

# CAST: Conditional Attribute Subsampling Toolkit for Fine-grained Evaluation

## Supplementary Material

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### Supplementary Overview

In Section 0.1, psuedo-code is provided for the generation of the CAST-11 (C11) benchmark, which was introduced in Section 4.4 of the main paper. In Section 0.2, attribute correlation heatmap matrices are provided for attributes calculated over WebFace42M. A complete table of attriute Pearson correlations is provided after the matrices.

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## 0.1. C11 Benchmark Generation

The following is pseudo code for the hard-pair mining in the C11 benchmark.

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### Algorithm 1: Psuedo-code for generation of CC11 Benchmark

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 $\mathcal{D} \leftarrow \text{Webface42M} \setminus \text{WebFace12M};$ 
 $\mathcal{F} \leftarrow \text{RESNET100};$ 
 $\mathcal{A} \leftarrow \{a_1..a_{11}\};$  /* attributes each sub-benchmark */
 $\mathcal{T} \leftarrow \{(t_1^+, t_1^-)..(t_{11}^+, t_{11}^-)\};$  /* upper lower quartile per attribute */
 $IP \leftarrow \{IP_1 \leftarrow \emptyset..IP_{11} \leftarrow \emptyset\};$  /* init per attribute impostor pairs set */
 $GP \leftarrow \{GP_1 \leftarrow \emptyset..GP_{11} \leftarrow \emptyset\};$  /* init per attribute genuine pairs set */
 $\gamma_- \leftarrow 0.15;$ 
 $\gamma_+ \leftarrow 0.30;$ 
for  $i \leftarrow 0$  to 11 do
     $\mathcal{D}_i \leftarrow \text{CAST\_FILTER}(\mathcal{D}, a_i, t_i^-, t_i^+);$ 
    while  $\|GP_i\| < 5000$  do
         $s_1, s_2 \leftarrow \text{random unseen matching pair};$ 
         $x_1, x_2 \leftarrow \mathcal{F}(s_1), \mathcal{F}(s_2);$ 
         $d \leftarrow \frac{x_1 \cdot x_2}{\|x_1\| \|x_2\|}$ 
        if  $\gamma_- \leq d \leq \gamma_+$  then
             $GP_i \leftarrow GP_i \cup \{(s_1, s_2)\}$ 
        else
            end
        while  $\|IP_i\| < 5000$  do
             $s_1, s_2 \leftarrow \text{random unseen non-matching pair};$ 
             $x_1, x_2 \leftarrow \mathcal{F}(s_1), \mathcal{F}(s_2);$ 
             $d \leftarrow \frac{x_1 \cdot x_2}{\|x_1\| \|x_2\|}$ 
            if  $\gamma_- \leq d \leq \gamma_+$  then
                 $IP_i \leftarrow IP_i \cup \{(s_1, s_2)\}$ 
            else
                end
            end
        end
    end
end

```

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## 0.2. Mild to Significant Attribute Correlations

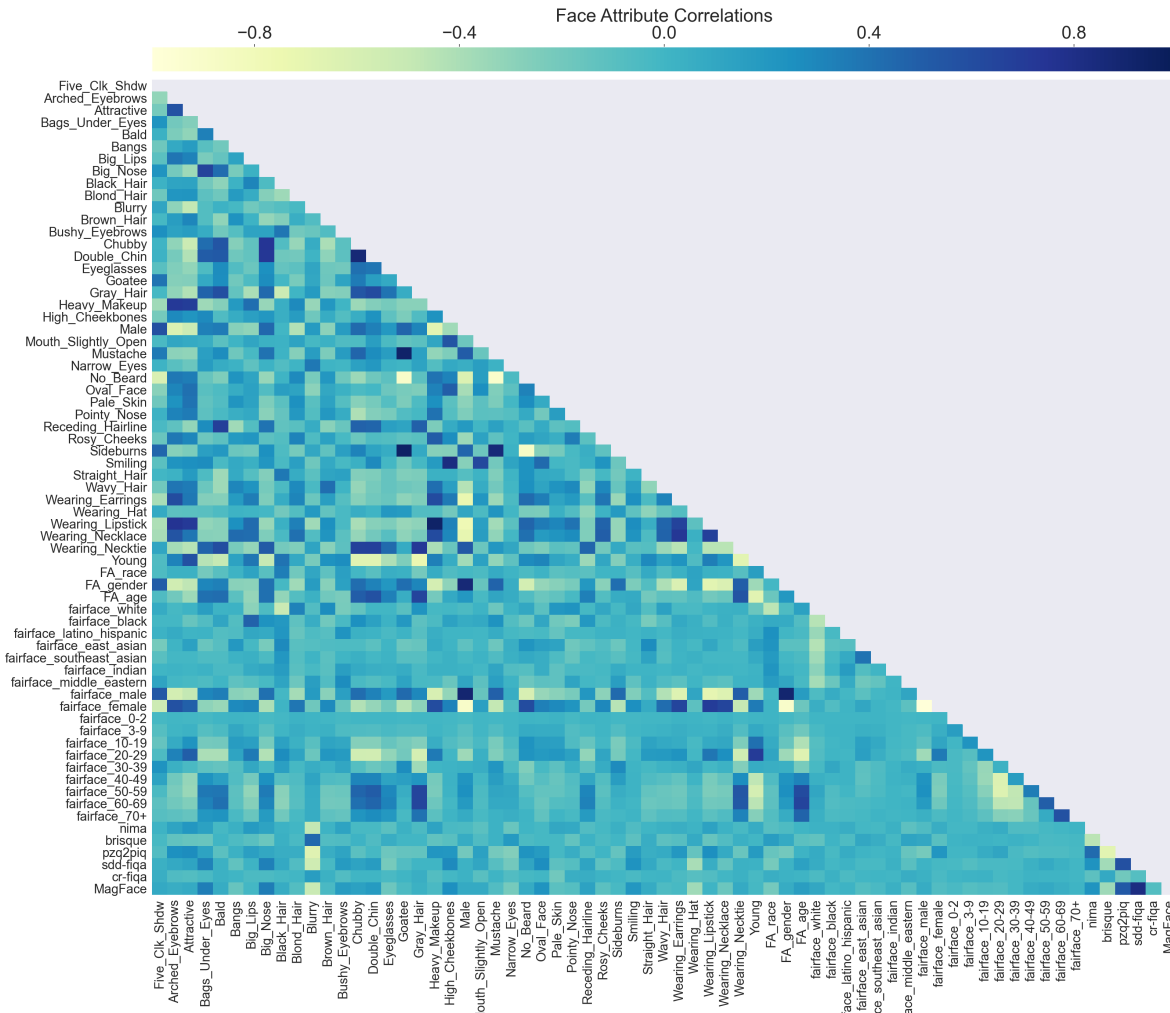


Figure 1. Full heat map depicting correlations across all attributes. Note that our quality metrics are all ascending except for *brisque*, which is descending (lower-is-better); as a result, it has negative correlation with the others. Please refer to Section 4.2 in main paper for details on attribute computations.

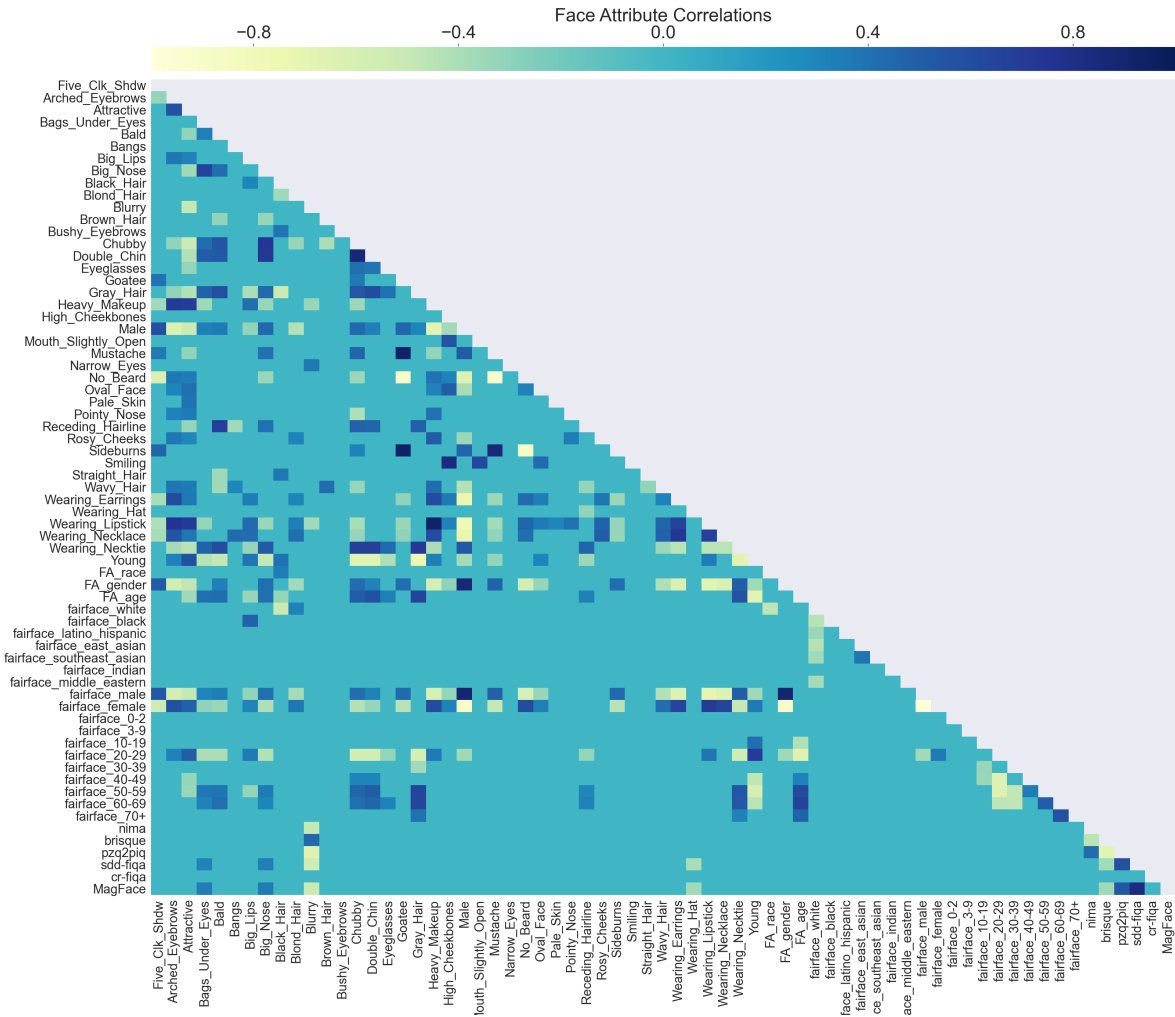


Figure 2. Heat map depicting moderate to strong correlations ( $p \geq \text{abs}(0.30)$ ) as listed in table 1. Weak associations were set to zero for readability.

Table 1: Attribute Correlation Coefficients

Attribute Pair		$p$
Mustache	No_Beard	-0.910
FA_gender	fairface_female	-0.905
Male	fairface_female	-0.898
No_Beard	Goatee	-0.892
No_Beard	Sideburns	-0.878
Wearing_Lipstick	Male	-0.769
Young	Gray_Hair	-0.741
Wearing_Earrings	Male	-0.728
Wearing_Necklace	Male	-0.704
Wearing_Lipstick	fairface_male	-0.697
pzq2piq	brisque	-0.677
Heavy_Makeup	Male	-0.675
Wearing_Lipstick	FA_gender	-0.672
Young	Wearing_Necktie	-0.672
FA_age	Young	-0.671
Double_Chin	Young	-0.661
Chubby	Young	-0.660
fairface_20-29	FA_age	-0.655
pzq2piq	Blurry	-0.651
fairface_male	Wearing_Necklace	-0.647
Wearing_Earrings	fairface_male	-0.644
fairface_50-59	fairface_20-29	-0.642
fairface_20-29	fairface_40-49	-0.638
Male	Arched_Eyebrows	-0.631
Wearing_Earrings	FA_gender	-0.623
No_Beard	Five_Clk_Shdw	-0.623
Wearing_Necklace	FA_gender	-0.621
fairface_male	Heavy_Makeup	-0.605
No_Beard	fairface_male	-0.602
Gray_Hair	fairface_20-29	-0.591
Young	fairface_50-59	-0.582
FA_gender	Heavy_Makeup	-0.580
FA_gender	No_Beard	-0.578
Arched_Eyebrows	fairface_male	-0.573
Double_Chin	fairface_20-29	-0.564
Chubby	fairface_20-29	-0.561

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Table 1: Attribute Correlation Coefficients (Continued)

Attribute Pair		$p$
FA_gender	Arched_Eyebrows	-0.557
Wearing_Necktie	fairface_20-29	-0.554
Blurry	sdd-fiqa	-0.552
Five_Clk_Shdw	fairface_female	-0.537
Attractive	Chubby	-0.531
Attractive	Male	-0.529
Black_Hair	Gray_Hair	-0.528
MagFace	Blurry	-0.520
fairface_white	Black_Hair	-0.516
Wearing_Necktie	fairface_female	-0.500
Bald	Young	-0.498
Young	Big_Nose	-0.498
Blurry	Attractive	-0.491
fairface_male	Attractive	-0.490
fairface_female	Mustache	-0.488
nima	Blurry	-0.486
fairface_50-59	fairface_30-39	-0.482
FA_gender	Attractive	-0.475
fairface_30-39	fairface_60-69	-0.471
fairface_40-49	Young	-0.469
fairface_20-29	fairface_60-69	-0.465
FA_race	fairface_white	-0.462
fairface_60-69	Young	-0.460
nima	brisque	-0.459
Wearing_Necktie	Wearing_Earrings	-0.450
Wearing_Necktie	Wearing_Necklace	-0.449
Wearing_Lipstick	Wearing_Necktie	-0.448
Bags_Under_Eyes	Young	-0.443
Wearing_Necktie	Attractive	-0.440
fairface_female	Goatee	-0.440
fairface_black	fairface_white	-0.440
Sideburns	fairface_female	-0.440
fairface_white	fairface_east_asian	-0.433
Male	Wavy_Hair	-0.432
Male	Blond_Hair	-0.429

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Table 1: Attribute Correlation Coefficients (Continued)

Attribute Pair		$p$
Chubby	fairface_female	-0.429
Attractive	Double_Chin	-0.428
Gray_Hair	Attractive	-0.427
Big_Nose	fairface_20-29	-0.426
Wavy_Hair	fairface_male	-0.425
FA_age	fairface_10-19	-0.415
Wearing_Lipstick	Five_Clk_Shdw	-0.412
Eyeglasses	Young	-0.412
Wavy_Hair	FA_gender	-0.409
Big_Nose	fairface_female	-0.407
Chubby	Brown_Hair	-0.405
fairface_20-29	Bald	-0.404
Big_Lips	Gray_Hair	-0.404
Bags_Under_Eyes	fairface_20-29	-0.403
Wearing_Necktie	Heavy_Makeup	-0.401
Five_Clk_Shdw	Wearing_Earrings	-0.397
Chubby	Wearing_Lipstick	-0.393
Wearing_Hat	sdd-fiqa	-0.392
Five_Clk_Shdw	Wearing_Necklace	-0.386
Male	Oval_Face	-0.385
Wearing_Necktie	Arched_Eyebrows	-0.382
fairface_white	fairface_middle_eastern	-0.376
fairface_male	Blond_Hair	-0.376
sdd-fiqa	brisque	-0.375
Wearing_Lipstick	Mustache	-0.373
Young	Male	-0.371
Receding_Hairline	Bangs	-0.365
MagFace	Wearing_Hat	-0.363
Gray_Hair	fairface_30-39	-0.363
fairface_white	fairface_southeast_asian	-0.362
Five_Clk_Shdw	Heavy_Makeup	-0.362
fairface_male	fairface_20-29	-0.362
Male	High_Cheekbones	-0.362
Blond_Hair	FA_gender	-0.361
Blurry	Wearing_Lipstick	-0.360

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Table 1: Attribute Correlation Coefficients (Continued)

Attribute Pair		$p$
Young	FA_gender	-0.359
Bald	Wavy_Hair	-0.357
Big_Nose	Attractive	-0.356
Bags_Under_Eyes	Heavy_Makeupe	-0.356
Young	fairface_male	-0.356
Attractive	FA_age	-0.355
Black_Hair	Blond_Hair	-0.354
fairface_20-29	Male	-0.354
brisque	MagFace	-0.354
fairface_20-29	FA_gender	-0.353
Straight_Hair	Bald	-0.352
No_Beard	Chubby	-0.351
Wearing_Necktie	Wavy_Hair	-0.351
Chubby	Heavy_Makeup	-0.351
Receding_Hairline	Young	-0.351
Wearing_Earrings	Mustache	-0.347
Rosy_Cheeks	Male	-0.346
fairface_white	fairface_latino_hispanic	-0.343
fairface_40-49	fairface_10-19	-0.342
Attractive	fairface_50-59	-0.341
fairface_female	Bald	-0.340
Big_Nose	Wearing_Lipstick	-0.338
Sideburns	Wearing_Earrings	-0.336
Blurry	Heavy_Makeup	-0.334
Blond_Hair	Chubby	-0.333
Wearing_Lipstick	Goatee	-0.331
Big_Nose	No_Beard	-0.331
Heavy_Makeup	Big_Nose	-0.330
fairface_male	Oval_Face	-0.329
fairface_30-39	fairface_10-19	-0.329
Attractive	fairface_40-49	-0.328
Wearing_Lipstick	Sideburns	-0.327
Sideburns	Wearing_Necklace	-0.326
Wearing_Necklace	Chubby	-0.326
Big_Lips	Wearing_Necktie	-0.325

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Table 1: Attribute Correlation Coefficients (Continued)

Attribute Pair		<i>p</i>
Chubby	Wavy_Hair	-0.324
FA_age	Big_Lips	-0.324
FA_gender	Oval_Face	-0.323
fairface_female	Double_Chin	-0.322
Big_Nose	Brown_Hair	-0.321
fairface_50-59	Big_Lips	-0.319
Bags_Under_Eyes	Wearing_Lipstick	-0.318
Young	Mustache	-0.317
High_Cheekbones	fairface_male	-0.316
Attractive	Receding_Hairline	-0.315
Eyeglasses	Attractive	-0.314
Mustache	Heavy_Makeup	-0.314
FA_age	Black_Hair	-0.314
fairface_20-29	Eyeglasses	-0.314
Five_Clk_Shdw	Arched_Eyebrows	-0.314
Receding_Hairline	fairface_20-29	-0.314
Receding_Hairline	Wavy_Hair	-0.314
Mustache	Wearing_Necklace	-0.312
Attractive	Bald	-0.312
Brown_Hair	Bald	-0.312
Receding_Hairline	Wearing_Hat	-0.310
Big_Lips	Male	-0.308
Arched_Eyebrows	Chubby	-0.308
Mustache	Attractive	-0.308
Arched_Eyebrows	Gray_Hair	-0.307
Wavy_Hair	Straight_Hair	-0.306
fairface_male	Big_Lips	-0.306
Bags_Under_Eyes	fairface_female	-0.303
High_Cheekbones	FA_gender	-0.303
Wearing_Necklace	Goatee	-0.303
Goatee	Wearing_Earrings	-0.302
Wearing_Lipstick	Gray_Hair	-0.300
Bags_Under_Eyes	FA_gender	0.300
Wearing_Lipstick	Pale_Skin	0.301
Bangs	Wavy_Hair	0.301

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Table 1: Attribute Correlation Coefficients (Continued)

Attribute Pair		<i>p</i>
fairface_50-59	Receding_Hairline	0.302
Attractive	Rosy_Cheeks	0.303
fairface_male	Bags_Under_Eyes	0.303
Double_Chin	fairface_40-49	0.305
fairface_female	Big_Lips	0.306
Gray_Hair	Male	0.307
Young	Oval_Face	0.307
Black_Hair	Big_Lips	0.307
Blond_Hair	Wearing_Earrings	0.308
Oval_Face	Arched_Eyebrows	0.308
Big_Nose	fairface_60-69	0.308
fairface_40-49	Chubby	0.312
Arched_Eyebrows	Pointy_Nose	0.313
Chubby	Sideburns	0.313
Eyeglasses	fairface_60-69	0.313
Rosy_Cheeks	Blond_Hair	0.314
No_Beard	High_Cheekbones	0.315
Wearing_Necktie	fairface_70+	0.315
FA_age	fairface_40-49	0.315
fairface_female	High_Cheekbones	0.316
Young	Arched_Eyebrows	0.317
Wearing_Earrings	Wavy_Hair	0.318
High_Cheekbones	Wearing_Lipstick	0.321
Oval_Face	No_Beard	0.321
fairface_male	Double_Chin	0.322
Attractive	Big_Lips	0.322
Bags_Under_Eyes	sdd-fiqa	0.323
Heavy_Makeup	Oval_Face	0.323
Double_Chin	FA_gender	0.324
Blond_Hair	fairface.white	0.324
fairface_20-29	Arched_Eyebrows	0.325
fairface_60-69	Receding_Hairline	0.326
fairface_60-69	Bags_Under_Eyes	0.326
fairface_female	Oval_Face	0.329
Male	Bags_Under_Eyes	0.329

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Table 1: Attribute Correlation Coefficients (Continued)

Attribute Pair		$p$
Receding_Hairline	FA_age	0.329
Wearing_Lipstick	Blond_Hair	0.331
Big_Nose	sdd-fqqa	0.331
Bald	Bags_Under_Eyes	0.331
FA_age	Eyeglasses	0.332
Bald	FA_gender	0.334
Young	Heavy_Makeup	0.334
Male	Double_Chin	0.335
Oval_Face	Wearing_Earrings	0.338
MagFace	Bags_Under_Eyes	0.338
fairface_male	Bald	0.340
FA_race	Black_Hair	0.341
Young	Wearing_Lipstick	0.342
Wearing_Earrings	Big_Lips	0.344
Rosy_Cheeks	Pointy_Nose	0.348
Attractive	No_Beard	0.349
fairface_50-59	fairface_40-49	0.350
MagFace	Big_Nose	0.351
Bald	Male	0.352
Wearing_Lipstick	Oval_Face	0.352
Attractive	Wavy_Hair	0.353
Big_Nose	fairface_50-59	0.354
Chubby	Goatee	0.354
Young	fairface_female	0.356
Attractive	Pointy_Nose	0.358
fairface_20-29	fairface_female	0.362
Five_Clk_Shdw	Mustache	0.363
fairface_20-29	Heavy_Makeup	0.363
Big_Lips	fairface_20-29	0.365
Wearing_Earrings	High_Cheekbones	0.367
Attractive	Wearing_Earrings	0.368
Straight_Hair	Black_Hair	0.369
Arched_Eyebrows	Rosy_Cheeks	0.370
Blurry	Narrow_Eyes	0.371
Bags_Under_Eyes	fairface_50-59	0.371

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Table 1: Attribute Correlation Coefficients (Continued)

Attribute Pair		$p$
Arched_Eyebrows	No_Beard	0.371
fairface_female	Blond_Hair	0.376
Young	Big_Lips	0.376
Bald	fairface_50-59	0.376
Wearing_Lipstickr	fairface_20-29	0.376
Wearing_Necklace	Attractive	0.381
Bushy_Eyebrows	Black_Hair	0.381
Double_Chin	Eyeglasses	0.384
Rosy_Cheeks	Wearing_Earrings	0.386
Big_Lips	Arched_Eyebrows	0.386
Wavy_Hair	Arched_Eyebrows	0.386
Big_Nose	Receding_Hairline	0.391
Gray_Hair	Eyeglasses	0.391
Heavy_Makeup	No_Beard	0.393
Black_Hair	Young	0.394
Pointy_Nose	Wearing_Lipstick	0.396
Five_Clk_Shdw	Goatee	0.396
Pale_Skin	Attractive	0.397
fairface_east_asian	fairface_southeast_asian	0.398
Heavy_Makeup	Pointy_Nose	0.400
Mustache	Big_Nose	0.400
fairface_70+	Gray_Hair	0.401
fairface_male	Big_Nose	0.407
Attractive	Oval_Face	0.408
fairface_60-69	Bald	0.409
Big_Nose	FA_gender	0.409
Wearing_Necklace	No_Beard	0.411
Big_Nose	FA_age	0.411
Chubby	fairface_60-69	0.411
Young	fairface_10-19	0.413
Wearing_Necklace	Blond_Hair	0.414
FA_age	Bags_Under_Eyes	0.414
Heavy_Makeup	Big_Lips	0.417
Heavy_Makeup	Wavy_Hair	0.420
Goatee	FA_gender	0.420

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Table 1: Attribute Correlation Coefficients (Continued)

Attribute Pair		$p$
Sideburns	FA_gender	0.420
Brown_Hair	Wavy_Hair	0.421
Bald	Big_Nose	0.422
Big_Lips	Wearing_Necklace	0.422
Chubby	Bags_Under_Eyes	0.424
fairface_female	Wavy_Hair	0.425
FA_gender	Chubby	0.426
FA_age	Bald	0.426
fairface_male	Chubby	0.429
nima	pzq2piq	0.432
Wearing_Necklace	Bangs	0.432
Wearing_Earrings	No_Beard	0.435
Big_Lips	Wearing_Lipstick	0.437
Oval_Face	Smiling	0.438
fairface_male	Sideburns	0.440
Goatee	fairface_male	0.440
Gray_Hair	Big_Nose	0.441
Eyeglasses	Wearing_Necktie	0.443
Chubby	Male	0.445
brisque	Blurry	0.446
Big_Nose	Male	0.451
Male	Sideburns	0.456
Sideburns	Five_Clk_Shdw	0.460
Wearing_Lipstick	No_Beard	0.461
Goatee	Male	0.461
Double_Chin	fairface_60-69	0.462
Receding_Hairline	Double_Chin	0.462
fairface_50-59	Chubby	0.464
Wearing_Necktie	Receding_Hairline	0.464
Chubby	Mustache	0.467
Wearing_Lipstick	Wavy_Hair	0.468
FA_gender	Mustache	0.470
Wearing_Necktie	Bags_Under_Eyes	0.474
Wavy_Hair	Wearing_Necklace	0.474
Rosy_Cheeks	Wearing_Lipstick	0.475

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Table 1: Attribute Correlation Coefficients (Continued)

Attribute Pair		$p$
Gray_Hair	Bags_Under_Eyes	0.476
FA_age	fairface_70+	0.476
Big_Lips	fairface_black	0.479
Chubby	Receding_Hairline	0.483
fairface_male	Mustache	0.488
Gray_Hair	Receding_Hairline	0.489
fairface_female	Attractive	0.490
Rosy_Cheeks	Wearing_Necklace	0.493
FA_gender	Wearing_Necktie	0.495
High_Cheekbones	Oval_Face	0.496
fairface_20-29	Attractive	0.496
fairface_50-59	fairface_60-69	0.497
fairface_male	Wearing_Necktie	0.500
FA_age	Chubby	0.503
Bags_Under_Eyes	Double_Chin	0.510
Heavy_Makeup	Rosy_Cheeks	0.511
Male	Mustache	0.512
Five_Clk_Shdw	FA_gender	0.514
fairface_50-59	Double_Chin	0.515
Big_Nose	Wearing_Necktie	0.517
Bald	Double_Chin	0.524
pzq2piq	MagFace	0.528
fairface_60-69	Wearing_Necktie	0.534
Male	Wearing_Necktie	0.534
Five_Clk_Shdw	fairface_male	0.537
Gray_Hair	Chubby	0.540
fairface_50-59	Wearing_Necktie	0.545
Bald	Chubby	0.551
Wearing_Necklace	Arched_Eyebrows	0.555
Mouth_Slightly_Open	High_Cheekbones	0.556
FA_age	Wearing_Necktie	0.561
Attractive	Arched_Eyebrows	0.566
FA_age	Double_Chin	0.571
Attractive	Young	0.572
Arched_Eyebrows	fairface_female	0.573

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Table 1: Attribute Correlation Coefficients (Continued)

Attribute Pair		$p$
fairface_60-69	fairface_70+	0.575
Five_Clk_Shdw	Male	0.579
pzq2piq	sdd-fiq	0.584
Bald	Gray_Hair	0.588
Bald	Wearing_Necktie	0.599
No_Beard	fairface_female	0.602
Wearing_Earrings	Arched_Eyebrows	0.604
Heavy_Makeup	fairface_female	0.605
Heavy_Makeup	Wearing_Earrings	0.610
Gray_Hair	Double_Chin	0.611
Heavy_Makeup	Wearing_Necklace	0.611
fairface_50-59	FA_age	0.613
Mouth_Slightly_Open	Smiling	0.632
fairface_50-59	Gray_Hair	0.642
fairface_60-69	Gray_Hair	0.642
fairface_female	Wearing_Earrings	0.644
fairface_female	Wearing_Necklace	0.647
fairface_60-69	FA_age	0.656
Gray_Hair	FA_age	0.656
Wearing_Earrings	Wearing_Lipstick	0.659
Big_Nose	Bags_Under_Eyes	0.660
Chubby	Wearing_Necktie	0.671
Double_Chin	Wearing_Necktie	0.678
Wearing_Necklace	Wearing_Lipstick	0.678
Receding_Hairline	Bald	0.685
Heavy_Makeup	Attractive	0.695
fairface_female	Wearing_Lipstick	0.697
Young	fairface_20-29	0.705
Arched_Eyebrows	Heavy_Makeup	0.715
Attractive	Wearing_Lipstick	0.718
Gray_Hair	Wearing_Necktie	0.719
Wearing_Earrings	Wearing_Necklace	0.728
Double_Chin	Big_Nose	0.730
Chubby	Big_Nose	0.735
Wearing_Lipstick	Arched_Eyebrows	0.750

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Table 1: Attribute Correlation Coefficients (Continued)

Attribute Pair		$p$
sdd-fiq	MagFace	0.822
High_Cheekbones	Smiling	0.830
Mustache	Sideburns	0.864
FA_gender	Male	0.870
Double_Chin	Chubby	0.872
fairface_male	Male	0.898
fairface_male	FA_gender	0.905
Goatee	Mustache	0.929
Heavy_Makeup	Wearing_Lipstick	0.934
Sideburns	Goatee	0.944