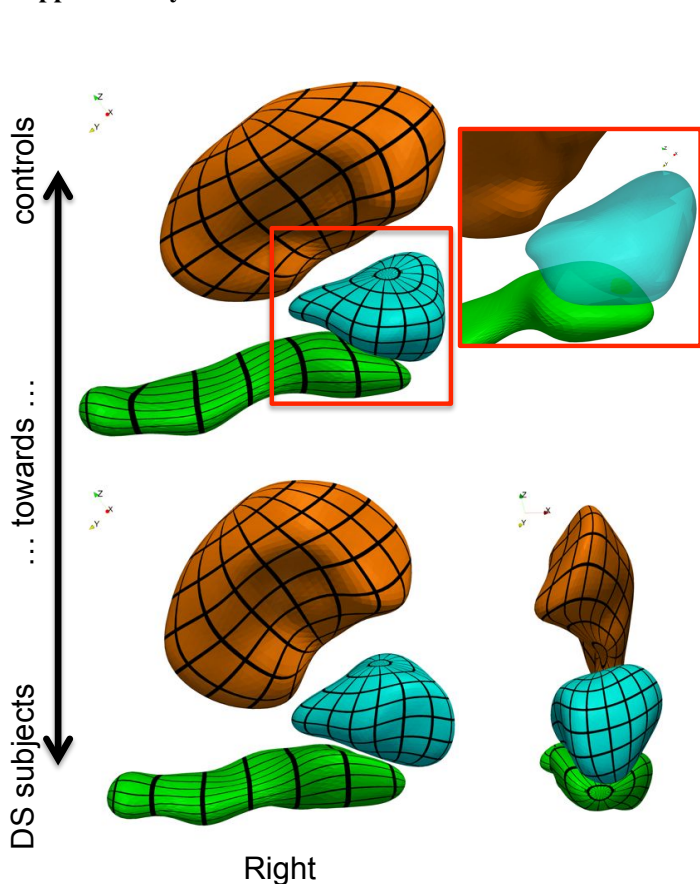**Supplementary Data**

Right

Figure S1: Most Discriminative Axis computed using a composite descriptor. The direction takes into account the correlations among the three structures. However, it does not parameterize a single space deformation, but three of them, and intersections between surfaces occur. Moreover the patterns of shape variations are rather different from the results using a single atlas of shape complex, in particular the relative position of the amygdala (in blue) with respect to the hippocampus (in green)
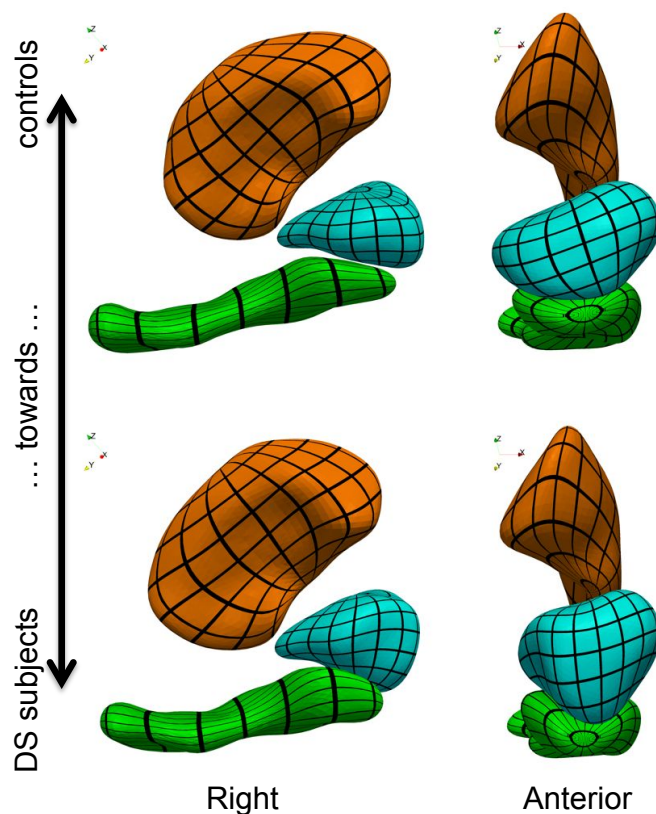

Right   Anterior

Figure S2: Most Discriminative Axis in the atlas with 8 control points. The patterns of shape variations are qualitatively similar with the axis shown using 105 control points, especially for the hippocampus and amygdala (in green and cyan), and to a lesser extent for the putamen. This experiment shows the robustness of the findings with respect to different initial conditions
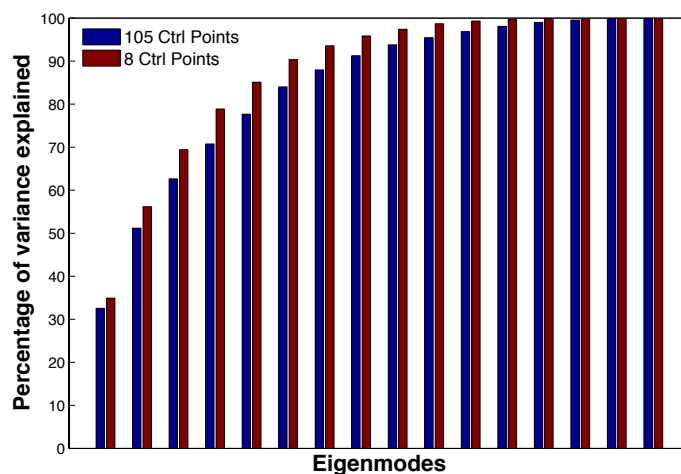

Figure S3: Cumulative variance explained using the sample covariance matrix of the momentum vectors. The spectrum is slightly more concentrated with 8 control points than with 105. The total variance explained in both cases is similar: $\sigma^2 = 27.1$ for 105 points and $\sigma^2 = 23.6$ for 8 points
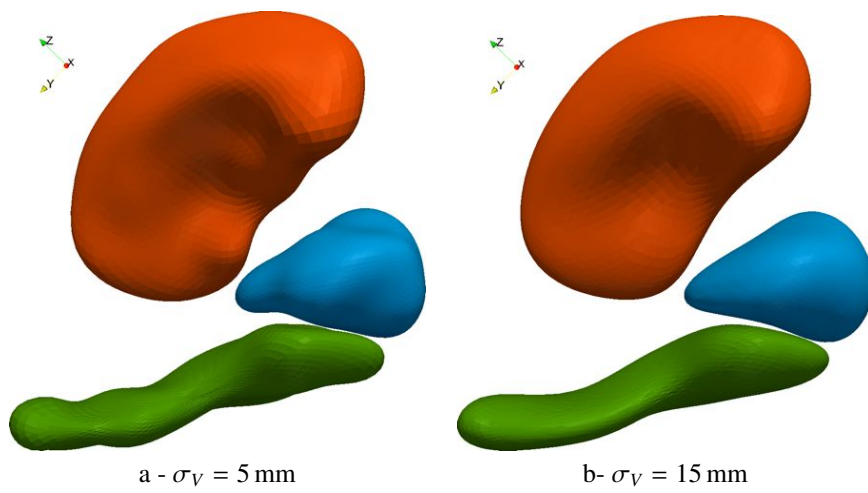
a - $\sigma_V = 5\,\text{mm}$ b- $\sigma_V = 15\,\text{mm}$

Figure S4: Template shape complex estimated with two different deformation kernel widths σ_V, while keeping $\sigma_W = 7.5$ mm. The smaller the width, the more local the variations captured by the model. The larger the width, the more global and rigid the variations captured by the model, resulting in surfaces with fewer details
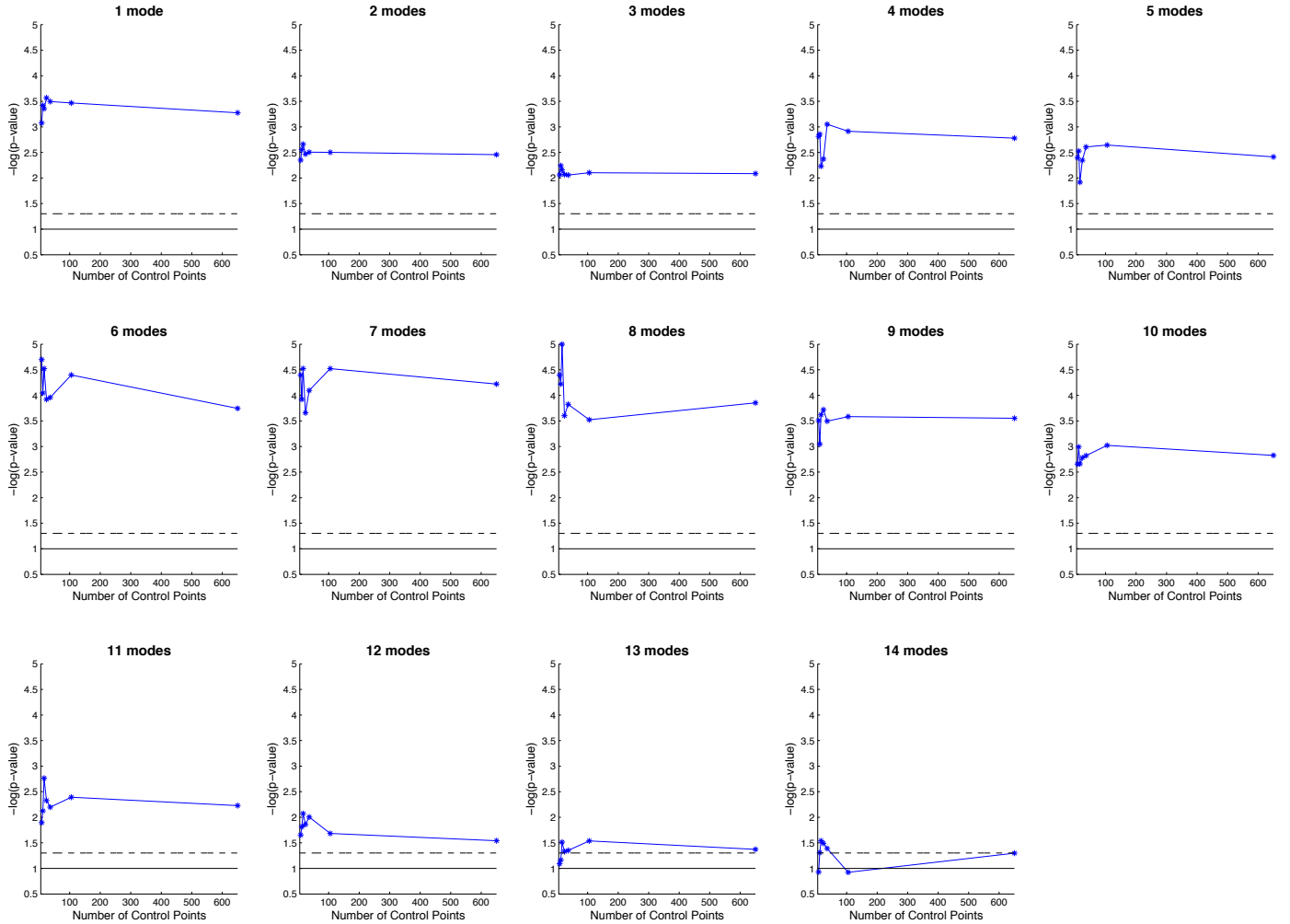
Figure S5: P-values computed for a different number of control points and a different number of selected modes. Solid (resp. dashed) lines correspond to the 10% (resp 5%) significance levels, respectively. For a given number of modes, the best p-value is never achieved for the largest number of control points, showing the interest of small-dimensional models. It seems also that there is an optimal number of modes to be selected, for which the statistical power is overall increased (between 6 and 8 modes). With a few subjects more, we could estimate a full-rank covariance matrix and make the method less and less sensitive to the number of modes selected. We hypothesize that the effect of the number of control points will be more pronounced in this regime (Note that the Fig. 5-b is built from these plots: for each number of control points, we picked the p-values that correspond to the number of modes explaining 95% of the variance, which was always either 8 or 9.)