Figure A.8: Bland-Altman plots of the Explained Variance (EV): Figure A shows the comparison of the linear and B-spline model, using the IDPs. Figure B shows the comparison of the warped and B-spline model, using the IDPs. Figure C shows the comparison of the warped and B-spline model, using the FreeSurfer measurements.

Appendix A.

Figure A.8 shows the Bland-Altman plots of the explained variance for the IDPs and FreeSurfer measurements comparing the different model settings.

Appendix B.

An example list of the IDPs, processed using FUNPACK (the FMRIB UKBiobank Normalisation, Parsing And Cleaning Kit), used in this study is given in B.1 The IDPs contained the following neuroimaging modalities [17]:

1. T1, from which the total brain volumes are calculated.
Table B.1: Example list of the IDP field names, processed using FUNPACK (the FMRIB UKBiobank Normalisation, Parsing And Cleaning Kit).

| Field Name                                                                 | Description                                                                 |
|---------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Volumetric scaling from T1 head image to standard space                  |                                                                            |
| Volume of white matter                                                   |                                                                            |
| Median T2star in thalamus (left)                                         |                                                                            |
| Mean FA in middle cerebellar peduncle on FA skeleton                     |                                                                            |
| Mean MD in middle cerebellar peduncle on FA skeleton                     |                                                                            |
| Mean MO in fornix on FA skeleton                                         |                                                                            |
| Mean L1 in body of corpus callosum on FA skeleton                        |                                                                            |
| Mean L2 in cerebral peduncle on FA skeleton (right)                       |                                                                            |
| Mean L2 in cerebral peduncle on FA skeleton (right)                       |                                                                            |
| Mean OD in posterior limb of internal capsule on FA skeleton (right)      |                                                                            |
| Mean ISOVF in splenium of corpus callosum on FA skeleton                 |                                                                            |
| Weighted-mean FA in tract acoustic radiation (left)                      |                                                                            |
| Weighted-mean MD in tract corticospinal tract (right)                    |                                                                            |
| Weighted-mean MO in tract acoustic radiation (right)                     |                                                                            |
| Weighted-mean L1 in tract acoustic radiation (left)                      |                                                                            |
| Weighted-mean L2 in tract acoustic radiation (left)                      |                                                                            |
| Discrepancy between T2 FLAIR brain image and T1 brain image              |                                                                            |
| Volume of grey matter in Frontal Pole (left)                             |                                                                            |

Appendix C.

We computed the differences between the BICs of a B-spline BLR and a warped BLR. Afterwards, we selected the top 30 IDPs where the B-spline model had the lowest BIC comparatively to the warped score or the other
way around. In table C.2 the model selection criteria of the top 30 best-fitted IDPs with the B-spline BLR compared to the warped BLR are shown. In table C.3 the model selection criteria of the top 30 best-fitted IDPs with the warped BLR compared to the B-spline BLR shown. These tables demonstrate that every neuroimaging modality has its optimal model settings and that one should carefully examine the model selection criteria and shape of the response distribution, before choosing a model.

Appendix D.

We used a paired-sample t-test, pairing the IDP results (EV, MSLL and BIC) of the different models to estimate the difference between performance measures of the warped and non-warped BLR. In table D.4 and D.5 the Cohen’s d effect sizes and p-values are reported. The results show that there is a large difference between the standard BLR and the B-spline BLR, which confirms that one should take into account the non-linearity of the data. For the warped BLR and the B-spline BLR model, there is only a significant difference in the BIC score. We argue that this is because the model selection criteria are not necessarily sensitive to the deviations in the residuals from normality. Therefore, we also recommend to, alongside the model selection criteria, look at the skewness and kurtosis values together with the QQ-plot to choose the optimal model settings for each modality.

Appendix E.

In table E.6 we listed the cognitive variables from the UK Biobank that were used in this study with their IDs.
| EV  | MSLL  | BIC           | Field                                                                 |
|-----|-------|---------------|----------------------------------------------------------------------|
| 0.206 | -0.115 | -166562.002  | Mean MD in superior fronto-occipital fasciculus on FA skeleton (right) |
| 0.134 | -0.072 | -46220.575   | Mean ISOVF in genu of corpus callosum on FA skeleton                  |
| 0.025 | -0.013 | -12455.567   | Mean MO in superior fronto-occipital fasciculus on FA skeleton (left)  |
| 0.159 | -0.087 | -163761.463  | Mean L2 in superior fronto-occipital fasciculus on FA skeleton (right) |
| 0.148 | -0.08  | -176269.475  | Mean MD in external capsule on FA skeleton (right)                    |
| 0.17  | -0.093 | -40955.602   | Discrepancy between T1 brain image and standard-space brain template (linearly-aligned) |
| 0.074 | -0.039 | -52218.319   | Mean ISOVF in anterior limb of internal capsule on FA skeleton (left)  |
| 0.066 | -0.034 | -50151.283   | Mean ISOVF in anterior limb of internal capsule on FA skeleton (right) |
| 0.135 | -0.072 | -175704.326  | Mean L3 in external capsule on FA skeleton (right)                    |
| 0.202 | -0.113 | -32491.645   | Mean ICVF in superior fronto-occipital fasciculus on FA skeleton (right) |
| 0.077 | -0.04  | -99708.396   | Inverted temporal signal-to-noise ratio in pre-processed tfMRI        |
| 0.188 | -0.104 | -171678.769  | Mean MD in anterior corona radiata on FA skeleton (left)              |
| 0.265 | -0.154 | -176057.846  | Weighted-mean MD in tract anterior thalamic radiation (left)          |
| 0.078 | -0.041 | -44211.387   | Mean ISOVF in superior fronto-occipital fasciculus on FA skeleton (left) |
| 0.143 | -0.077 | -59646.162   | Weighted-mean ISOVF in tract anterior thalamic radiation (right)      |
| 0.177 | -0.098 | -172620.769  | Mean MD in anterior corona radiata on FA skeleton (right)             |
| 0.273 | -0.16  | -176331.153  | Weighted-mean MD in tract anterior thalamic radiation (right)         |
| 0.174 | -0.096 | -170432.707  | Mean L2 in anterior corona radiata on FA skeleton (right)             |
| 0.054 | -0.028 | 101219.506   | Volume of grey matter in Pallidium (right)                           |
| 0.175 | -0.096 | -169471.163  | Mean MD in genu of corpus callosum on FA skeleton                    |
| 0.229 | -0.13  | -175866.701  | Weighted-mean L2 in tract anterior thalamic radiation (right)         |
| 0.163 | -0.089 | -177074.476  | Mean MD in anterior limb of internal capsule on FA skeleton (left)    |
| 0.079 | -0.041 | -53234.386   | Mean ISOVF in posterior corona radiata on FA skeleton (left)          |
| 0.159 | -0.087 | -58912.836   | Weighted-mean ISOVF in tract anterior thalamic radiation (left)       |
| 0.04  | -0.02  | -25966.018   | Mean ICVF in fornix on FA skeleton                                    |
| 0.076 | -0.04  | -56374.466   | Mean ISOVF in anterior corona radiata on FA skeleton (left)           |
| 0.14  | -0.075 | -55319.609   | Weighted-mean OD in tract superior thalamic radiation (left)          |
| 0.076 | -0.039 | -57122.197   | Weighted-mean ISOVF in tract superior longitudinal fasciculus (left)  |
| 0.039 | -0.02  | -57205.686   | Mean ISOVF in anterior corona radiata on FA skeleton (right)          |
| 0.103 | -0.054 | -51036.79    | Mean ISOVF in posterior corona radiata on FA skeleton (right)         |

Table C.2: Model selection criteria of the top 30 IDPs, ranked according to difference between the BIC of a B-spline BLR and a SinhArcsineh warped BLR, where the B-spline BLR had a lower BIC score.
| EV   | MSLL | BIC  | Field                                                                 |
|------|------|------|----------------------------------------------------------------------|
| 0.249| -0.143 | 184900.524 | Total volume of white matter hyperintensities (from T1 and T2-FLAIR images) |
| 0.147| -0.079  | -29710.013 | Mean OD in fornix on FA skeleton                                       |
| 0.285| -0.164  | -137192.133 | Mean MD in fornix on FA skeleton                                       |
| 0.276| -0.153  | -136161.29  | Mean L3 in fornix on FA skeleton                                       |
| 0.275| -0.151  | -134595.545 | Mean L2 in fornix on FA skeleton                                       |
| 0.153| -0.083  | -87376.141  | Inverted temporal signal-to-noise ratio in pre-processed rfMRI         |
| 0.27 | -0.157  | -24636.152  | Mean FA in fornix on FA skeleton                                       |
| 0.171| -0.093  | -32985.173  | Mean MO in anterior limb of internal capsule on FA skeleton (right)     |
| 0.094| -0.049  | -22330.216  | Mean MO in tapetum on FA skeleton (left)                               |
| 0.043| -0.022  | -26681.768  | Mean MO in tapetum on FA skeleton (right)                              |
| 0.141| -0.076  | -33305.028  | Mean MO in anterior limb of internal capsule on FA skeleton (left)      |
| 0.054| -0.027  | -42459.737  | Weighted-mean ISOVF in tract parahippocampal part of cingulum (left)   |
| 0.117| -0.062  | -71451.215  | Mean OD in splenium of corpus callosum on FA skeleton                  |
| 0.064| -0.033  | -40476.534  | Weighted-mean FA in tract parahippocampal part of cingulum (right)     |
| 0.307| -0.183  | -15506.712  | Mean ISOVF in fornix on FA skeleton                                    |
| 0.182| -0.1    | -34039.973  | Discrepancy between T2 FLAIR brain image and T1 brain image            |
| 0.047| -0.024  | -41660.315  | Weighted-mean FA in tract parahippocampal part of cingulum (left)      |
| 0.058| -0.03   | -51125.932  | Mean OD in tapetum on FA skeleton (left)                               |
| 0.199| -0.111  | -172072.977 | Weighted-mean MD in tract posterior thalamic radiation (left)          |
| 0.311| -0.186  | -26746.982  | Discrepancy between tfMRI brain image and T1 brain image               |
| 0.131| -0.071  | -169248.259 | Mean MD in posterior thalamic radiation on FA skeleton (left)          |
| 0.089| -0.046  | -181090.417 | Mean MD in inferior cerebellar peduncle on FA skeleton (left)          |
| 0.07 | -0.036  | -41654.584  | Weighted-mean ISOVF in tract parahippocampal part of cingulum (right) |
| 0.028| -0.014  | -35788.551  | Mean MO in posterior limb of internal capsule on FA skeleton (right)    |
| 0.069| -0.036  | -62423.772  | Weighted-mean OD in tract forceps major                                |
| 0.027| -0.014  | -52538.461  | Mean ISOVF in middle cerebellar peduncle on FA skeleton                |
| 0.314| -0.188  | -27837.003  | Discrepancy between rfMRI brain image and T1 brain image              |
| 0.085| -0.044  | -170720.346 | Weighted-mean MD in tract medial lemniscus (right)                    |

Table C.3: Model selection criteria of the top 30 IDPs, ranked according to the difference between the BIC of a B-spline BLR and a SinhArcsinh warped BLR, where the SinhArcsinh warped BLR had a lower BIC score.
Table D.4: Table presenting a paired-sample t-test between the B-spline and standard BLR models, using the IDP data, showing a significant difference between the model selection criteria of the B-spline BLR and the standard BLR, with a large effect size.

| Criteria | t   | p     | d   |
|----------|-----|-------|-----|
| EV       | 27.511 | p < 0.001 | 0.922 |
| MSLL     | -26.538 | p < 0.001 | -0.889 |
| BIC      | -15.95 | p < 0.001 | -0.534 |

Table D.5: Table presenting a paired-sample t-test between the B-spline and warped BLR models, using the IDP data, showing only a significant difference between the model selection criteria of the B-spline BLR and the B-spline SinhArcsinh warped BLR using the BIC score, with a small effect size.

| Criteria | t   | p     | d   |
|----------|-----|-------|-----|
| EV       | -0.897 | 0.37 | -0.03 |
| MSLL     | 0.026 | 0.979 | 0.001 |
| BIC      | 9.279 | p < 0.001 | 0.311 |
Table E.6: Cognitive variables of the UK Biobank that were used in this study.

| Field                                           | FieldID |
|-------------------------------------------------|---------|
| Number of times snap-button pressed             | 403     |
| Duration to first press of snap-button in each round | 404     |
| Mean time to correctly identify matches         | 20023   |
| Time elapsed                                    | 4256    |
| Digits entered correctly                        | 4259    |
| Number of rounds of numeric memory test performed | 4283    |
| Time to complete test                           | 4285    |
| Duration screen displayed                       | 4290    |
| Number of attempts                              | 4291    |
| Prospective memory result                       | 20018   |
| Fluid intelligence score                        | 20016   |
| Number of fluid intelligence questions attempted within time limit | 20128   |
| Duration to complete numeric path (trail 1)     | 6348    |
| Total errors traversing numeric path (trail 1)  | 6349    |
| Duration to complete alphanumeric path (trail 2)| 6350    |
| Total errors traversing alphanumeric path (trail 2)| 6351   |
| Errors before selecting correct item in numeric path (trail 1) | 6770    |
| Errors before selecting correct item in alphanumeric path (trail 2) | 6771    |
| Interval between previous point and current one in numeric path (trail 1) | 6772    |
| Interval between previous point and current one in alphanumeric path (trail 2) | 6773    |
| Number of puzzles correctly solved              | 6373    |
| Number of puzzles viewed                        | 6374    |
| Number of puzzles correct                       | 6382    |
| Number of puzzles attempted                     | 6383    |
| Number of puzzles correct                       | 21004   |
| Number of symbol digit matches attempted        | 23323   |
| Number of symbol digit matches made correctly   | 23324   |