ANTsX neuroimaging-derived structural phenotypes of UK Biobank

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Contents

1 Age

Age (regression)

Figure 1: Age

1.1 Feature ranking: Linear

- FSL

    - range: [NA , NA]
    - std: NA
    - skewness: NA

- FreeSurfer

    - range: [0.1526888 , 15.03373]
    - std: 2.686921
    - skewness: 2.324572

- ANTsX

    - range: [0.1354494 , 17.57277]
    - std: 2.308719
    - skewness: 2.238218

1.1.1 Package-based ranking (top 10 features)

- FSL: rank = 363 , imp = 77.09145

- FreeSurfer: rank = 80 , imp = 121.5785

- ANTsX: rank = 166 , imp = 108.6568

Table 1: Age

Package	Pipeline	Feature
ANTsX	Atropos	Cerebellum
FreeSurfer	ASEG	Volume of WM-hypointensities (whole brain)
ANTsX	Cereb	L_III volume
FreeSurfer	ASEG	Volume of CerebralWhiteMatter (left hemisphere)
FreeSurfer	ASEG	Volume of CerebralWhiteMatter (right hemisphere)
FreeSurfer	ASEG	Volume of CC-Central (whole brain)
FreeSurfer	ASEG	Volume of SupraTentorial (whole brain)
FSL	Other	Continuous Volume of grey matter
FreeSurfer	ASEG	Volume of TotalGray (whole brain)
FreeSurfer	ASEG	Volume of Cortex (left hemisphere)
FreeSurfer	ASEG	Volume of VentricleChoroid (whole brain)
FreeSurfer	ASEG	Volume of Cortex (right hemisphere)
ANTsX	Cereb	CerebellarCSF volume
FreeSurfer	ASEG	Volume of VentralDC (right hemisphere)
ANTsX	Region	Right cerebellum exterior
FreeSurfer	ASEG	Volume of VentralDC (left hemisphere)
ANTsX	Cereb	CerebellarWhiteMatter volume
FreeSurfer	ASEG	Volume of SubCortGray (whole brain)
ANTsX	Region	Cerebellar vermal lobules VI VII
ANTsX	Region	Left caudate
FreeSurfer	ASEG	Volume of Amygdala (right hemisphere)
ANTsX	Region	Right lateral ventricle
ANTsX	Atropos	BrainStem
FreeSurfer	ASEG	Volume of Cerebellum-Cortex (left hemisphere)
FreeSurfer	ASEG	Volume of Caudate (left hemisphere)

1.1.2 Package-based ranking (top 25 features)

- FSL: rank = 1615 , imp = 155.1536

- FreeSurfer: rank = 561 , imp = 241.8775

- ANTsX: rank = 919 , imp = 205.7617

1.1.3 Package-based ranking (top 50 features)

- FSL: rank = 5368 , imp = 248.9677

- FreeSurfer: rank = 3346 , imp = 355.6919

- ANTsX: rank = 3177 , imp = 331.0176

2 FluidIntelligenceScore

FluidIntelligenceScore (regression)
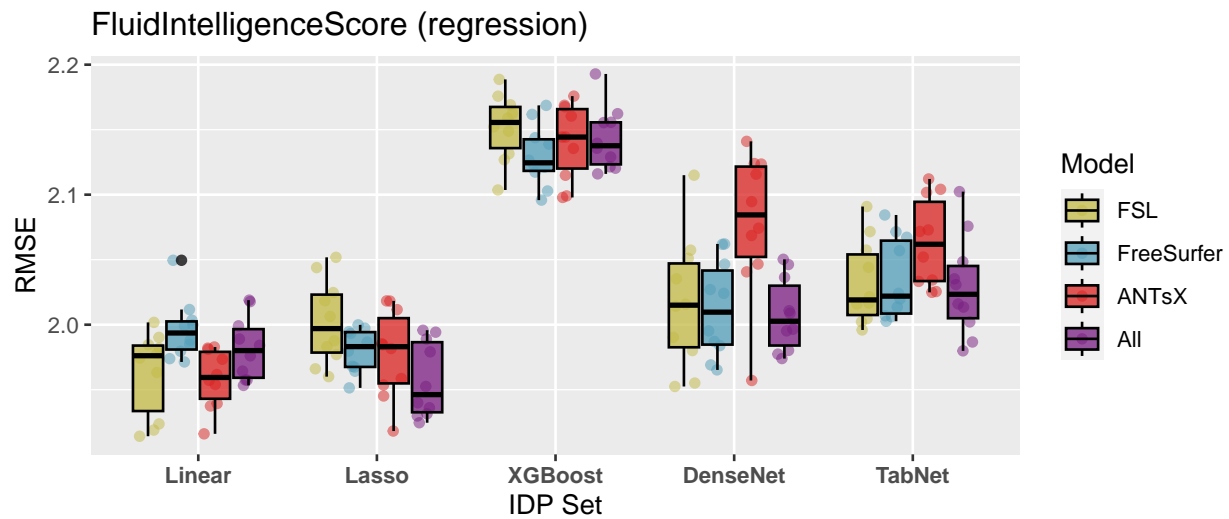
Figure 2: FluidIntelligenceScore

2.1 Feature ranking: Linear

- FSL

    - range: [0.1864763 , 4.409947]
    - std: 0.6514862
    - skewness: 1.818237

- FreeSurfer

    - range: [0.1644809 , 4.097554]
    - std: 0.5718555
    - skewness: 1.554328

- ANTsX

    - range: [0.1397266 , 3.695379]
    - std: 0.5723668
    - skewness: 1.259365

2.1.1 Package-based ranking (top 10 features)

- FSL: rank = 170 , imp = 26.70319

- FreeSurfer: rank = 151 , imp = 24.63818

- ANTsX: rank = 195 , imp = 24.59515

Table 2: FluidIntelligenceScore

Package	Pipeline	Feature
FSL	FAST	Volume of grey matter in Amygdala (right)
FreeSurfer	ASEG	Volume of CC-Mid-Anterior (whole brain)
ANTsX	Thickness	Left paracentral
FSL	FAST	Volume of grey matter in Intracalcarine Cortex (right)
FSL	Other	Continuous Volume of peripheral cortical grey matter
ANTsX	Thickness	Left superior frontal
FSL	FAST	Volume of grey matter in Amygdala (left)
ANTsX	Thickness	Left inferior temporal
FSL	FAST	Volume of grey matter in Middle Temporal Gyrus - posterior division (left)
ANTsX	Region	Left hippocampus
FreeSurfer	Thickness	Mean thickness of superiorparietal (left hemisphere)
FreeSurfer	Thickness	Mean thickness of isthmuscingulate (right hemisphere)
FreeSurfer	ASEG	Volume of Inf-Lat-Vent (left hemisphere)
FSL	FAST	Volume of grey matter in Superior Temporal Gyrus - posterior division (right)
FreeSurfer	ASEG	Volume of Cortex (left hemisphere)
FSL	FAST	Volume of grey matter in X Cerebellum (left)
FreeSurfer	Thickness	Mean thickness of fusiform (right hemisphere)
FreeSurfer	ASEG	Volume of Cortex (right hemisphere)
ANTsX	Cortical	Left rostral middle frontal volume
FreeSurfer	HippAmyg	Volume of subiculum-body (right hemisphere)
FreeSurfer	HippAmyg	Volume of HATA (right hemisphere)
FreeSurfer	HippAmyg	Volume of CA4-body (right hemisphere)
FreeSurfer	HippAmyg	Volume of Hippocampal-tail (right hemisphere)
FreeSurfer	HippAmyg	Volume of parasubiculum (right hemisphere)
ANTsX	Thickness	Left caudal middle frontal

2.1.2 Package-based ranking (top 25 features)

- FSL: rank = 1437 , imp = 52.0111

- FreeSurfer: rank = 764 , imp = 54.65516

- ANTsX: rank = 957 , imp = 53.44664

2.1.3 Package-based ranking (top 50 features)

- FSL: rank = 5444 , imp = 84.00483

- FreeSurfer: rank = 3010 , imp = 96.27253

- ANTsX: rank = 3534 , imp = 92.52846

3 NeuroticismScore
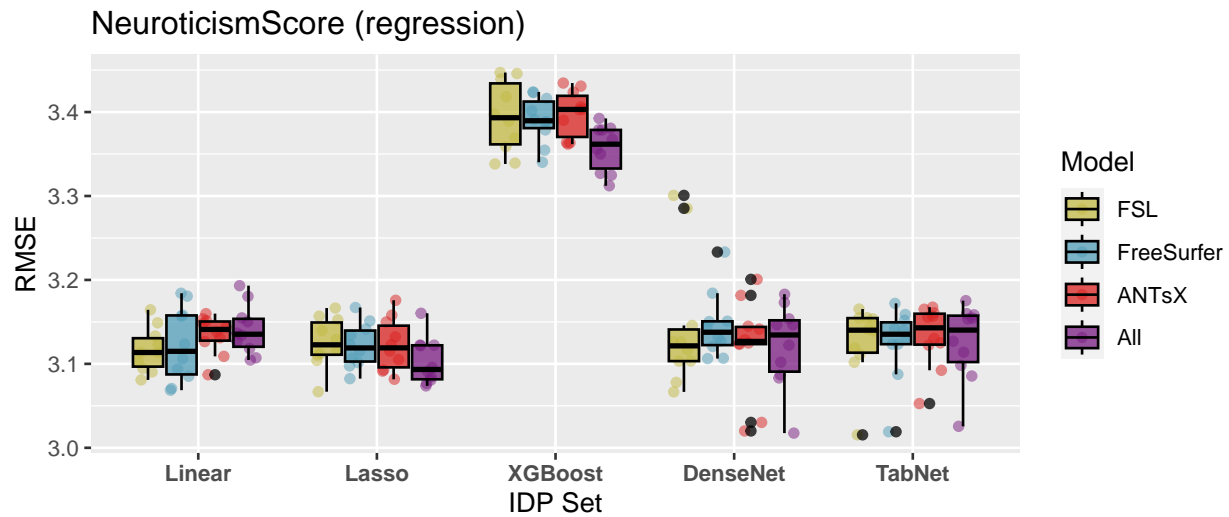
Figure 3: NeuroticismScore

3.1 Feature ranking: Lasso

- FSL

    - range: [0.000000004743372 , 0.06772924]
    - std: 0.006896142
    - skewness: 8.905521

- FreeSurfer

    - range: [0.000000003567677 , 0.06191656]
    - std: 0.01080398
    - skewness: 2.993756

- ANTsX

    - range: [0.00000002994948 , 0.05547663]
    - std: 0.008088334
    - skewness: 3.708592

3.1.1 Package-based ranking (top 10 features)

- FSL: rank = 1567 , imp = 0.1329233

- FreeSurfer: rank = 97 , imp = 0.4832962

- ANTsX: rank = 174 , imp = 0.3840031

Table 3: NeuroticismScore

Package	Pipeline	Feature
FSL	FAST	Volume of grey matter in Amygdala (right)
FreeSurfer	Thickness	Mean thickness of superiortemporal (right hemisphere)
FreeSurfer	Thickness	Mean thickness of posteriorcingulate (left hemisphere)
FSL	Other	Continuous Volume of peripheral cortical grey matter
ANTsX	Thickness	Left supramarginal
FreeSurfer	Thickness	Mean thickness of posteriorcingulate (right hemisphere)
FreeSurfer	Thickness	Mean thickness of isthmuscingulate (left hemisphere)
ANTsX	Thickness	Right posterior cingulate
ANTsX	Thickness	Left lateral orbitofrontal
FreeSurfer	HippAmyg	Volume of AV (right hemisphere)
FreeSurfer	Thickness	Mean thickness of lateralorbitofrontal (left hemisphere)
FreeSurfer	Thickness	Mean thickness of superiorparietal (right hemisphere)
ANTsX	Thickness	Right supramarginal
FreeSurfer	Thickness	Mean thickness of superiortemporal (left hemisphere)
FreeSurfer	Thickness	Mean thickness of inferiortemporal (left hemisphere)
ANTsX	Thickness	Left precentral
FreeSurfer	Thickness	Mean thickness of transversetemporal (left hemisphere)
FreeSurfer	Thickness	Mean thickness of lingual (left hemisphere)
FreeSurfer	Thickness	Mean thickness of isthmuscingulate (right hemisphere)
ANTsX	Thickness	Left posterior cingulate
FreeSurfer	Thickness	Mean thickness of rostralanteriorcingulate (right hemisphere)
FreeSurfer	Thickness	Mean thickness of lateralorbitofrontal (right hemisphere)
FreeSurfer	HippAmyg	Volume of AV (left hemisphere)
ANTsX	Thickness	Left isthmus cingulate
ANTsX	Thickness	Right precentral

3.1.2   Package-based ranking (top 25 features)

- FSL: rank = 5819 , imp = 0.1333615
- FreeSurfer: rank = 544 , imp = 0.8983481
- ANTsX: rank = 896 , imp = 0.6587533

3.1.3   Package-based ranking (top 50 features)

- FSL: rank = 14572 , imp = 0.1336889
- FreeSurfer: rank = 2122 , imp = 1.230213
- ANTsX: rank = 3261 , imp = 0.8462698

4 NumericMemory
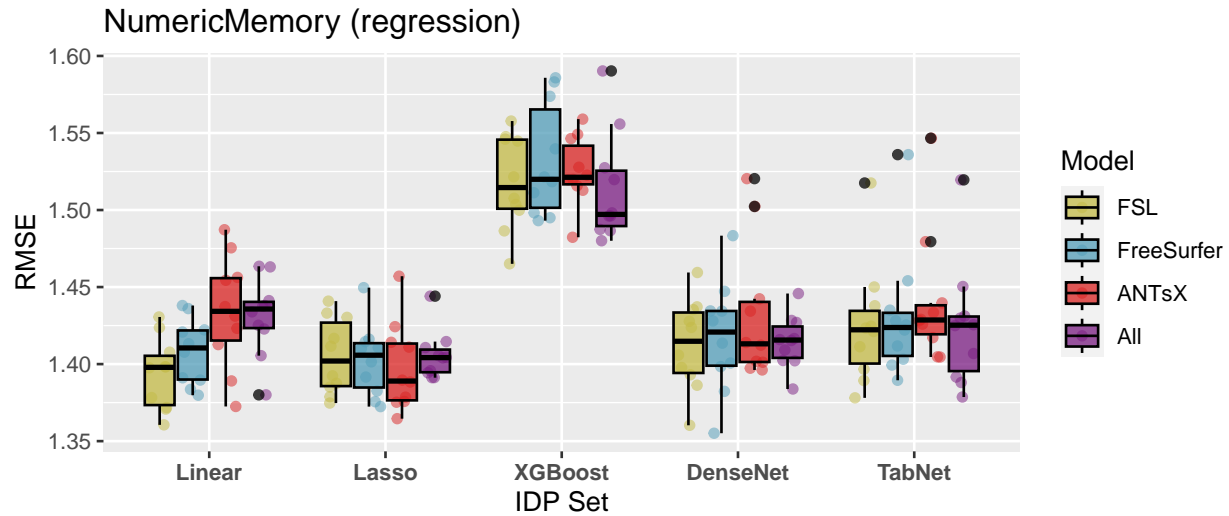
Figure 4: NumericMemory

4.1 Feature ranking: Lasso

- FSL

    - range: [0.000000002930496 , 0.007651691]
    - std: 0.0005948515
    - skewness: 12.559

- FreeSurfer

    - range: [0.000000004589048 , 0.0106752]
    - std: 0.001189512
    - skewness: 4.543139

- ANTsX

    - range: [0.000000006963895 , 0.004325757]
    - std: 0.0007972568
    - skewness: 2.364202

4.1.1 Package-based ranking (top 10 features)

- FSL: rank = 1905 , imp = 0.008571247

- FreeSurfer: rank = 72 , imp = 0.05603193

- ANTsX: rank = 175 , imp = 0.03091613

Table 4: NumericMemory

Package	Pipeline	Feature
FreeSurfer	HippAmyg	Volume of AV (right hemisphere)
FreeSurfer	Thickness	Mean thickness of isthmuscingulate (left hemisphere)
FSL	Other	Continuous Volume of peripheral cortical grey matter
FreeSurfer	Thickness	Mean thickness of postcentral (right hemisphere)
FreeSurfer	Thickness	Mean thickness of inferiorparietal (left hemisphere)
FreeSurfer	HippAmyg	Volume of AV (left hemisphere)
FreeSurfer	Thickness	Mean thickness of precuneus (left hemisphere)
ANTsX	Thickness	Right lateral orbitofrontal
ANTsX	Thickness	Right medial orbitofrontal
FreeSurfer	Thickness	Mean thickness of lingual (left hemisphere)
FreeSurfer	Thickness	Mean thickness of supramarginal (left hemisphere)
FreeSurfer	Thickness	Mean thickness of isthmuscingulate (right hemisphere)
ANTsX	Thickness	Right transverse temporal
FreeSurfer	Thickness	Mean thickness of insula (left hemisphere)
ANTsX	Thickness	Left fusiform
FreeSurfer	Thickness	Mean thickness of rostralmiddlefrontal (left hemisphere)
ANTsX	Thickness	Right superior temporal
ANTsX	Thickness	Left lateral orbitofrontal
FreeSurfer	Thickness	Mean thickness of medialorbitofrontal (right hemisphere)
FreeSurfer	Thickness	Mean thickness of parsorbitalis (left hemisphere)
ANTsX	Thickness	Left transverse temporal
FreeSurfer	Thickness	Mean thickness of insula (right hemisphere)
ANTsX	Cortical	Left caudal middle frontal volume
FreeSurfer	Thickness	Mean thickness of lateralorbitofrontal (right hemisphere)
ANTsX	Thickness	Left medial orbitofrontal

4.1.2   Package-based ranking (top 25 features)

- FSL: rank = 6300 , imp = 0.008641978
- FreeSurfer: rank = 625 , imp = 0.08951268
- ANTsX: rank = 724 , imp = 0.06428639

4.1.3   Package-based ranking (top 50 features)

- FSL: rank = 14864 , imp = 0.00870102
- FreeSurfer: rank = 2642 , imp = 0.1201725
- ANTsX: rank = 2518 , imp = 0.09986517

5 BMI

BMI (regression)
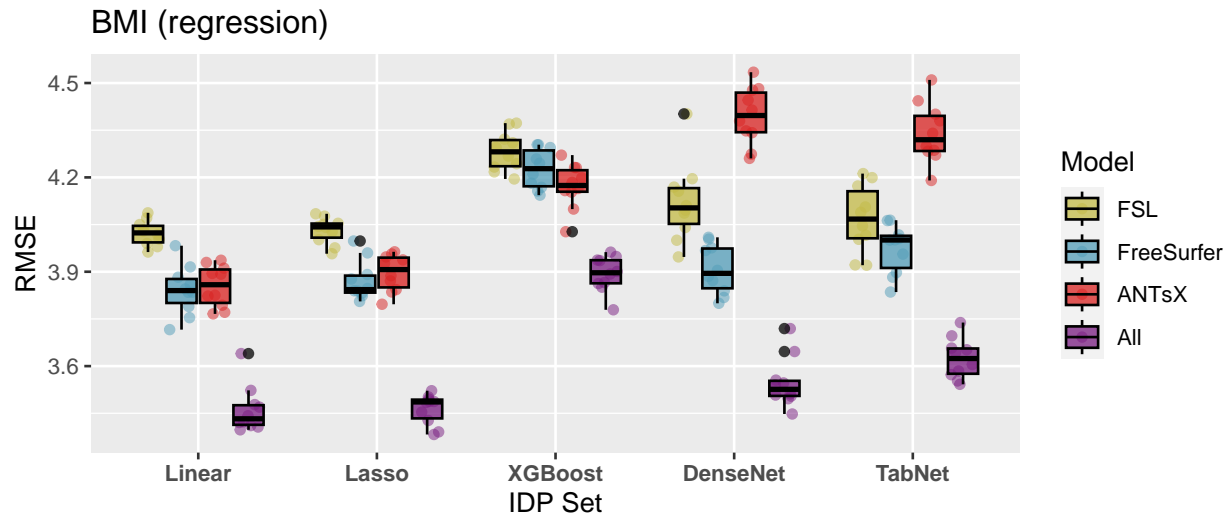
Figure 5: BMI

5.1 Feature ranking: Linear

- FSL

  - range: [0.1562628 , 12.46823]
  - std: 2.429514
  - skewness: 1.476122

- FreeSurfer

  - range: [0.159632 , 12.3667]
  - std: 2.219477
  - skewness: 1.776937

- ANTsX

  - range: [0.1637263 , 12.64787]
  - std: 1.924288
  - skewness: 2.005405

5.1.1 Package-based ranking (top 10 features)

- FSL: rank = 131 , imp = 94.45128

- FreeSurfer: rank = 164 , imp = 91.74847

- ANTsX: rank = 210 , imp = 88.12971

Table 5: BMI

Package	Pipeline	Feature
ANTsX	Thickness	Left paracentral
FSL	FAST	Volume of grey matter in Amygdala (left)
FreeSurfer	ASEG	Volume of Cerebellum-White-Matter (right hemisphere)
ANTsX	Cereb	CerebellarGrayMatter volume
FreeSurfer	ASEG	Volume of Cerebellum-White-Matter (left hemisphere)
ANTsX	Thickness	Left lingual
FreeSurfer	ASEG	Volume of EstimatedTotalIntraCranial (whole brain)
ANTsX	Atropos	BrainStem
FSL	Other	Continuous Volume of peripheral cortical grey matter (normalised for head size)
FSL	FAST	Volume of grey matter in Occipital Fusiform Gyrus (right)
FSL	FAST	Volume of grey matter in Lateral Occipital Cortex - superior division (right)
FSL	FAST	Volume of grey matter in Amygdala (right)
FSL	FAST	Volume of grey matter in Lingual Gyrus (right)
FreeSurfer	ASEG	Volume of VentralDC (right hemisphere)
FreeSurfer	ASEG	Volume of SupraTentorialNotVent (whole brain)
FSL	FAST	Volume of grey matter in Caudate (left)
FreeSurfer	Thickness	Mean thickness of superiorfrontal (left hemisphere)
FSL	FAST	Volume of grey matter in Cuneal Cortex (left)
FSL	FAST	Volume of grey matter in VIIIa Cerebellum (left)
ANTsX	Region	Left thalamus proper
FSL	FAST	Volume of grey matter in Pallidum (right)
FSL	FAST	Volume of grey matter in IX Cerebellum (right)
FreeSurfer	Volume	Volume of transversetemporal (right hemisphere)
FSL	FIRST	Volume of caudate (left)
FreeSurfer	Volume	Volume of isthmuscingulate (right hemisphere)

5.1.2   Package-based ranking (top 25 features)

- FSL: rank = 923 , imp = 187.4333
- FreeSurfer: rank = 796 , imp = 188.4521
- ANTsX: rank = 1220 , imp = 172.7291

5.1.3   Package-based ranking (top 50 features)

- FSL: rank = 4453 , imp = 284.1735
- FreeSurfer: rank = 3170 , imp = 307.6056
- ANTsX: rank = 4106 , imp = 277.511

6 TownsendDeprivationIndex

TownsendDeprivationIndex (regression)

Figure 6: TownsendDeprivationIndex

6.1 Feature ranking: Linear

- FSL

    - range: [0.139757 , 12.48687]
    - std: 1.248796
    - skewness: 4.841903

- FreeSurfer

    - range: [0.1699931 , 3.64896]
    - std: 0.6524566
    - skewness: 1.065419

- ANTsX

    - range: [0.158075 , 3.297345]
    - std: 0.6863873
    - skewness: 1.076649

6.1.1 Package-based ranking (top 10 features)

- FSL: rank = 93 , imp = 44.74012

- FreeSurfer: rank = 233 , imp = 29.08779

- ANTsX: rank = 193 , imp = 29.35449

Table 6: TownsendDeprivationIndex

Package	Pipeline	Feature
FSL	FAST	Volume of grey matter in Amygdala (left)
FSL	Other	Continuous Volume of peripheral cortical grey matter
FSL	FAST	Volume of grey matter in Heschl's Gyrus (includes H1 and H2) (left)
FSL	Other	Continuous Volume of ventricular cerebrospinal fluid
FSL	Other	Continuous Volume of ventricular cerebrospinal fluid (normalised for head size)
FreeSurfer	ASEG	Volume of SupraTentorial (whole brain)
FreeSurfer	ASEG	Volume of VentralDC (left hemisphere)
FSL	FAST	Volume of grey matter in Heschl's Gyrus (includes H1 and H2) (right)
ANTsX	SYSU WMH	Left cerebellum
FreeSurfer	ASEG	Volume of TotalGray (whole brain)
FSL	FAST	Volume of grey matter in Superior Parietal Lobule (right)
FreeSurfer	Thickness	Mean thickness of superiorfrontal (right hemisphere)
ANTsX	Cereb	CerebellarGrayMatter volume
ANTsX	Cereb	L_III volume
ANTsX	Region	Right caudal anterior cingulate
ANTsX	Cortical	Left insula volume
FreeSurfer	ASEG	Volume of SupraTentorialNotVent (whole brain)
FSL	FAST	Volume of grey matter in Thalamus (left)
ANTsX	Thickness	Left superior parietal
FSL	FAST	Volume of grey matter in Inferior Temporal Gyrus - temporooccipital part (left)
FSL	FAST	Volume of grey matter in Frontal Pole (right)
FSL	FAST	Volume of grey matter in Planum Temporale (left)
ANTsX	Cereb	R_X volume
FreeSurfer	Thickness	Mean thickness of superiortemporal (left hemisphere)
FSL	FAST	Volume of grey matter in Occipital Fusiform Gyrus (left)

6.1.2 Package-based ranking (top 25 features)

- FSL: rank = 763 , imp = 80.4624
- FreeSurfer: rank = 1274 , imp = 60.26641
- ANTsX: rank = 891 , imp = 64.35683

6.1.3 Package-based ranking (top 50 features)

- FSL: rank = 4128 , imp = 121.9611
- FreeSurfer: rank = 4139 , imp = 104.0827
- ANTsX: rank = 3281 , imp = 111.1481

7 GeneticSex
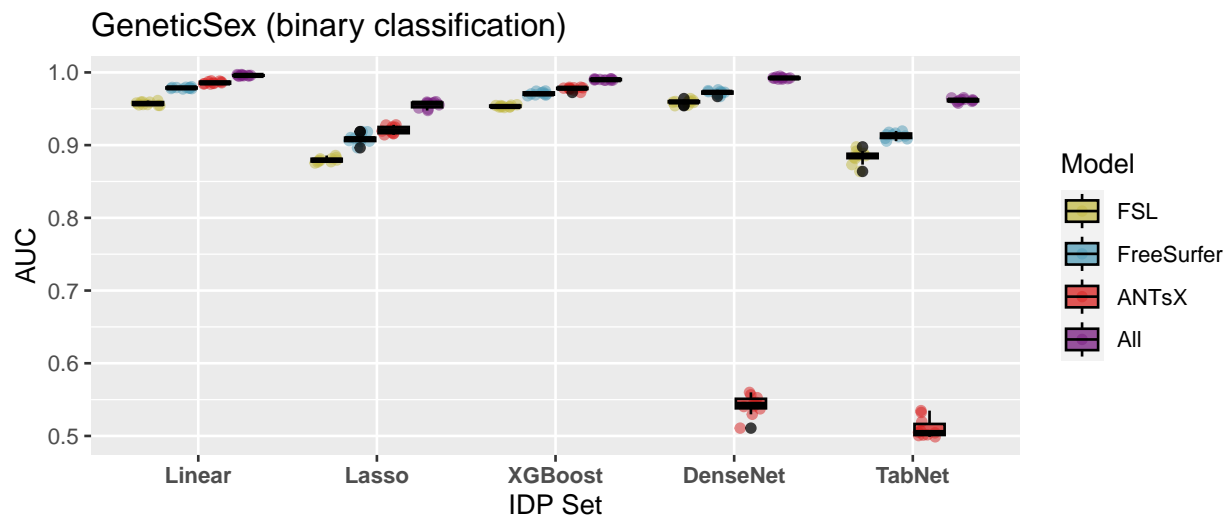

GeneticSex (binary classification)

Figure 7: GeneticSex

7.1 Feature ranking: Linear

- FSL

  - range: [NA , NA]
  - std: NA
  - skewness: NA

- FreeSurfer

  - range: [0.1737775 , 10.24362]
  - std: 1.567378
  - skewness: 2.222905

- ANTsX

  - range: [0.1889526 , 10.59129]
  - std: 1.589695
  - skewness: 1.313573

7.1.1 Package-based ranking (top 10 features)

- FSL: rank = 305 , imp = 56.68502

- FreeSurfer: rank = 93 , imp = 74.87624

- ANTsX: rank = 158 , imp = 66.55404

Table 7: GeneticSex

Package	Pipeline	Feature
ANTsX	Atropos	DeepGrayMatter
FreeSurfer	HippAmyg	Volume of AV (right hemisphere)
FreeSurfer	ASEG	Volume of VentralDC (right hemisphere)
FreeSurfer	ASEG	Volume of CerebralWhiteMatter (left hemisphere)
ANTsX	Region	Left thalamus proper
FreeSurfer	ASEG	Volume of CerebralWhiteMatter (right hemisphere)
FreeSurfer	ASEG	Volume of Cortex (right hemisphere)
FreeSurfer	ASEG	Volume of Cortex (left hemisphere)
FreeSurfer	ASEG	Volume of CC-Central (whole brain)
FSL	FIRST	Volume of accumbens (left)
FSL	FAST	Volume of grey matter in Lateral Occipital Cortex - superior division (left)
ANTsX	Cortical	Right lateral occipital volume
FSL	FAST	Volume of grey matter in Frontal Medial Cortex (left)
ANTsX	Region	Right caudate
–	–	NA
FreeSurfer	Thickness	Mean thickness of paracentral (right hemisphere)
FreeSurfer	Volume	Volume of transversetemporal (left hemisphere)
ANTsX	Cereb	R_IX thickness
ANTsX	Cortical	Left parahippocampal volume
ANTsX	Cereb	R_VIIB thickness
FreeSurfer	HippAmyg	Volume of AV (left hemisphere)
ANTsX	Cortical	Right superior parietal volume
ANTsX	Cereb	CerebellarWhiteMatter volume
ANTsX	Region	Right inferior parietal
FSL	FAST	Volume of grey matter in Intracalcarine Cortex (right)

7.1.2 Package-based ranking (top 25 features)

- FSL: rank = 1498 , imp = 117.6986
- FreeSurfer: rank = 868 , imp = 146.3458
- ANTsX: rank = 781 , imp = 142.2774

7.1.3 Package-based ranking (top 50 features)

- FSL: rank = 5321 , imp = 194.8791
- FreeSurfer: rank = 4226 , imp = 228.9607
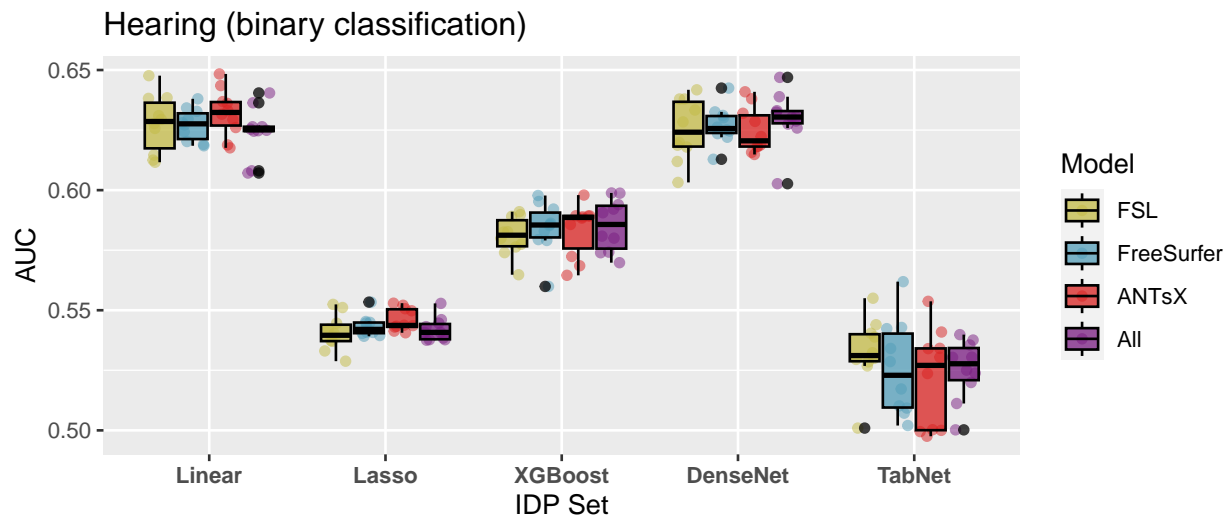- ANTsX: rank = 2835 , imp = 243.0013

8 Hearing

Figure 8: Hearing

8.1   Feature ranking: Linear

- FSL

    - range: [0.1400707 , 15.84752]
    - std: 1.370073
    - skewness: 7.933981

- FreeSurfer

    - range: [0.1609316 , 3.033436]
    - std: 0.6188603
    - skewness: 1.169872

- ANTsX

    - range: [0.09976114 , 3.424184]
    - std: 0.6634497
    - skewness: 1.186676

8.1.1   Package-based ranking (top 10 features)

- FSL: rank = 157 , imp = 41.91777

- FreeSurfer: rank = 195 , imp = 26.48697

- ANTsX: rank = 126 , imp = 28.82698

Table 8: Hearing

Package	Pipeline	Feature
FSL	FAST	Volume of grey matter in Amygdala (left)
FSL	FAST	Volume of grey matter in Amygdala (right)
ANTsX	Thickness	Right lingual
ANTsX	Cereb	L_IX volume
ANTsX	DeepFLASH	Left aLEC
ANTsX	Thickness	Left transverse temporal
FreeSurfer	Volume	Volume of caudalanteriorcingulate (left hemisphere)
FSL	FAST	Volume of grey matter in X Cerebellum (right)
FreeSurfer	Volume	Volume of medialorbitofrontal (left hemisphere)
FSL	FAST	Volume of grey matter in Temporal Fusiform Cortex - posterior division (left)
FreeSurfer	Thickness	Mean thickness of posteriorcingulate (right hemisphere)
FSL	Other	Continuous Volume of grey matter
FreeSurfer	Volume	Volume of paracentral (left hemisphere)
ANTsX	Region	Right thalamus proper
ANTsX	Cereb	L_Crus_I volume
ANTsX	Cereb	L_I_II volume
FreeSurfer	Volume	Volume of inferiorparietal (left hemisphere)
FreeSurfer	Thickness	Mean thickness of inferiorparietal (left hemisphere)
ANTsX	Cereb	R_VI volume
ANTsX	Region	Right caudate
FSL	FAST	Volume of grey matter in VI Cerebellum (right)
FSL	FAST	Volume of grey matter in Parahippocampal Gyrus - posterior division (left)
FSL	FAST	Volume of grey matter in Middle Temporal Gyrus - temporooccipital part (right)
ANTsX	Region	Right middle temporal
ANTsX	Cereb	L_Crus_II volume

8.1.2 Package-based ranking (top 25 features)

- FSL: rank = 1280 , imp = 70.92944
- FreeSurfer: rank = 933 , imp = 59.54118
- ANTsX: rank = 820 , imp = 62.38052

8.1.3 Package-based ranking (top 50 features)

- FSL: rank = 5838 , imp = 103.0179
- FreeSurfer: rank = 3514 , imp = 101.4115
- ANTsX: rank = 3120 , imp = 106.2714

9 RiskTaking
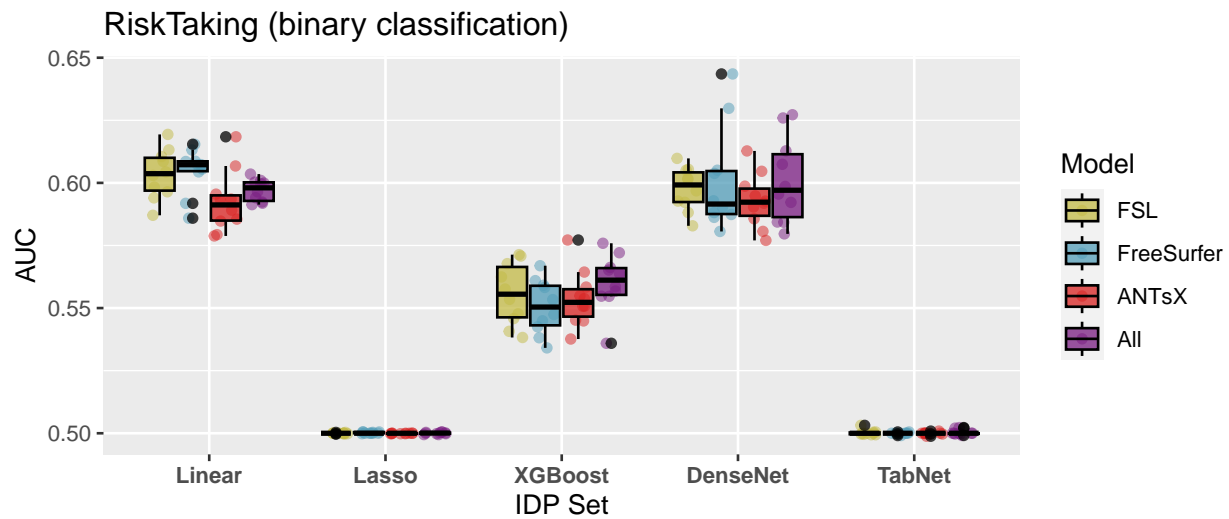
RiskTaking (binary classification)

Figure 9: RiskTaking

9.1 Feature ranking: Linear

- FSL

  - range: [0.1795269 , 10.14113]
  - std: 0.9923587
  - skewness: 5.553114

- FreeSurfer

  - range: [0.1836498 , 3.657539]
  - std: 0.6951129
  - skewness: 0.6690752

- ANTsX

  - range: [0.1370474 , 2.901573]
  - std: 0.6013431
  - skewness: 0.9711023

9.1.1 Package-based ranking (top 10 features)

- FSL: rank = 261 , imp = 34.88583

- FreeSurfer: rank = 90 , imp = 30.03523

- ANTsX: rank = 250 , imp = 25.28125

Table 9: RiskTaking

Package	Pipeline	Feature
FSL	FAST	Volume of grey matter in Amygdala (right)
FSL	FAST	Volume of grey matter in Amygdala (left)
FreeSurfer	ASEG	Volume of BrainSeg (whole brain)
FSL	FAST	Volume of grey matter in Frontal Orbital Cortex (left)
FreeSurfer	Thickness	Mean thickness of parsorbitalis (left hemisphere)
FreeSurfer	HippAmyg	Volume of CL (left hemisphere)
FreeSurfer	HippAmyg	Volume of Hippocampal-tail (left hemisphere)
ANTsX	Thickness	Left caudal anterior cingulate
FreeSurfer	HippAmyg	Volume of parasubiculum (left hemisphere)
FreeSurfer	HippAmyg	Volume of presubiculum-body (left hemisphere)
FreeSurfer	HippAmyg	Volume of CA3-body (left hemisphere)
FreeSurfer	HippAmyg	Volume of CA4-body (left hemisphere)
FreeSurfer	HippAmyg	Volume of subiculum-body (left hemisphere)
FreeSurfer	HippAmyg	Volume of HATA (left hemisphere)
FSL	FAST	Volume of grey matter in Temporal Fusiform Cortex - anterior division (left)
FSL	FAST	Volume of grey matter in Intracalcarine Cortex (left)
FreeSurfer	Thickness	Mean thickness of lateralorbitofrontal (right hemisphere)
ANTsX	DeepFLASH	Right perirhinal
ANTsX	Cortical	Right pericalcarine volume
ANTsX	DeepFLASH	Right MTL
ANTsX	Region	Right pericalcarine
FreeSurfer	HippAmyg	Volume of AV (right hemisphere)
FreeSurfer	ASEG	Volume of Amygdala (left hemisphere)
FreeSurfer	ASEG	Volume of TotalGray (whole brain)
FreeSurfer	Thickness	Mean thickness of entorhinal (left hemisphere)

9.1.2   Package-based ranking (top 25 features)

- FSL: rank = 2255 , imp = 59.555
- FreeSurfer: rank = 552 , imp = 65.86192
- ANTsX: rank = 1073 , imp = 55.84686

9.1.3   Package-based ranking (top 50 features)

- FSL: rank = 8514 , imp = 90.72164
- FreeSurfer: rank = 2525 , imp = 111.9594
- ANTsX: rank = 3945 , imp = 97.4797

10   SameSexIntercourse

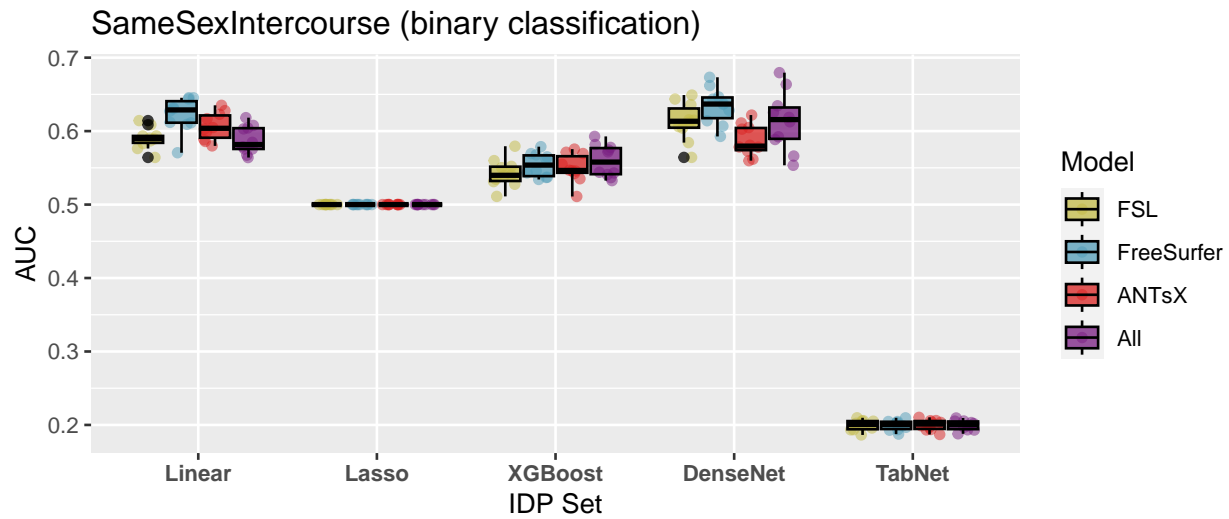SameSexIntercourse (binary classification)

Figure 10: SameSexIntercourse

10.1   Feature ranking: DenseNet

- FSL

    - range: [0.000000000003268539 , 0.00000001664616]
    - std: 0.000000004021121
    - skewness: 1.41056

- FreeSurfer

    - range: [0.000000000002240486 , 0.00000002967567]
    - std: 0.000000003728902
    - skewness: 2.520695

- ANTsX

    - range: [0.000000000005047014 , 0.00000001821027]
    - std: 0.000000003795055
    - skewness: 1.806069

10.1.1   Package-based ranking (top 10 features)

- FSL: rank = 214 , imp = 0.0000001407956

- FreeSurfer: rank = 245 , imp = 0.0000001539418

- ANTsX: rank = 118 , imp = 0.0000001631049

Table 10: SameSexIntercourse

Package	Pipeline	Feature
–	–	GeneticSex
–	–	Age
FreeSurfer	Volume	Volume of pericalcarine (left hemisphere)
FreeSurfer	ASEG	Volume of 4th-Ventricle (whole brain)
ANTsX	Thickness	Left transverse temporal
ANTsX	Cereb	R_Crus_II volume
FreeSurfer	Thickness	Mean thickness of medialorbitofrontal (left hemisphere)
ANTsX	SYSU WMH	Right temporal
ANTsX	Cereb	CerebellarCSF volume
FSL	FAST	Volume of grey matter in Lingual Gyrus (left)
ANTsX	Region	Left pars triangularis
ANTsX	Cortical	Right pars orbitalis volume
FSL	FAST	Volume of grey matter in IX Cerebellum (vermis)
FSL	Other	Continuous Volumetric scaling from T1 head image to standard space
ANTsX	DeepFLASH	Left perirhinal
ANTsX	Region	Right pars orbitalis
ANTsX	SYSU WMH	Right brain stem
FSL	FAST	Volume of grey matter in VIIb Cerebellum (left)
ANTsX	Thickness	Right pericalcarine
FSL	FAST	Volume of grey matter in Parahippocampal Gyrus - anterior division (left)
ANTsX	Cortical	Right lateral occipital volume
ANTsX	Region	Right postcentral
FSL	FAST	Volume of grey matter in Crus I Cerebellum (left)
ANTsX	Region	Right pericalcarine
FreeSurfer	Thickness	Mean thickness of lingual (right hemisphere)

10.1.2 Package-based ranking (top 25 features)

- FSL: rank = 1092 , imp = 0.0000002926681

- FreeSurfer: rank = 1110 , imp = 0.0000003048706

- ANTsX: rank = 840 , imp = 0.0000003275384

10.1.3 Package-based ranking (top 50 features)

- FSL: rank = 4920 , imp = 0.000000438526

- FreeSurfer: rank = 3773 , imp = 0.0000004926684

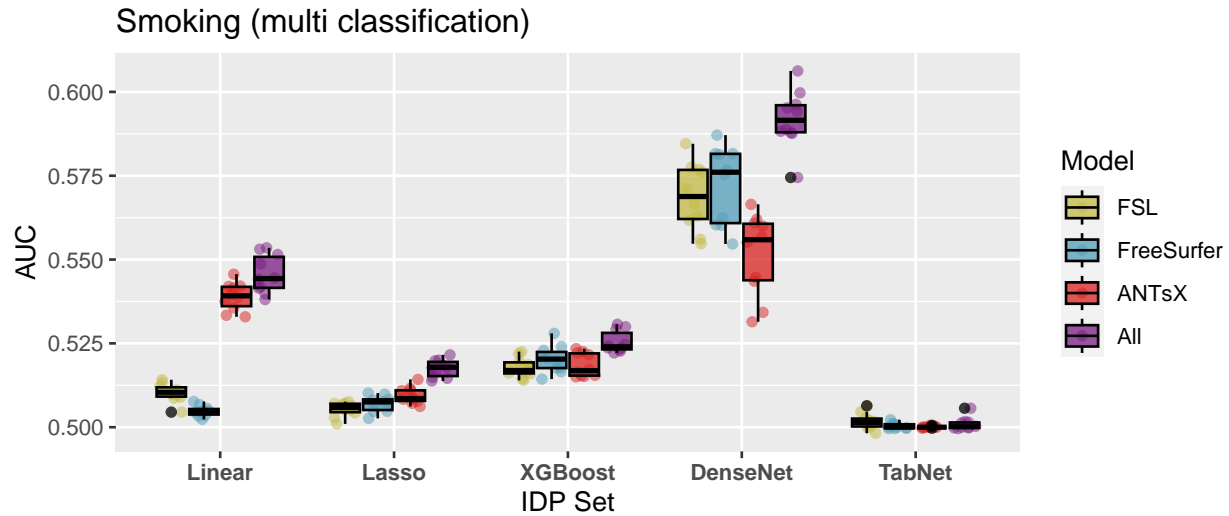- ANTsX: rank = 3373 , imp = 0.0000005208619

11 Smoking

Smoking (multi classification)

Figure 11: Smoking

11.1 Feature ranking: DenseNet

- FSL

  - range: [0.000000000003270309 , 0.0000000005886711]
  - std: 0.000000001163567
  - skewness: 1.513629

- FreeSurfer

  - range: [0.000000000003655943 , 0.000000001000974]
  - std: 0.000000001167341
  - skewness: 2.716113

- ANTsX

  - range: [0.000000000001786802 , 0.000000000638014]
  - std: 0.000000000120871
  - skewness: 1.511429

11.1.1 Package-based ranking (top 10 features)

- FSL: rank = 280 , imp = 0.000000004373141

- FreeSurfer: rank = 159 , imp = 0.000000005361177

- ANTsX: rank = 130 , imp = 0.000000005191133

Table 11: Smoking

Package	Pipeline	Feature
FreeSurfer	ASEG	Volume of choroid-plexus (left hemisphere)
–	–	Age
ANTsX	SYSU WMH	Left parietal
ANTsX	Thickness	Left pericalcarine
FreeSurfer	Thickness	Mean thickness of transversetemporal (left hemisphere)
FSL	FAST	Volume of grey matter in Amygdala (left)
FreeSurfer	Thickness	Mean thickness of fusiform (left hemisphere)
ANTsX	SYSU WMH	Left occipital
ANTsX	Cereb	R_VIIIA thickness
ANTsX	Cortical	Left insula volume
FreeSurfer	HippAmyg	Volume of GC-ML-DG-body (right hemisphere)
FSL	FAST	Volume of grey matter in IX Cerebellum (vermis)
ANTsX	Cereb	L_V thickness
ANTsX	Thickness	Right precentral
FreeSurfer	Thickness	Mean thickness of lingual (right hemisphere)
FSL	FIRST	Volume of amygdala (left)
FreeSurfer	Thickness	Mean thickness of postcentral (left hemisphere)
FSL	FAST	Volume of grey matter in Superior Parietal Lobule (left)
–	–	GeneticSex
ANTsX	Atropos	DeepGrayMatter
FSL	FAST	Volume of grey matter in VIIIa Cerebellum (right)
FreeSurfer	Volume	Volume of precuneus (right hemisphere)
ANTsX	Region	Left thalamus proper
FreeSurfer	Volume	Volume of supramarginal (right hemisphere)
FreeSurfer	HippAmyg	Volume of parasubiculum (left hemisphere)

11.1.2   Package-based ranking (top 25 features)

- FSL: rank = 1346 , imp = 0.000000008911815

- FreeSurfer: rank = 1105 , imp = 0.00000001018895

- ANTsX: rank = 728 , imp = 0.00000001080129

11.1.3   Package-based ranking (top 50 features)

- FSL: rank = 5736 , imp = 0.00000001346166

- FreeSurfer: rank = 4092 , imp = 0.00000001577306

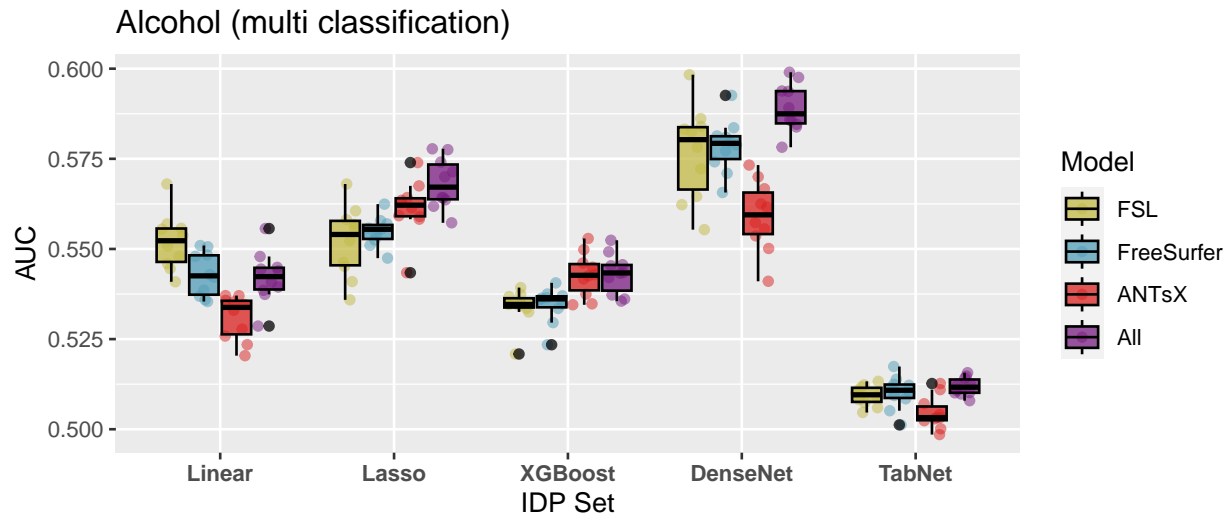- ANTsX: rank = 2811 , imp = 0.00000001777281

12 Alcohol

Figure 12: Alcohol

12.1 Feature ranking: DenseNet

- FSL

  - range: [0.000000000001317874 , 0.000000001049847]
  - std: 0.000000000177729
  - skewness: 1.846177

- FreeSurfer

  - range: [0.000000000005249085 , 0.000000001679132]
  - std: 0.0000000001983307
  - skewness: 3.149707

- ANTsX

  - range: [0.0000000000005087941 , 0.000000001512374]
  - std: 0.0000000002030513
  - skewness: 2.066722

12.1.1 Package-based ranking (top 10 features)

- FSL: rank = 308 , imp = 0.000000006732736

- FreeSurfer: rank = 166 , imp = 0.00000000911108

- ANTsX: rank = 126 , imp = 0.00000000857335

Table 12: Alcohol

Package	Pipeline	Feature
FreeSurfer	Thickness	Mean thickness of parsopercularis (left hemisphere)
ANTsX	Cortical	Right entorhinal volume
FreeSurfer	Thickness	Mean thickness of superiortemporal (right hemisphere)
FreeSurfer	Thickness	Mean thickness of lateraloccipital (right hemisphere)
FSL	FAST	Volume of grey matter in Middle Temporal Gyrus - anterior division (right)
ANTsX	Thickness	Right pericalcarine
ANTsX	Cortical	Right inferior temporal volume
FSL	FAST	Volume of grey matter in Subcallosal Cortex (left)
FreeSurfer	Thickness	Mean thickness of lingual (right hemisphere)
ANTsX	Cortical	Left posterior cingulate volume
ANTsX	Region	Right inferior temporal
FSL	FAST	Volume of grey matter in Subcallosal Cortex (right)
–	–	Age
ANTsX	Region	Left cuneus
FSL	FAST	Volume of grey matter in VIIIb Cerebellum (right)
FreeSurfer	ASEG	Volume of Inf-Lat-Vent (right hemisphere)
ANTsX	Thickness	Right rostral middle frontal
ANTsX	Thickness	Left lateral occipital
FreeSurfer	Volume	Volume of rostralmiddlefrontal (right hemisphere)
ANTsX	Cortical	Right fusiform volume
ANTsX	Region	Left inferior temporal
FSL	FAST	Volume of grey matter in Inferior Frontal Gyrus - pars triangularis (right)
ANTsX	Region	Left pars opercularis
ANTsX	DeepFLASH	Left extra hippocampal
FreeSurfer	Volume	Volume of cuneus (left hemisphere)

12.1.2 Package-based ranking (top 25 features)

- FSL: rank = 1596 , imp = 0.00000001311022

- FreeSurfer: rank = 1020 , imp = 0.00000001669101

- ANTsX: rank = 636 , imp = 0.00000001763453

12.1.3 Package-based ranking (top 50 features)

- FSL: rank = 6042 , imp = 0.0000000200281

- FreeSurfer: rank = 3724 , imp = 0.00000002605897

- ANTsX: rank = 2726 , imp = 0.00000002838635