten Ritter



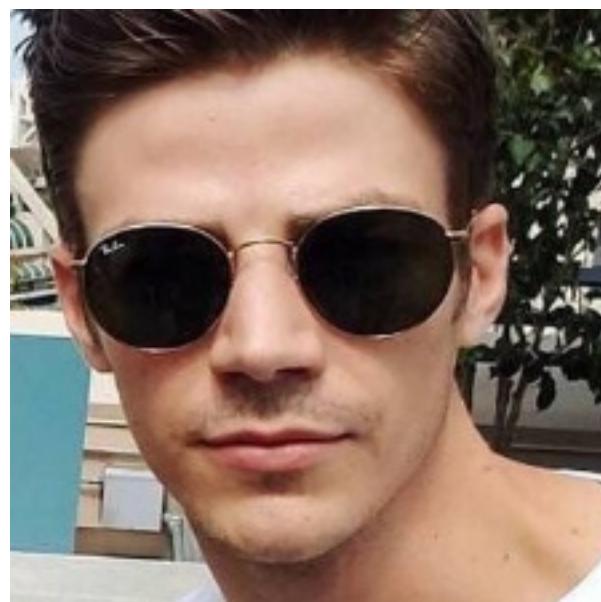
Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = grant gustin Predicted = grant gustin



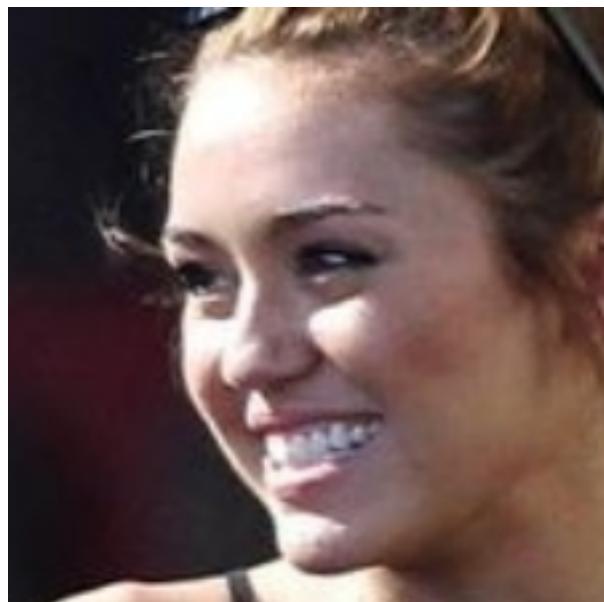
Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = grant gustin Predicted = Brenton Thwaites



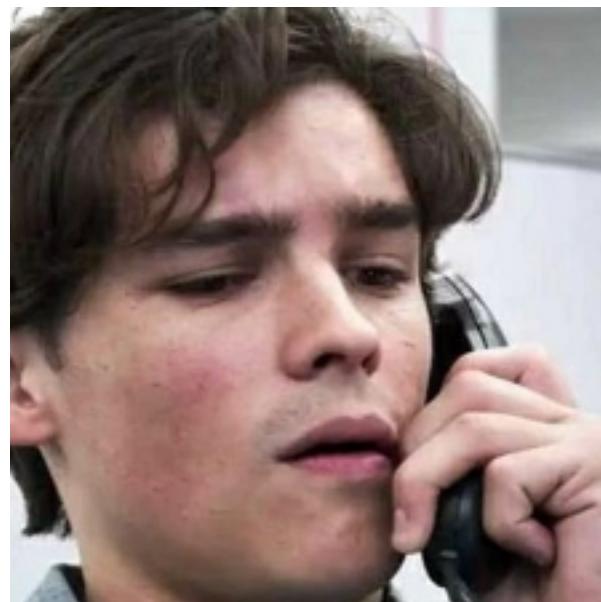
Actual = Zoe Saldana Predicted = Zoe Saldana



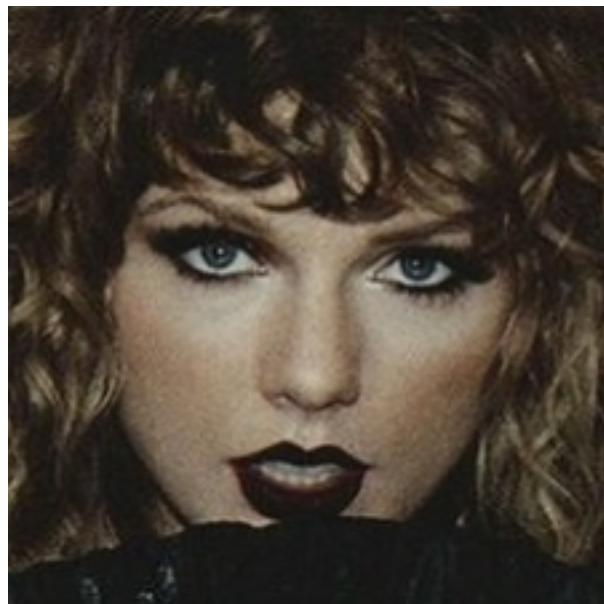
Actual = Miley Cyrus Predicted = amber heard



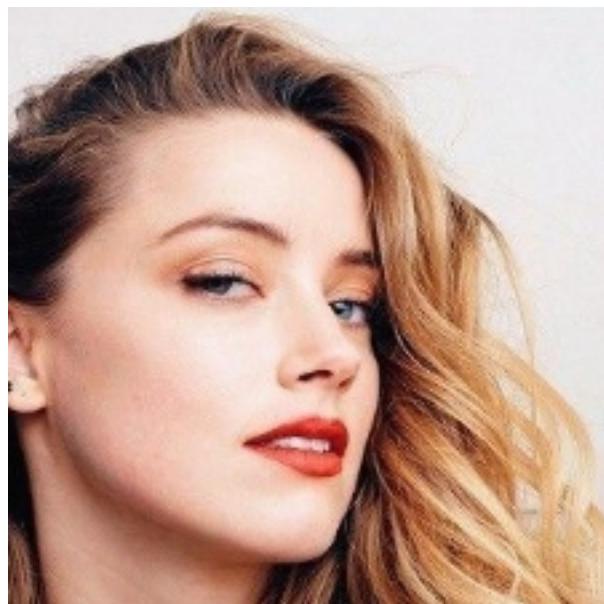
Actual = Anne Hathaway Predicted = Anne Hathaway



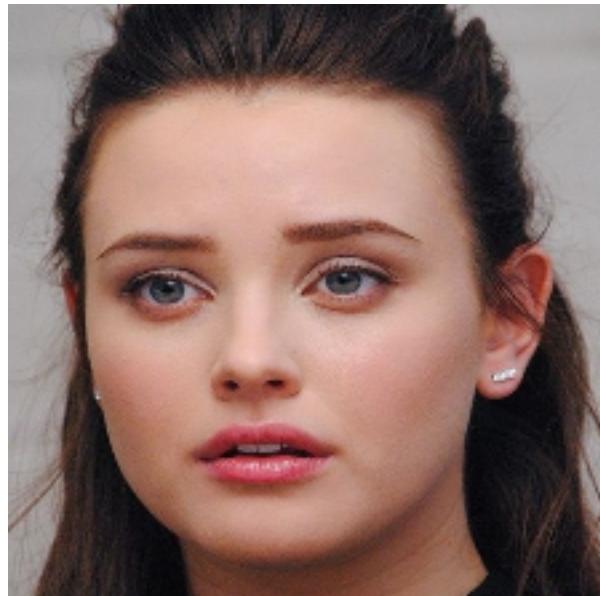
Actual = Brenton Thwaites Predicted = Brenton Thwaites



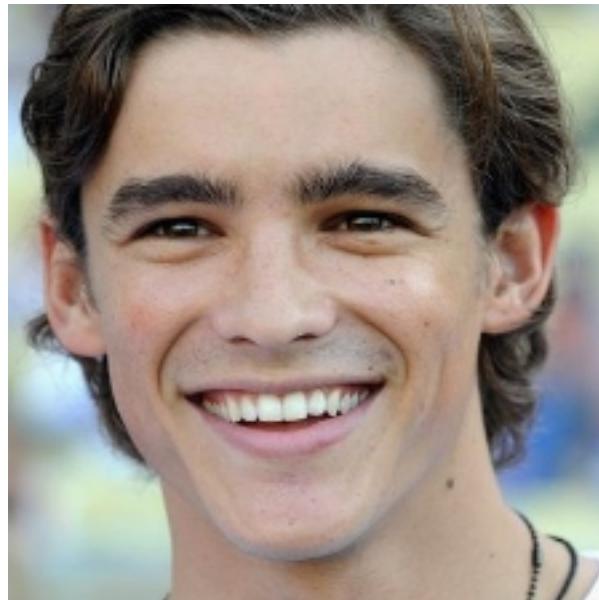
Actual = Taylor Swift Predicted = Taylor Swift



Actual = amber heard Predicted = amber heard



Actual = Katherine Langford Predicted = Katherine Langford



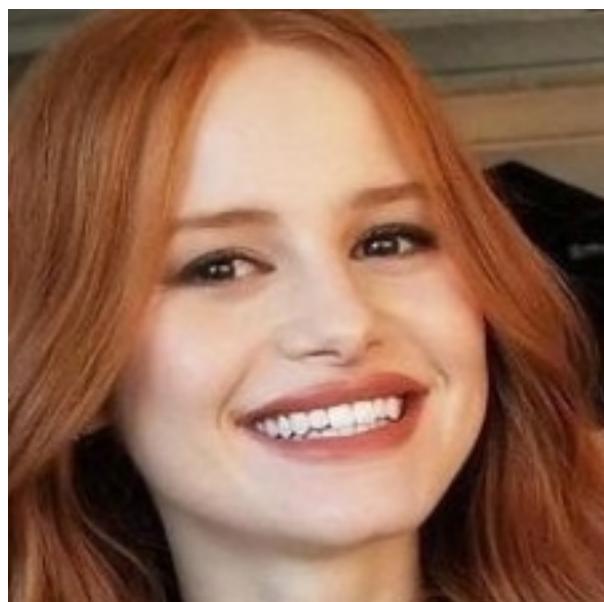
Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = amber heard Predicted = amber heard



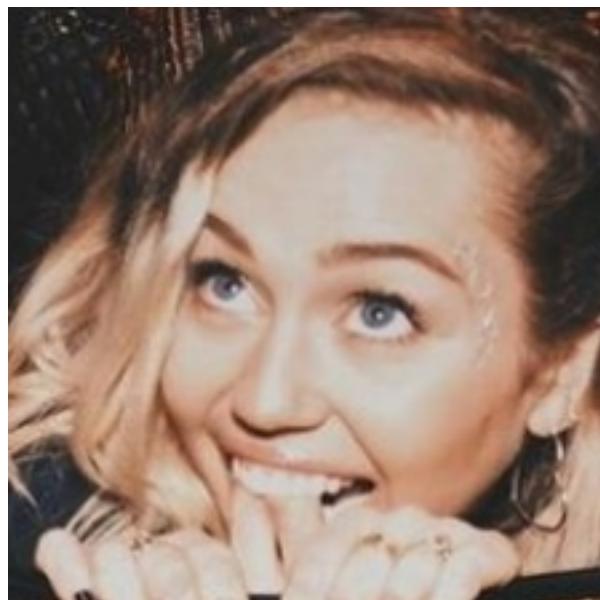
Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = Bill Gates Predicted = Bill Gates



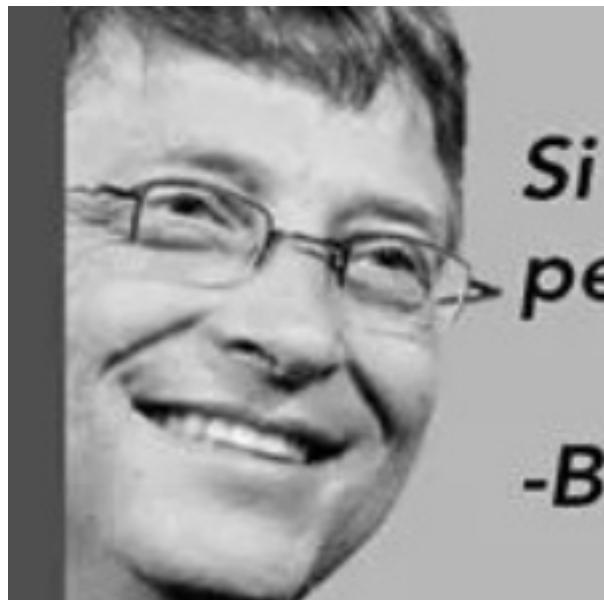
Actual = Anne Hathaway Predicted = Millie Bobby Brown



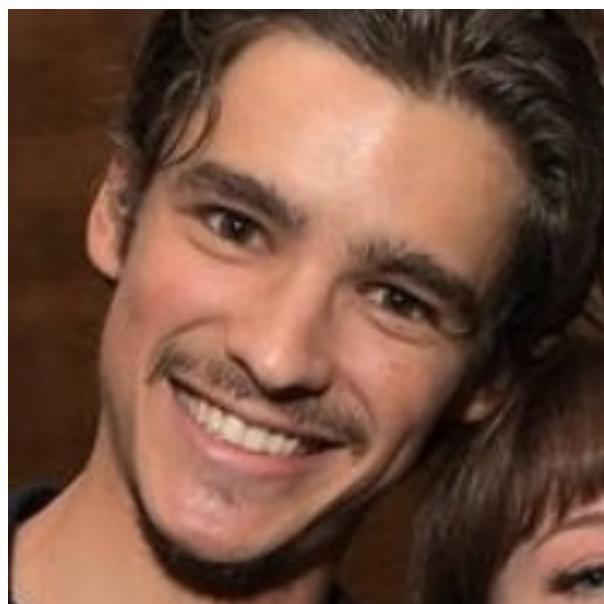
Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = amber heard Predicted = grant gustin



Actual = Bill Gates Predicted = Bill Gates



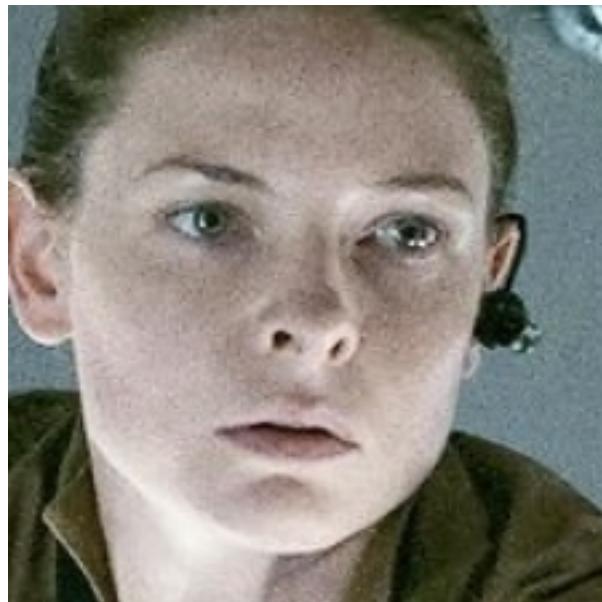
Actual = Brenton Thwaites Predicted = Brenton Thwaites



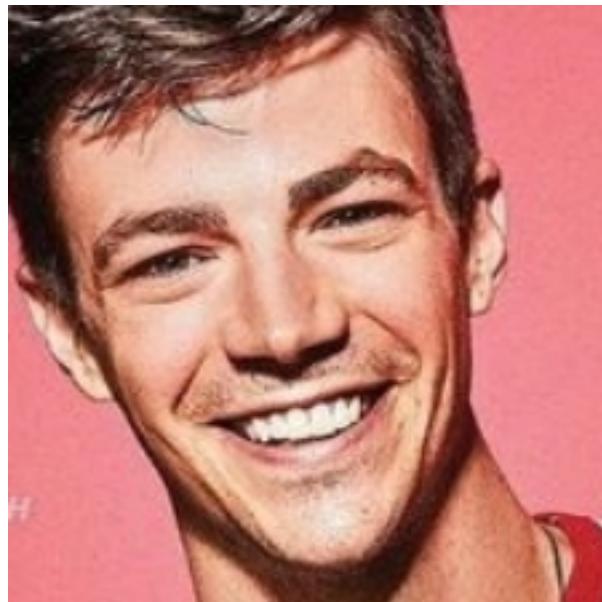
Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



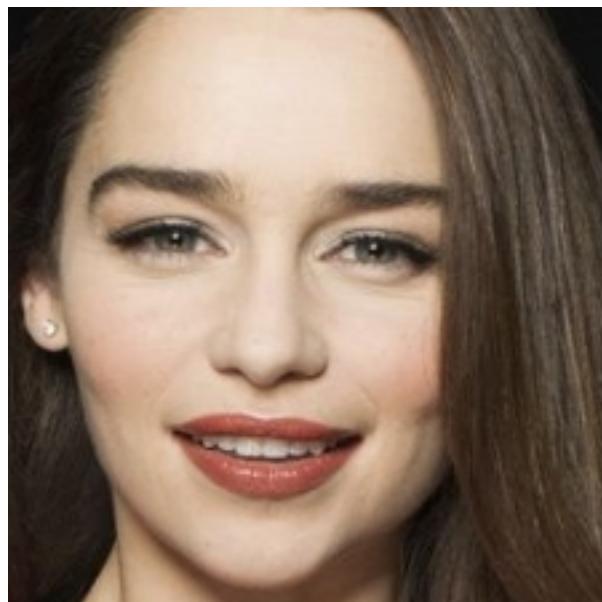
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Rebecca Ferguson Predicted = Millie Bobby Brown



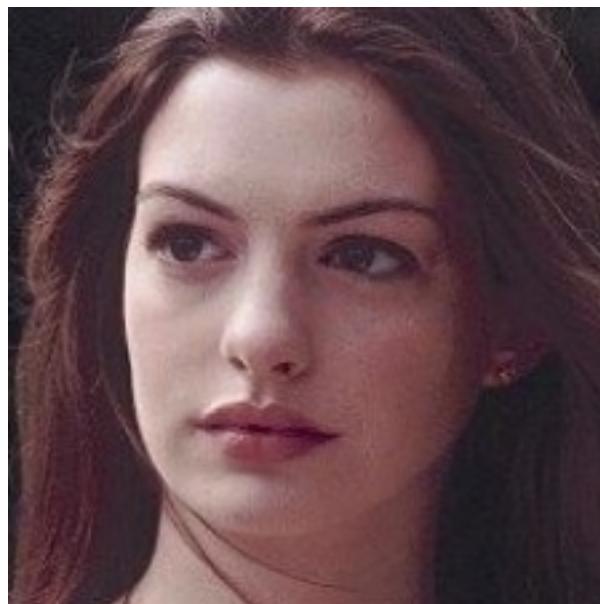
Actual = grant gustin Predicted = grant gustin



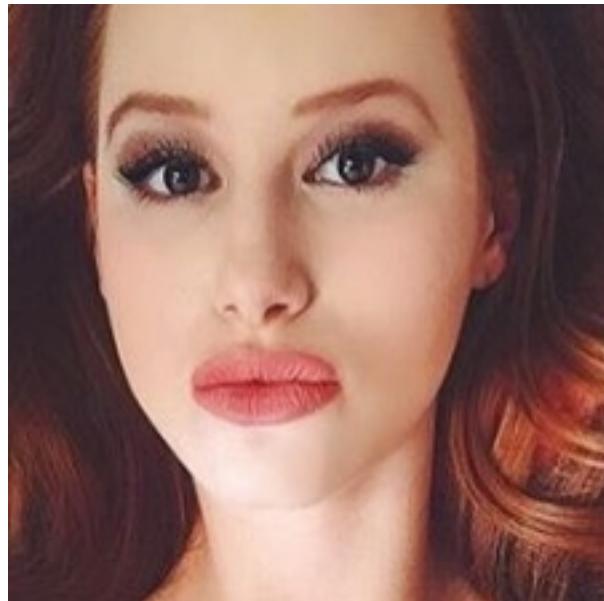
Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Stephen Amell Predicted = Stephen Amell



Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = grant gustin Predicted = grant gustin



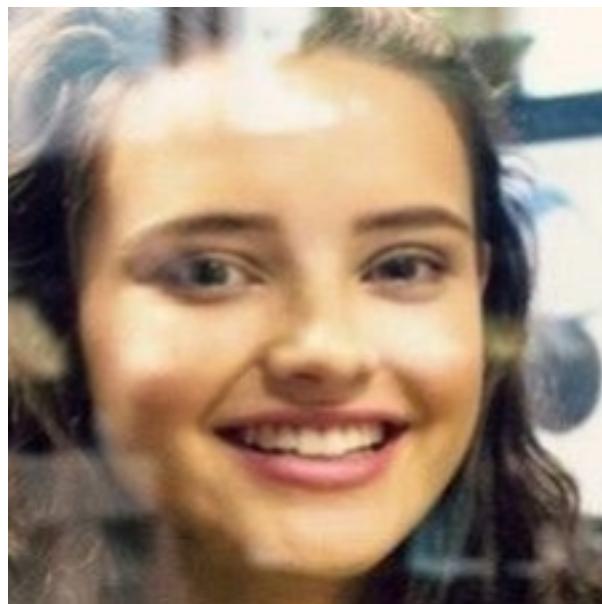
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Taylor Swift Predicted = Taylor Swift



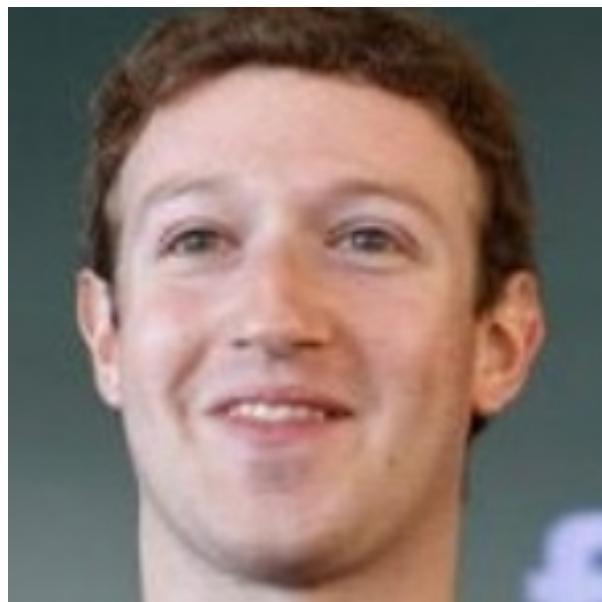
Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Katherine Langford Predicted = Katherine Langford



Actual = Jeremy Renner Predicted = Jeremy Renner



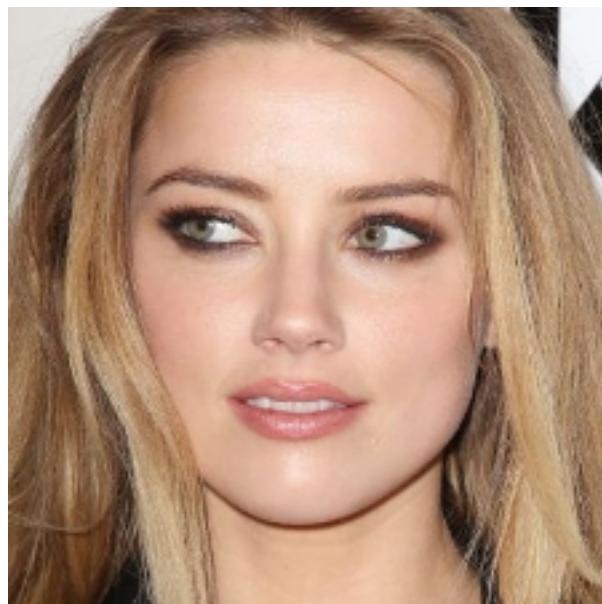
Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



Actual = Anne Hathaway Predicted = Krysten Ritter



Actual = Taylor Swift Predicted = Brenton Thwaites



Actual = amber heard Predicted = amber heard



Actual = Emilia Clarke Predicted = Emilia Clarke



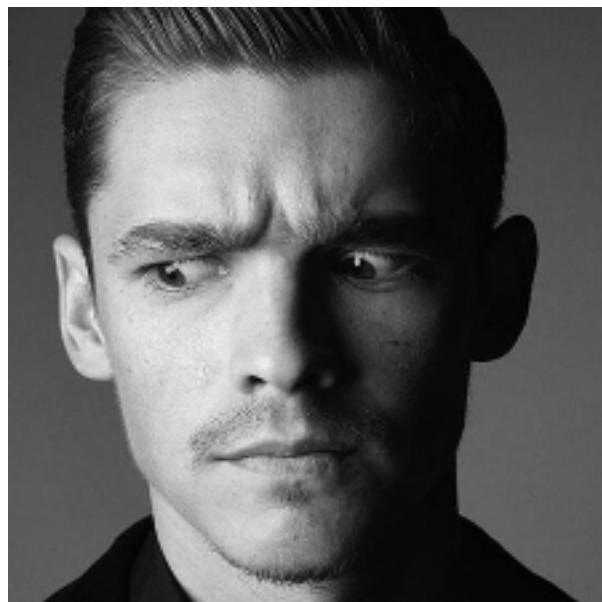
Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



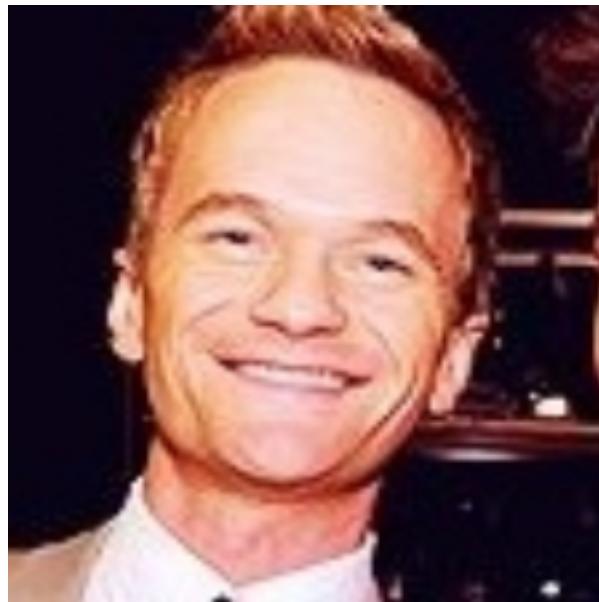
Actual = Brenton Thwaites Predicted = Brenton Thwaites



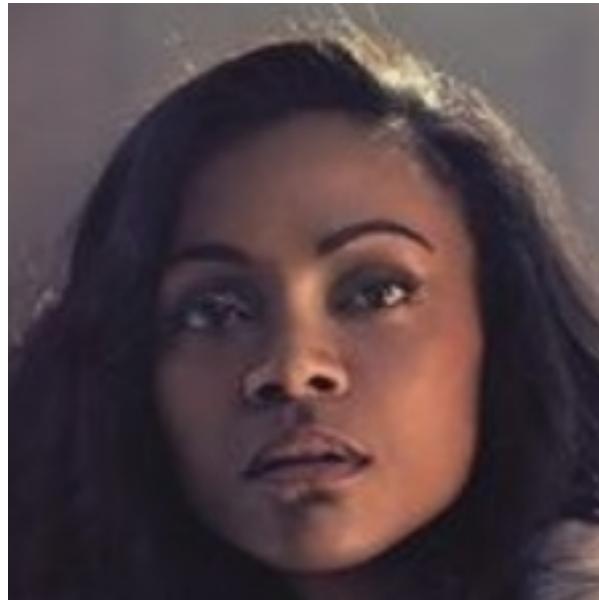
Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Anne Hathaway Predicted = Krysten Ritter



Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Taylor Swift Predicted = Taylor Swift



Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Stephen Amell Predicted = Stephen Amell



Actual = Bill Gates Predicted = Bill Gates



Actual = Emilia Clarke Predicted = Emilia Clarke



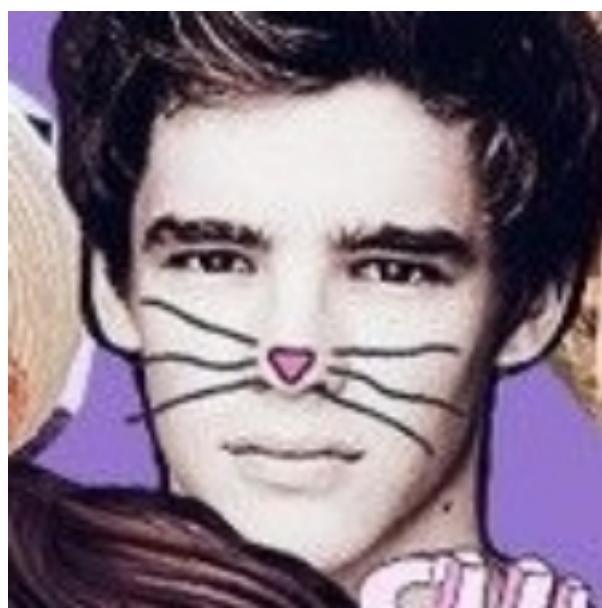
Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = amber heard Predicted = amber heard



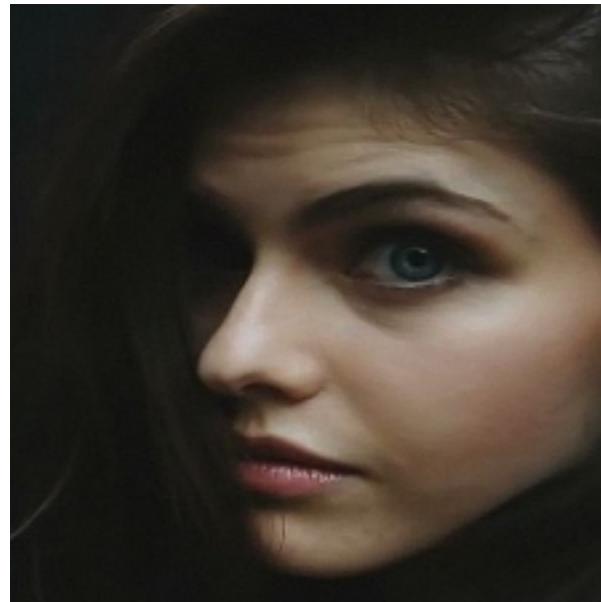
Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Brenton Thwaites Predicted = Brenton Thwaites



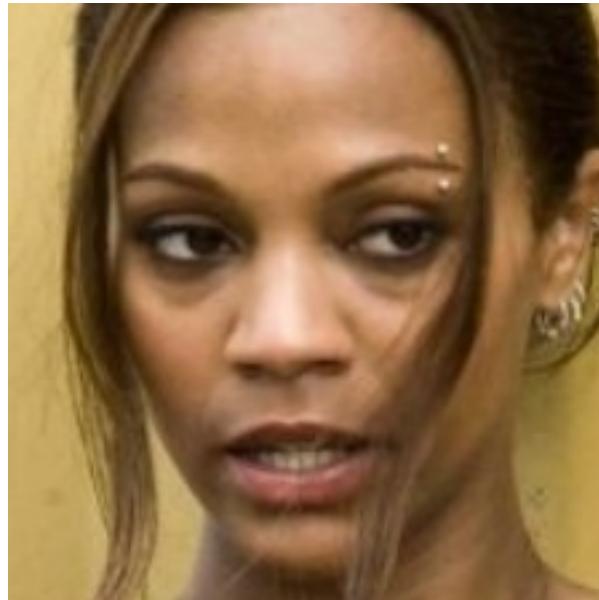
Actual = Stephen Amell Predicted = Stephen Amell



Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Stephen Amell Predicted = Stephen Amell



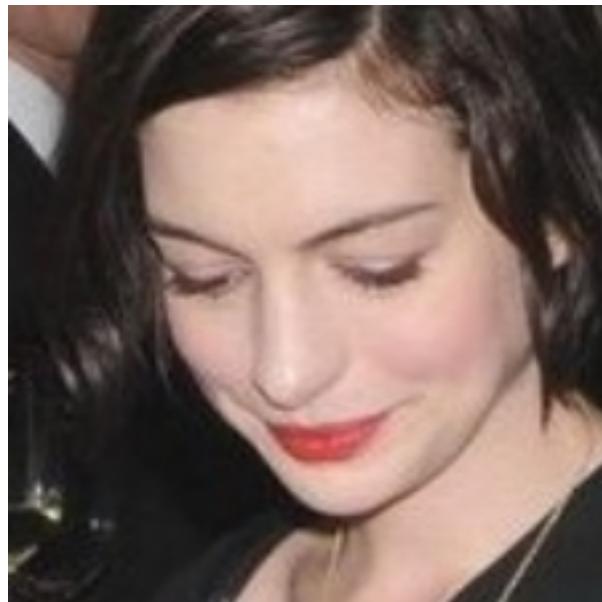
Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Taylor Swift Predicted = Taylor Swift



Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = Emilia Clarke Predicted = Emilia Clarke



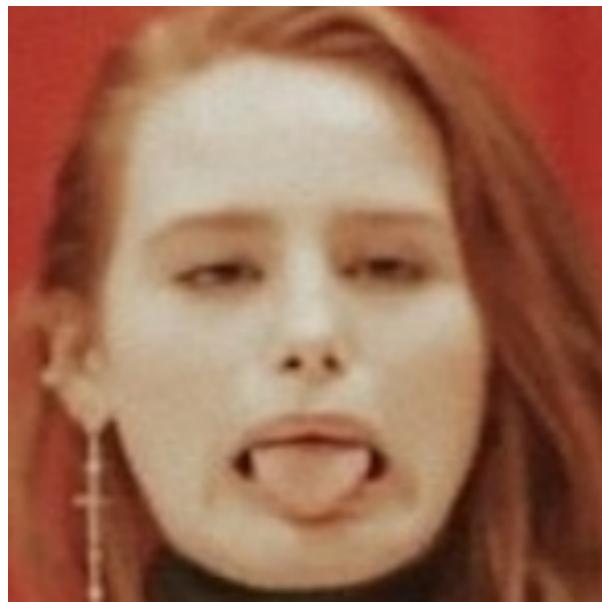
Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = amber heard Predicted = amber heard



Actual = Katherine Langford Predicted = amber heard



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Taylor Swift Predicted = Taylor Swift



Actual = Bill Gates Predicted = Bill Gates



Actual = grant gustin Predicted = grant gustin



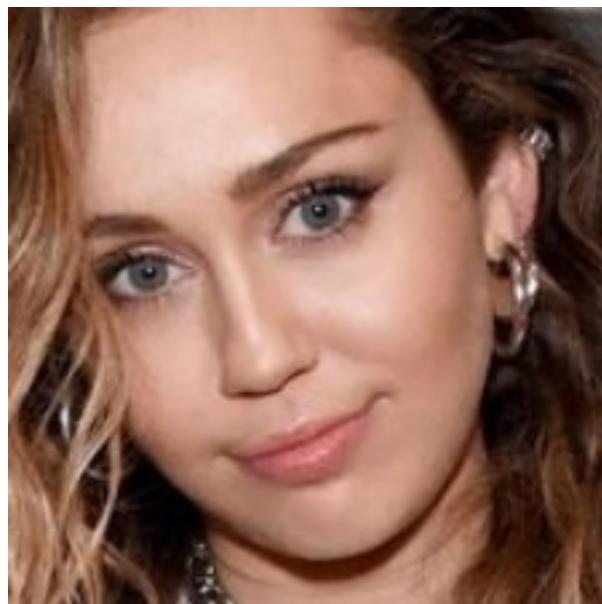
Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Jeremy Renner Predicted = Jeremy Renner



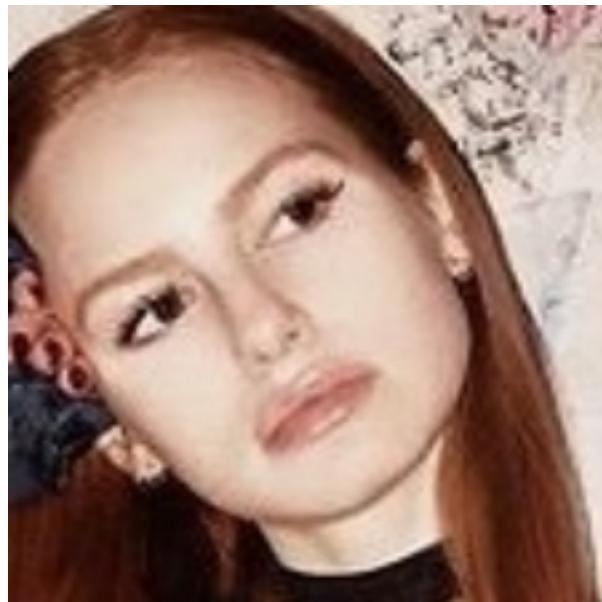
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = Emilia Clarke Predicted = Katherine Langford



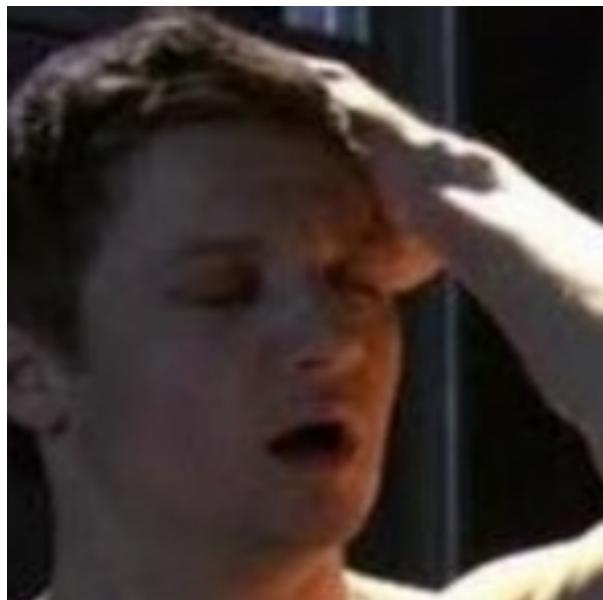
Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



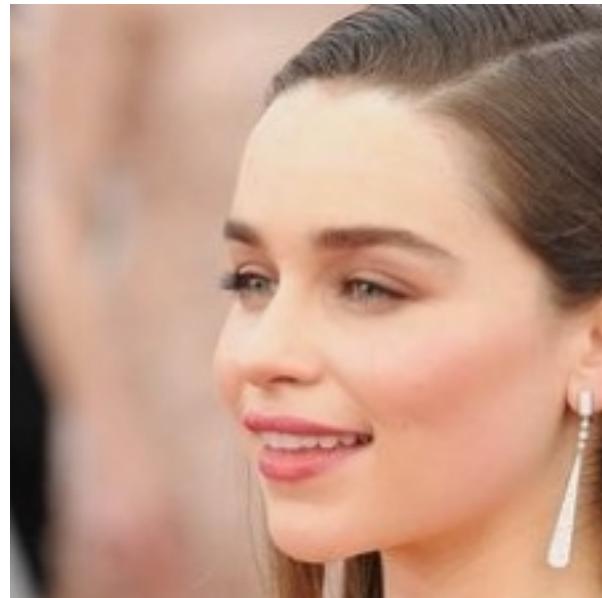
Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = Jeremy Renner Predicted = Neil Patrick Harris



Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



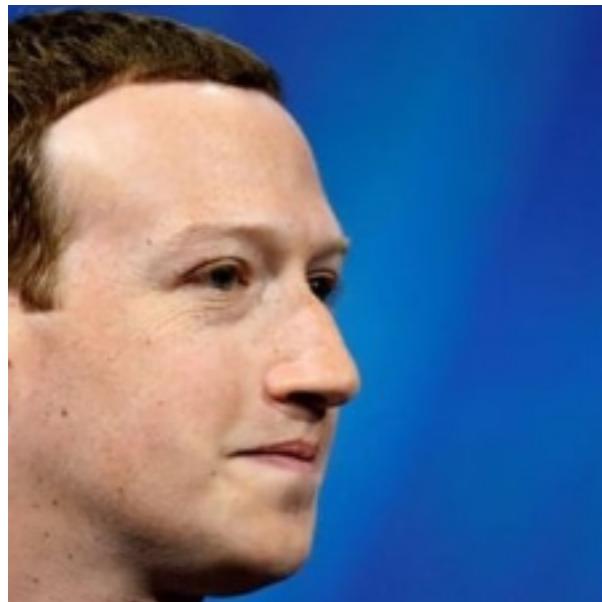
Actual = Emilia Clarke Predicted = Katherine Langford



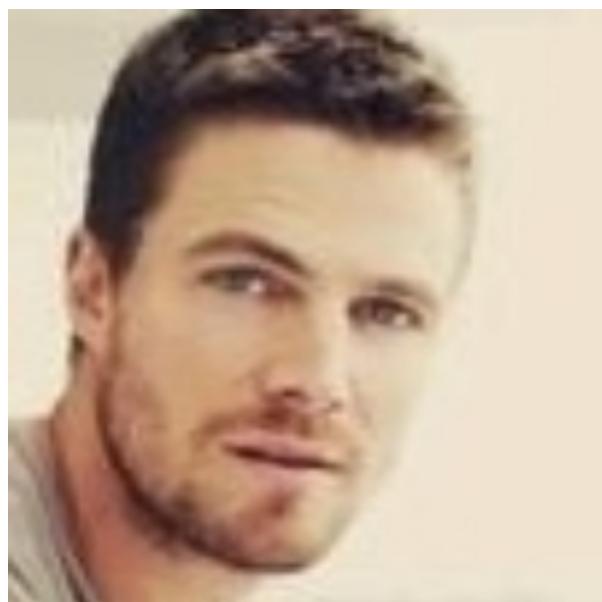
Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Brenton Thwaites Predicted = Brenton Thwaites



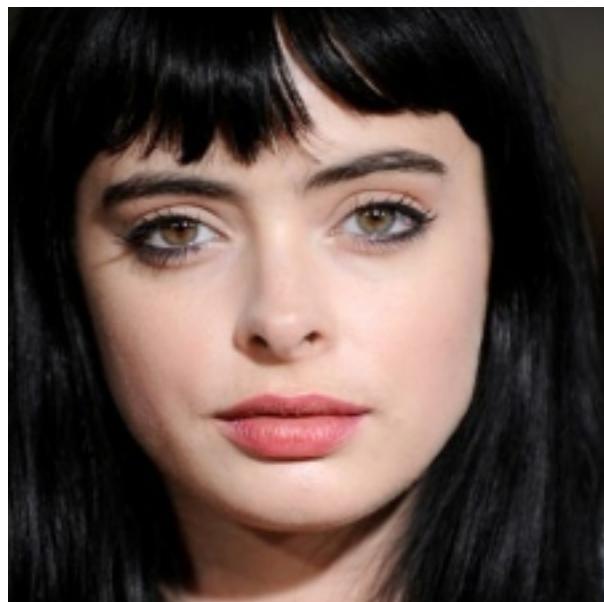
Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



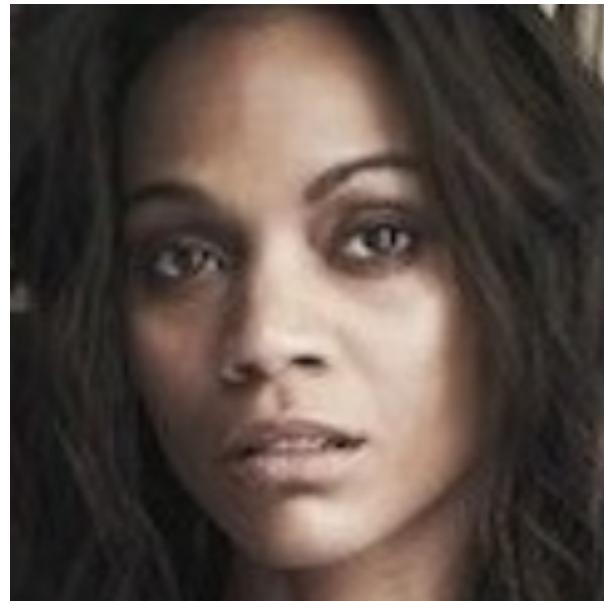
Actual = Stephen Amell Predicted = Stephen Amell



Actual = Rebecca Ferguson Predicted = Emilia Clarke



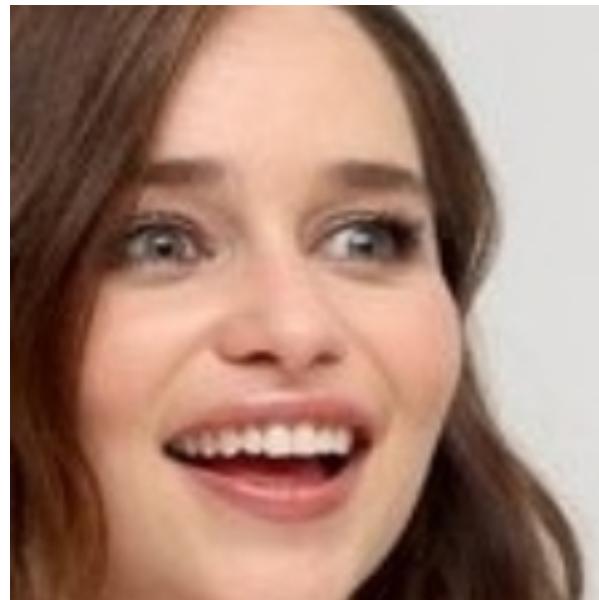
Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Emilia Clarke Predicted = Emilia Clarke



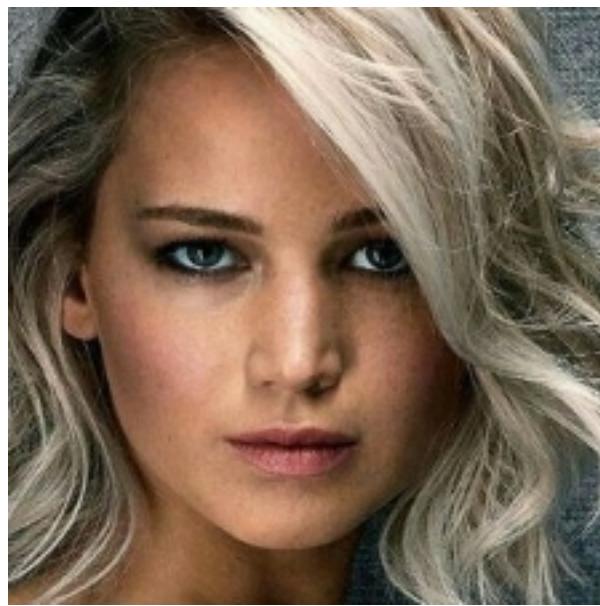
Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = grant gustin Predicted = grant gustin



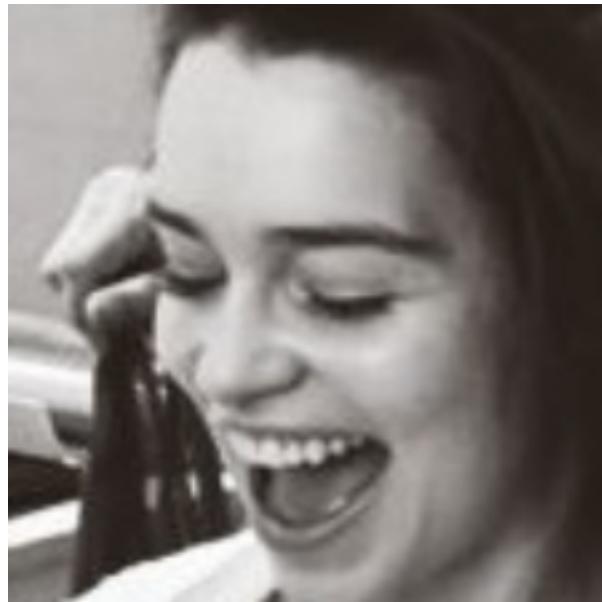
Actual = Brenton Thwaites Predicted = Brenton Thwaites



Actual = Jennifer Lawrence Predicted = Jennifer Lawrence



Actual = Madelaine Petsch Predicted = Millie Bobby Brown



Actual = Emilia Clarke Predicted = Katherine Langford



Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Jeremy Renner Predicted = Bill Gates



Actual = amber heard Predicted = amber heard



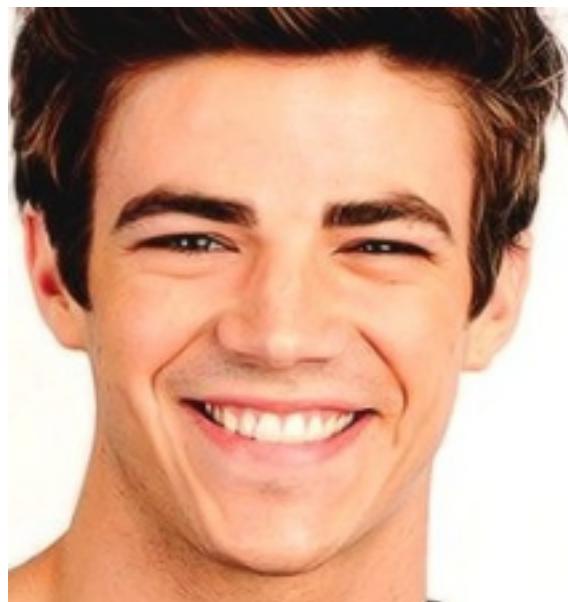
Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



Actual = Krysten Ritter Predicted = Krysten Ritter



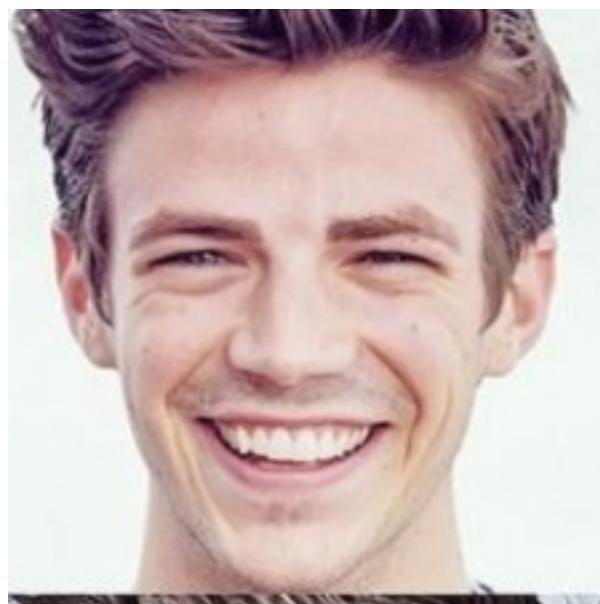
Actual = amber heard Predicted = amber heard



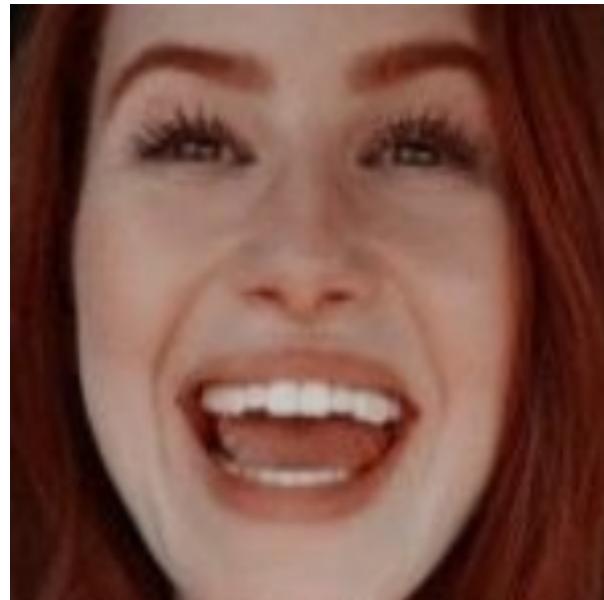
Actual = grant gustin Predicted = grant gustin



Actual = Rebecca Ferguson Predicted = Millie Bobby Brown



Actual = grant gustin Predicted = grant gustin



Actual = Madelaine Petsch Predicted = Madelaine Petsch



Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Alexandra Daddario Predicted = Millie Bobby Brown



Actual = Brenton Thwaites Predicted = Brenton Thwaites



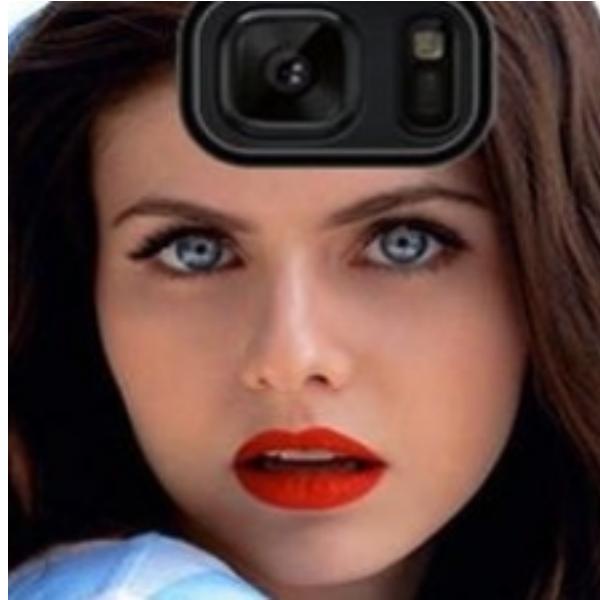
Actual = Krysten Ritter Predicted = Krysten Ritter



Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



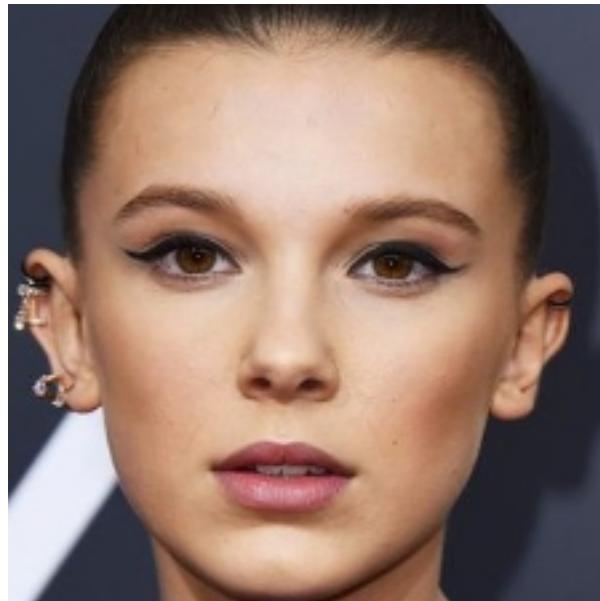
Actual = Madelaine Petsch Predicted = Madelaine Petsch



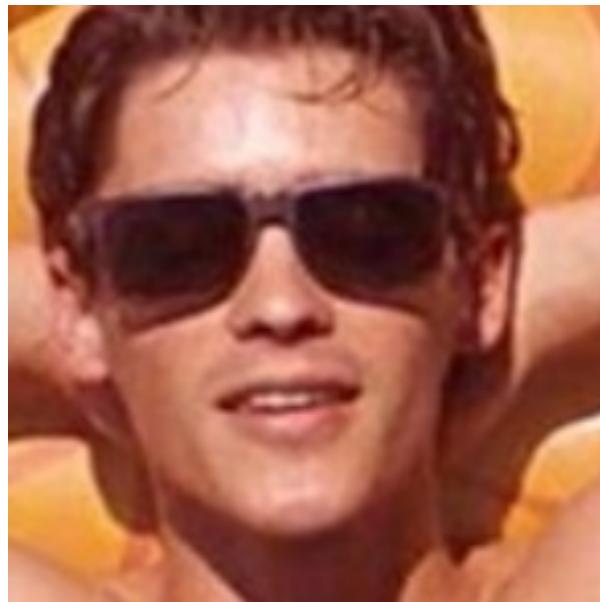
Actual = Alexandra Daddario Predicted = Alexandra Daddario



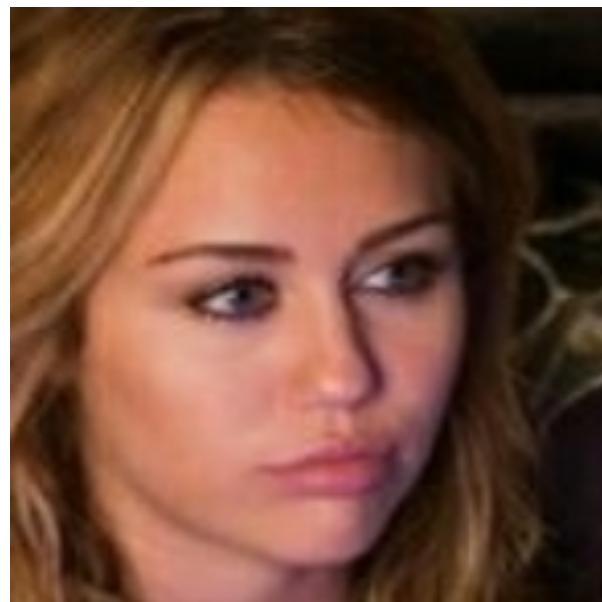
Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



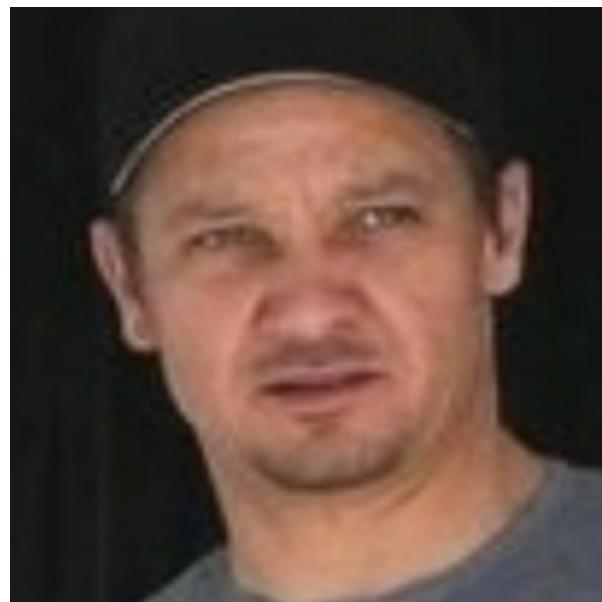
Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



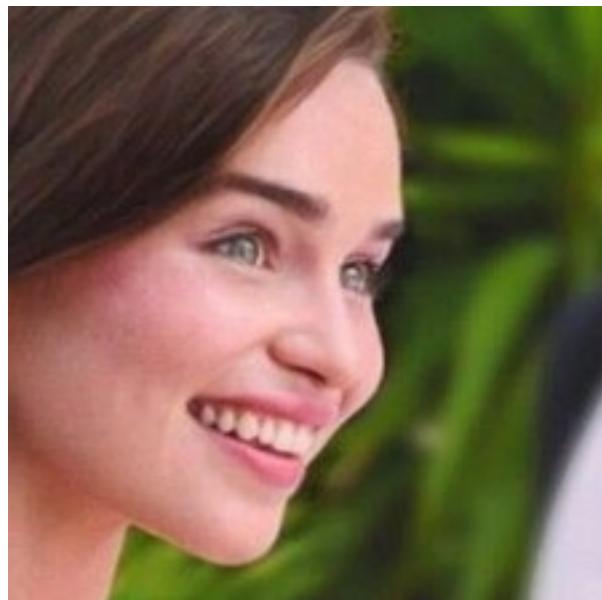
Actual = Brenton Thwaites Predicted = Brenton Thwaites



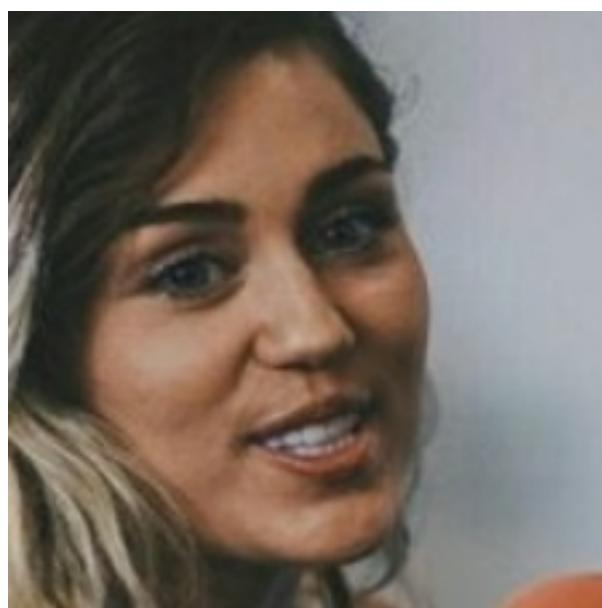
Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = Jeremy Renner Predicted = Jeremy Renner



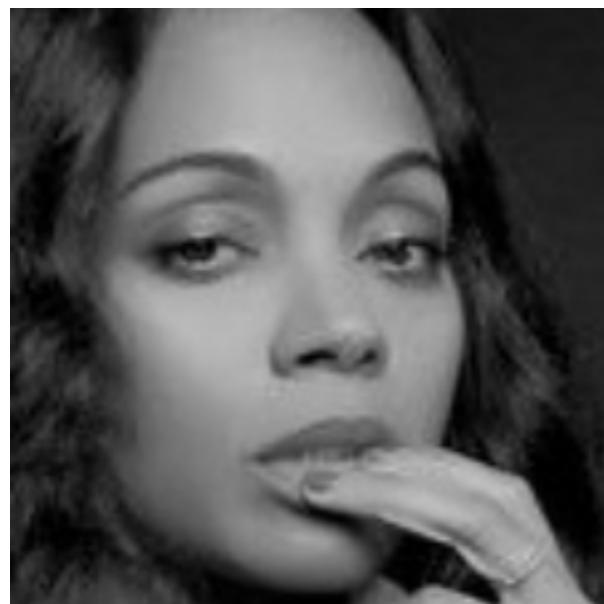
Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Miley Cyrus Predicted = Miley Cyrus



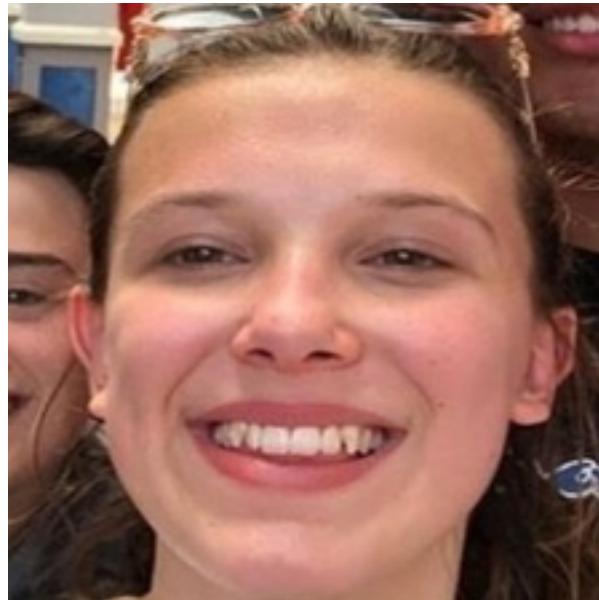
Actual = Stephen Amell Predicted = Stephen Amell



Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Alexandra Daddario Predicted = Alexandra Daddario



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



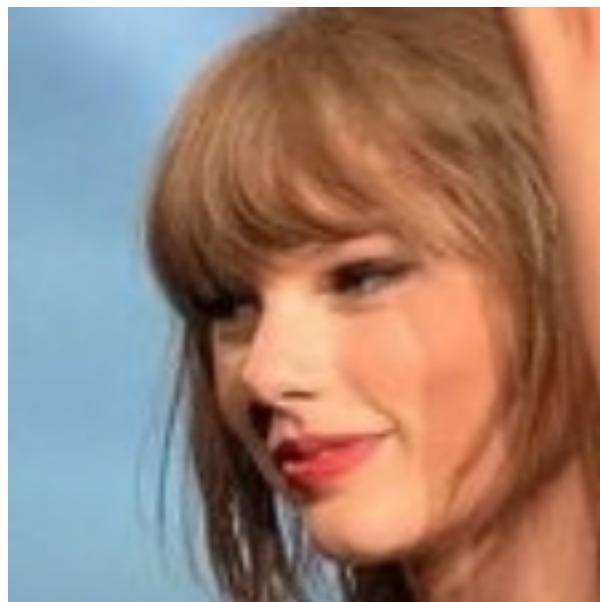
Actual = Neil Patrick Harris Predicted = Neil Patrick Harris



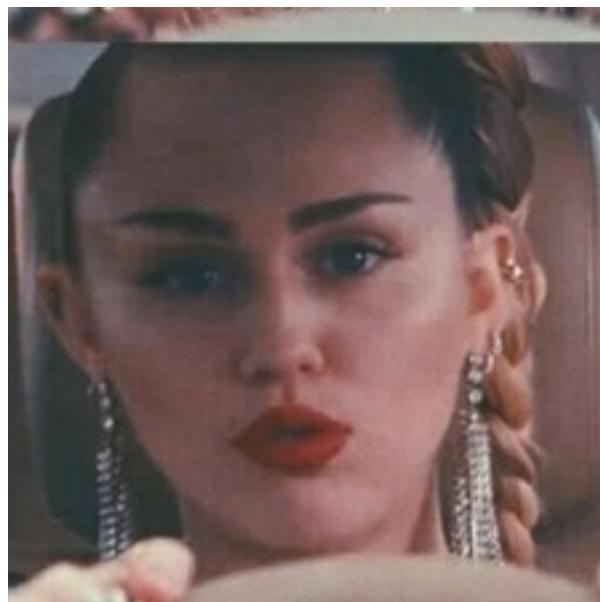
Actual = Stephen Amell Predicted = Stephen Amell



Actual = Jennifer Lawrence Predicted = Taylor Swift



Actual = Taylor Swift Predicted = Taylor Swift



Actual = Miley Cyrus Predicted = Miley Cyrus



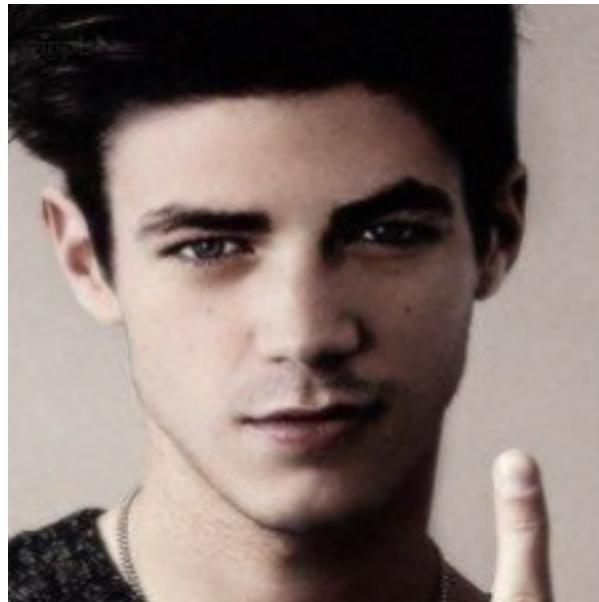
Actual = Anne Hathaway Predicted = Anne Hathaway



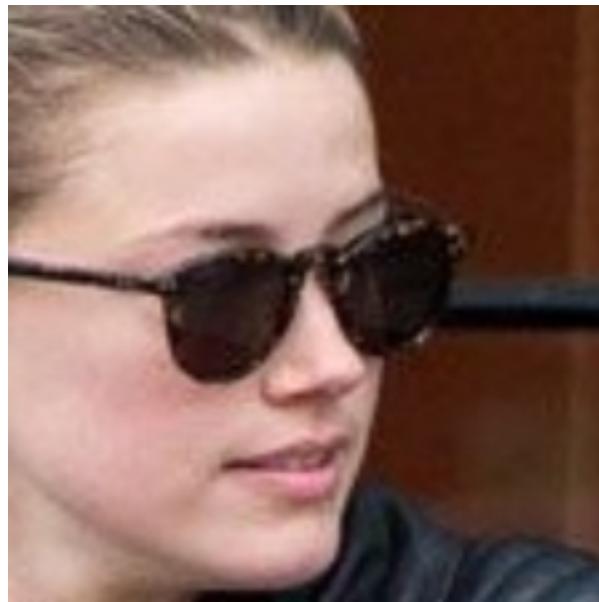
Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



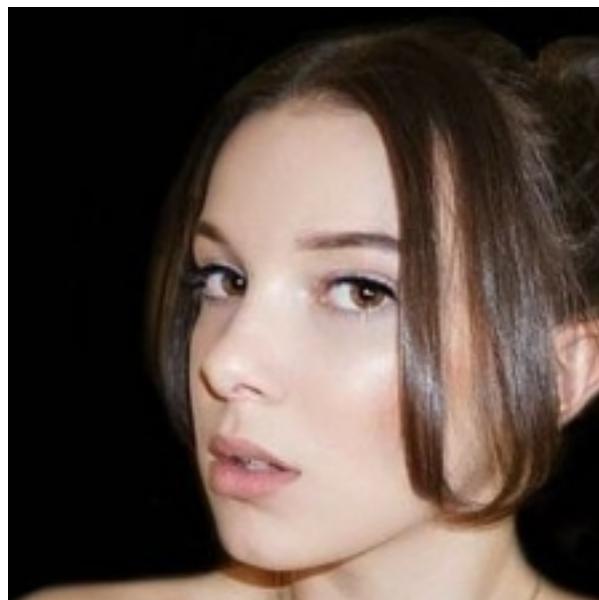
Actual = grant gustin Predicted = grant gustin



Actual = amber heard Predicted = Millie Bobby Brown



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Millie Bobby Brown Predicted = Millie Bobby Brown



Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = Emilia Clarke Predicted = Katherine Langford



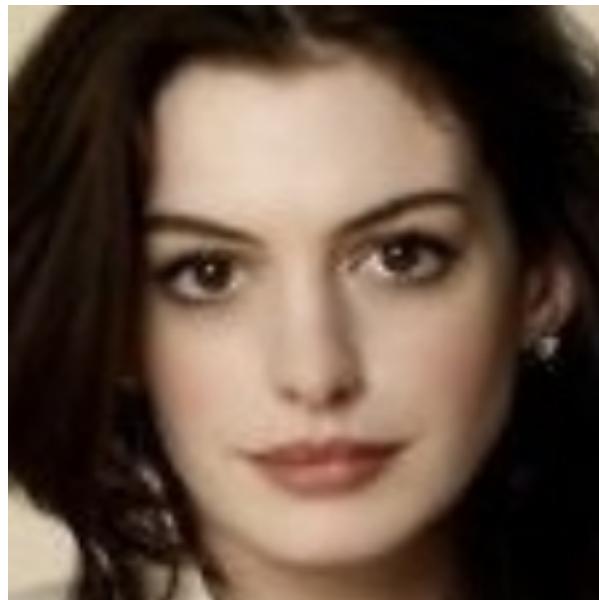
Actual = Jeremy Renner Predicted = Jeremy Renner



Actual = amber heard Predicted = amber heard



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Anne Hathaway Predicted = Anne Hathaway



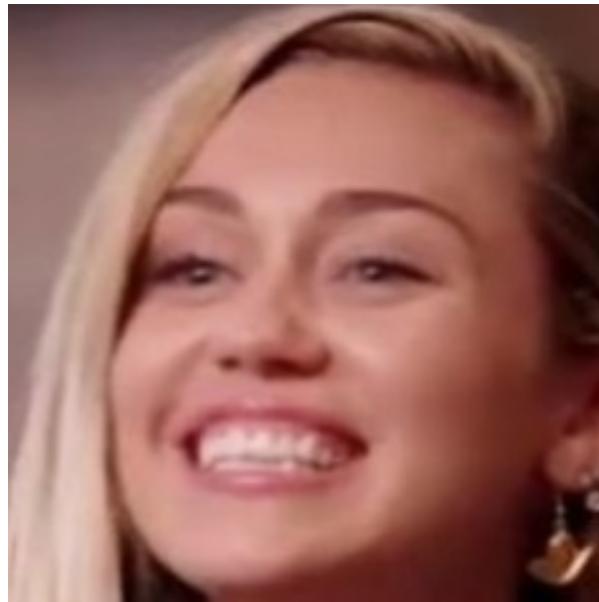
Actual = Emilia Clarke Predicted = Emilia Clarke



Actual = Anne Hathaway Predicted = Anne Hathaway



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



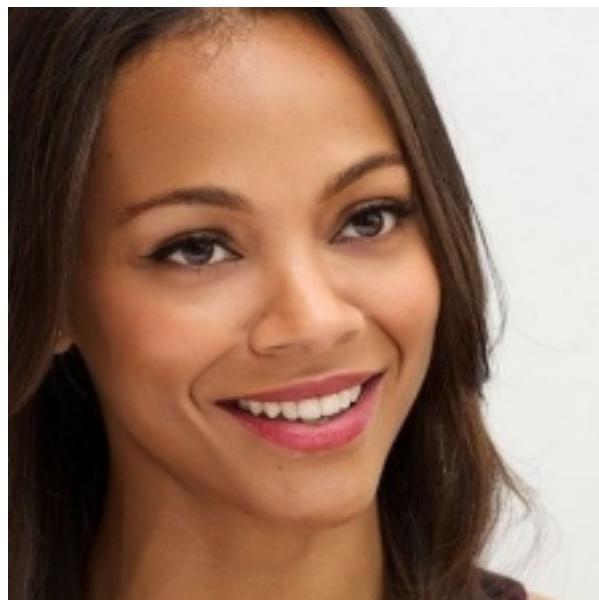
Actual = Miley Cyrus Predicted = Miley Cyrus



Actual = Mark Zuckerberg Predicted = Mark Zuckerberg



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Zoe Saldana Predicted = Zoe Saldana



Actual = Rebecca Ferguson Predicted = Rebecca Ferguson



Actual = Bill Gates Predicted = Bill Gates

```
[ ]: print("Out of Sample Accuracy = ", count/len(y_cat))

[39]: NB_EPOCHS = 64
#np.abs(np.subtract(val_loss_trace,loss_trace))
m = []
for i in range(1,NB_EPOCHS+1):
    m.append(i)

[40]: plot_save = '/content/drive/My Drive/Colab Notebooks/ProjectData/
        ↪FaceRecognition/plots/
        ↪holly_test_train_split(checkpoint_holly_MobileNet_2_test)/'
!mkdir '{plot_save}'

loss_trace = r.history['loss']
val_loss_trace = r.history['val_loss']
delta = np.abs(np.subtract(val_loss_trace,loss_trace))
min_lo = np.argmin(delta) +1# +1 because the indexing starts from 1
plt.axvline(x=min_lo,c = 'k', linestyle='-.')
s = 'Min loss difference is =',delta[min_lo-1]

plt.plot(m,delta, c = 'g')
plt.plot(m,loss_trace, c='r')
plt.plot(m,val_loss_trace, c='b')
plt.xlabel('Epoch Number')
plt.ylabel('Loss')
plt.legend([s,'Abs(train loss - test loss)', 'Training loss', 'Validation loss'], loc='upper right')
plt.savefig(plot_save+'loss.png')
plt.show()

accuracy_trace = r.history['accuracy']
val_accuracy_trace = r.history['val_accuracy']

max_acc = np.argmax(val_accuracy_trace) +1 # +1 because the indexing starts from 1
plt.axvline(x=max_acc,c = 'k', linestyle='-.')
s0 = 'Max Accuracy on Testset is =',val_accuracy_trace[max_acc-1]

plt.plot(m,accuracy_trace, c='r')
plt.plot(m,val_accuracy_trace, c='b')
plt.xlabel('Epoch Number')
```

```

plt.ylabel('Accuracy')
plt.legend([s0,'Training acc', 'Validation acc'], loc='lower right')
plt.savefig(plot_save+'acc.png')
plt.show()

precision_trace = r.history['precision']
val_precision_trace = r.history['val_precision']

max_pre = np.argmax(val_precision_trace) +1 # +1 because the indexing starts
    ↪from 1
plt.axvline(x=max_pre,c = 'k', linestyle='-.')
s1 = 'Max Precision on Testset is =',val_precision_trace[max_pre-1]

plt.plot(m,precision_trace, c='r')
plt.plot(m,val_precision_trace, c='b')
plt.xlabel('Epoch Number')
plt.ylabel('Precision')
plt.legend([s1,'Training precision', 'Validation precision'], loc='lower
    ↪right')
plt.savefig(plot_save+'pre.png')
plt.show()

recall_trace = r.history['recall']
val_recall_trace = r.history['val_recall']

max_recall = np.argmax(val_recall_trace) +1 # +1 because the indexing starts
    ↪from 1
plt.axvline(x=max_recall,c = 'k', linestyle='-.')
s2 = 'Max Recall on Testset is =',val_recall_trace[max_recall-1]

plt.plot(m,recall_trace, c='r')
plt.plot(m,val_recall_trace, c='b')
plt.xlabel('Epoch Number')
plt.ylabel('Recall')
plt.legend([s2,'Training recall', 'Validation recall'], loc='lower right')
plt.savefig(plot_save+'recall.png')
plt.show()

f1_score = 2*(np.multiply(precision_trace , recall_trace))/(np.
    ↪add(precision_trace ,recall_trace))

```

```

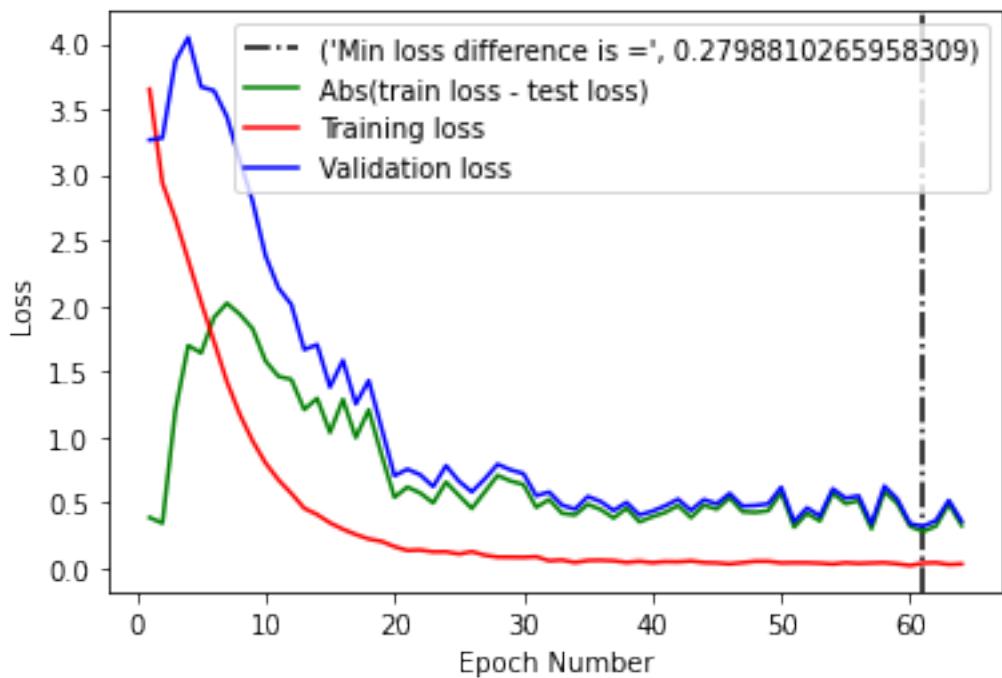
val_f1_score = 2*(np.multiply(val_precision_trace , val_recall_trace))/(np.
↪add(val_precision_trace ,val_recall_trace))

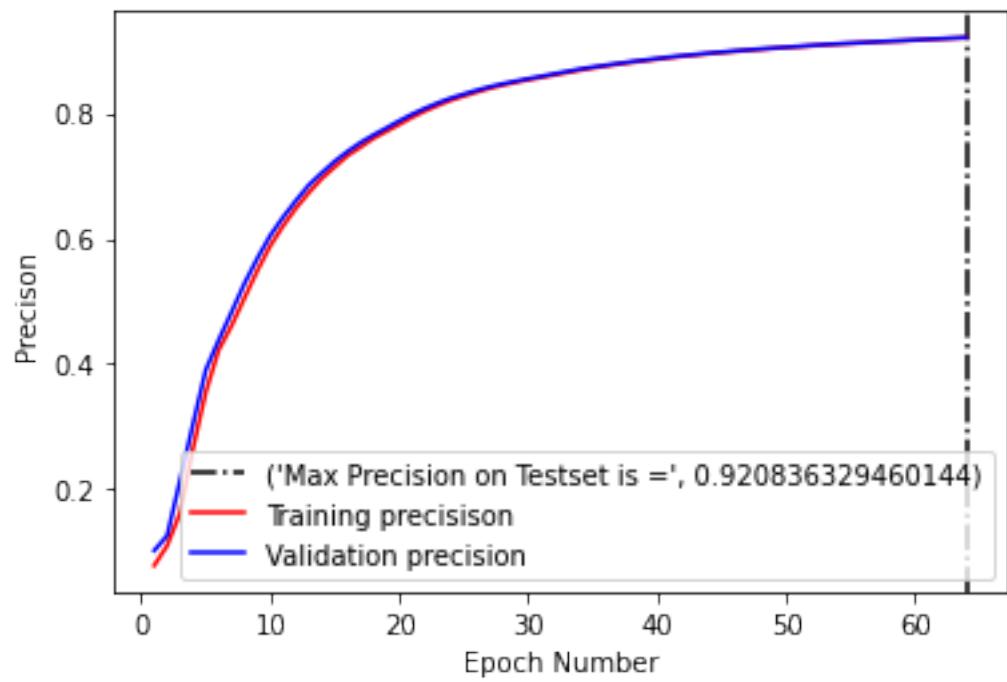
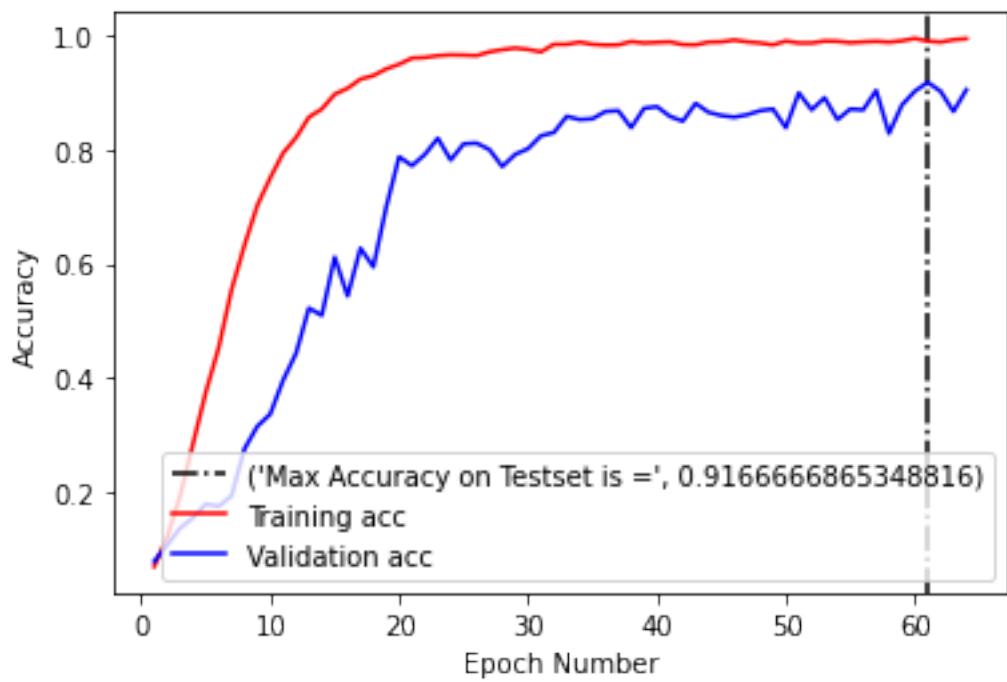
f1_trace = f1_score
val_recall_trace = val_f1_score

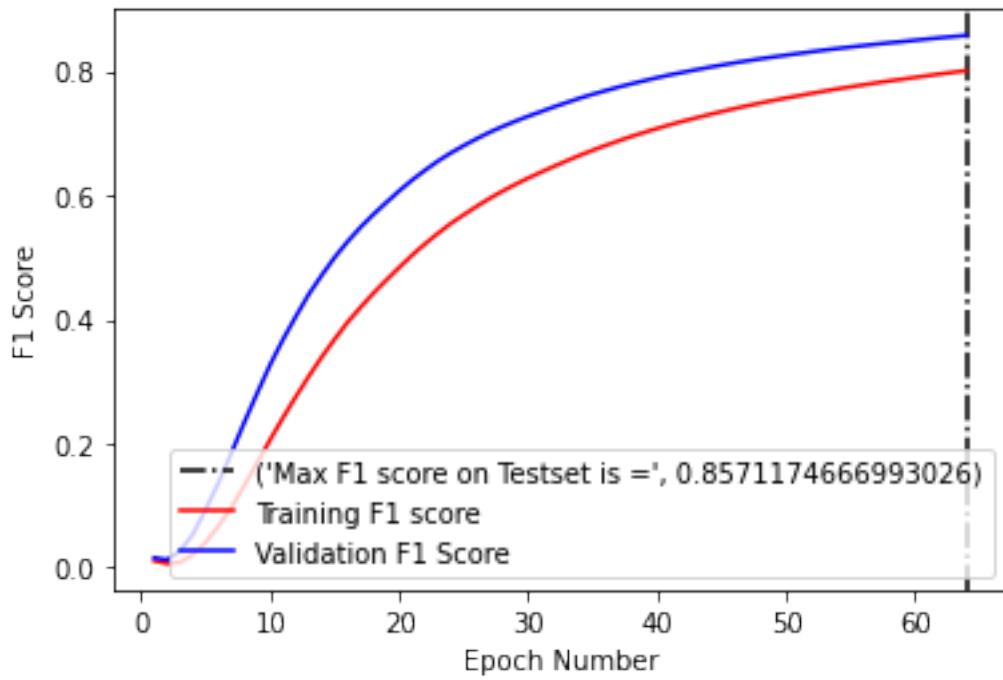
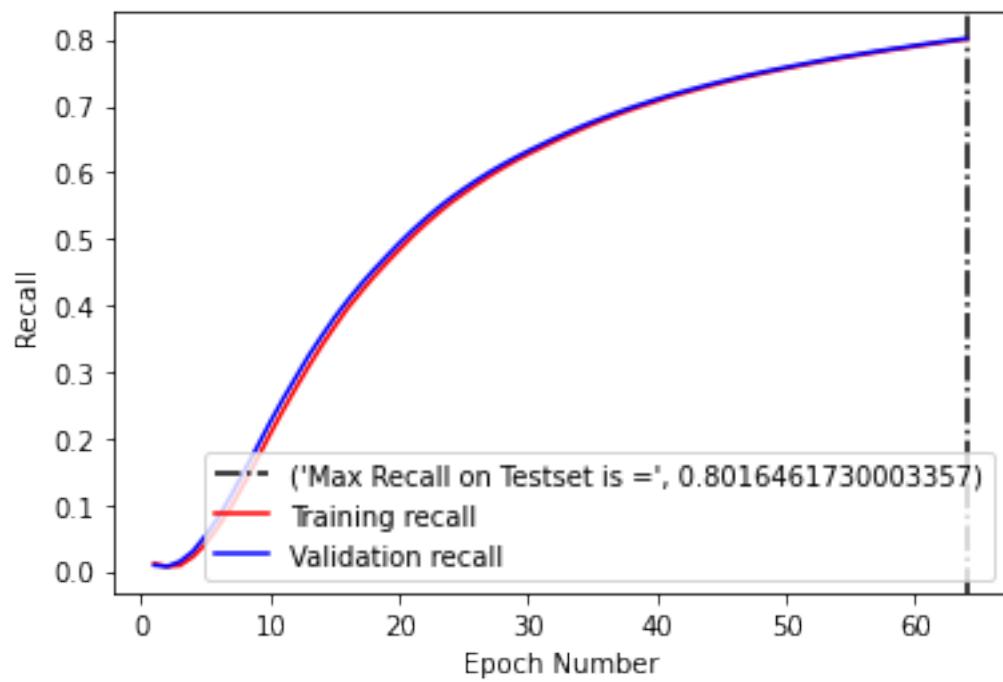
max_f1 = np.argmax(val_f1_score) +1 # +1 because the indexing starts from 1
plt.axvline(x=max_f1,c = 'k', linestyle='-.')
s3 = 'Max F1 score on Testset is =',val_f1_score[max_f1-1]

plt.plot(m,recall_trace, c='r')
plt.plot(m,val_recall_trace, c='b')
plt.xlabel('Epoch Number')
plt.ylabel('F1 Score')
plt.legend([s3, 'Training F1 score', 'Validation F1 Score'], loc='lower right')
plt.savefig(plot_save+f1.png')
plt.show()

```







[34] : delta

```
[34]: array([0.19526958, 0.50082946, 0.78491998, 0.97639704, 1.14457297,
       1.06516719, 0.72714484, 0.98575008, 1.0870626 , 1.15515399,
       1.17374057, 1.04473025, 0.77131969, 0.83597994, 0.58045527,
       0.65904495, 0.77399996, 0.63790347, 1.02128492, 0.55944136,
       0.77147141, 0.50878549, 0.41847786, 0.53288539, 0.49613889,
       0.33872102, 0.5840486 , 0.31435278, 0.33630261, 0.34017517,
       0.39900458, 0.36987109])
```

```
[48]: path = '/content/drive/My Drive/Colab Notebooks/ProjectData/FaceRecognition/
         →faceMobileNet_TransferLearning.ipynb'
```

```
[ ]:
```

```
[50]: !jupyter nbconvert '{path}' --to pdf
```

```
[NbConvertApp] Converting notebook /content/drive/My Drive/Colab
Notebooks/ProjectData/FaceRecognition/faceMobileNet_TransferLearning.ipynb to
pdf
[NbConvertApp] Support files will be in faceMobileNet_TransferLearning_files/
[NbConvertApp] Making directory ./faceMobileNet_TransferLearning_files
[NbConvertApp] Writing 223399 bytes to ./notebook.tex
[NbConvertApp] Building PDF
Traceback (most recent call last):
  File "/usr/local/bin/jupyter-nbconvert", line 8, in <module>
    sys.exit(main())
  File "/usr/local/lib/python2.7/dist-packages/jupyter_core/application.py",
line 267, in launch_instance
    return super(JupyterApp, cls).launch_instance(argv=argv, **kwargs)
  File "/usr/local/lib/python2.7/dist-packages/traitlets/config/application.py",
line 658, in launch_instance
    app.start()
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/nbconvertapp.py", line
338, in start
    self.convert_notebooks()
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/nbconvertapp.py", line
508, in convert_notebooks
    self.convert_single_notebook(notebook_filename)
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/nbconvertapp.py", line
479, in convert_single_notebook
    output, resources = self.export_single_notebook(notebook_filename,
```

```
resources, input_buffer=input_buffer)
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/nbconvertapp.py", line
408, in export_single_notebook
    output, resources = self.exporter.from_filename(notebook_filename,
resources=resources)
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/exporters/exporter.py",
line 179, in from_filename
    return self.from_file(f, resources=resources, **kw)
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/exporters/exporter.py",
line 197, in from_file
    return self.from_notebook_node(nbformat.read(file_stream, as_version=4),
resources=resources, **kw)
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/exporters/pdf.py", line
178, in from_notebook_node
    rc = self.run_latex(tex_file)
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/exporters/pdf.py", line
149, in run_latex
    self.latex_count, log_error)
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/exporters/pdf.py", line
111, in run_command
    "at {link}.".format(formatter=command_list[0], link=link))
OSErr: xelatex not found on PATH, if you have not installed xelatex you may
need to do so. Find further instructions at
https://nbconvert.readthedocs.io/en/latest/install.html#installing-tex.
```

[]: