**Supplementary Information**

**Multimodal neuroimaging measures and intelligence influence pedophile child sexual offense behavior**

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**Structural Image Processing**

Cortical reconstruction was performed on all T1-weighted images using the Freesurfer image analysis suite (http://surfer.nmr.mgh.harvard.edu/). The technical details of these procedures are described in prior publications ([Avants *et al*, 2008](#_ENREF_1); [Fischl and Dale, 2000](#_ENREF_4); [Fischl *et al*, 2001](#_ENREF_5); [Fischl *et al*, 2002](#_ENREF_6); [Fischl *et al*, 2004](#_ENREF_7); [Fischl *et al*, 1999a](#_ENREF_8); [Fischl *et al*, 1999b](#_ENREF_9); [Han *et al*, 2006](#_ENREF_10); [Kuperberg *et al*, 2003](#_ENREF_11); [Reuter *et al*, 2012](#_ENREF_16); [Rosas *et al*, 2002](#_ENREF_17); [Salat *et al*, 2004](#_ENREF_18); [Segonne *et al*, 2004](#_ENREF_19); [Segonne *et al*, 2007](#_ENREF_20)). This process includes removal of non-brain tissue using a hybrid watershed/surface deformation procedure([Segonne *et al*, 2004](#_ENREF_19)), automated Talairach transformation, segmentation of the subcortical white matter and deep gray matter volumetric structures([Fischl *et al*, 2002](#_ENREF_6); [Fischl *et al*, 2004](#_ENREF_7)), intensity normalization ([Sled *et al*, 1998](#_ENREF_21)), tessellation of the gray matter white matter boundary, automated topology correction([Fischl *et al*, 2001](#_ENREF_5); [Segonne *et al*, 2007](#_ENREF_20)), and surface deformation following intensity gradients to optimally place the gray/white and gray/cerebrospinal fluid borders at the location where the greatest shift in intensity defines the transition to the other tissue class([Dale *et al*, 1999](#_ENREF_3); [Fischl *et al*, 2000](#_ENREF_4)). Once the cortical models were complete, a number of deformable procedures were performed including surface inflation([Fischl *et al*, 1999a](#_ENREF_8)), registration to a spherical atlas which is based on individual cortical folding patterns to match cortical geometry across subjects([Fischl *et al*, 1999b](#_ENREF_9)), and creation of a variety of surface based data including maps of curvature and sulcal depth.

This method uses both intensity and continuity information from the entire three dimensional MR volume in segmentation and deformation procedures to produce representations of cortical thickness, calculated as the closest distance from the gray/white boundary to the gray/CSF boundary at each vertex on the tessellated surface([Fischl *et al*, 2000](#_ENREF_4)). The maps are created using spatial intensity gradients across tissue classes and are therefore not simply reliant on absolute signal intensity. The maps produced are not restricted to the voxel resolution of the original data and thus are capable of detecting submillimeter differences between groups. Procedures for the measurement of cortical thickness have been validated against histological analysis([Rosas *et al*, 2002](#_ENREF_17)), and manual measurements([Kuperberg *et al*, 2003](#_ENREF_11); [Salat *et al*, 2004](#_ENREF_18)). Freesurfer morphometric procedures have been demonstrated to show good test-retest reliability across scanner manufacturers and across field strengths([Han *et al*, 2006](#_ENREF_10); [Reuter *et al*, 2012](#_ENREF_16)).

For group analyses, a template of all subjects is created using TFCE\_mediation([Lett *et al*, 2017](#_ENREF_12)) employing standard Freesurfer methods. A list of subjects is submitted to create a template with an option for either cortical thickness or surface area. For each subject, surface data is then resampled to the ‘fsaverage’ using surface-based registration where the cortical manifold is inflated to a sphere and homologous neuroanatomical features are matched([Fischl *et al*, 1999a](#_ENREF_8); [Fischl *et al*, 1999b](#_ENREF_9)). After registration, all subjects are merged into a single image separately for each hemisphere. The images are smoothed using full-width half maximum (FWHM) of 3mm.

**DW-MRI Processing**

The DW-MRI processing applied to the data was previously explained in detail ([Lett *et al*, 2017](#_ENREF_12)). After visual inspection, all DW-MRI scans underwent automated quality control, eddy current, and motion correction using DTIprep (<https://www.nitrc.org/projects/dtiprep/>)([Oguz *et al*, 2014](#_ENREF_14)). The b0 images were averaged using mcflirt, and also skull stripped using BET([Smith, 2002](#_ENREF_22)). Each corrected image was visually inspected. Fractional anisotropy (FA) images were created by fitting a tensor model at each voxel using FSL DTIFit([Smith *et al*, 2004](#_ENREF_24)). FA data was skeletonized using tract-based spatial statistics (TBSS) version 1.2([Smith *et al*, 2006](#_ENREF_23)). Briefly, FA images first underwent nonlinear registration to the FMRIB58\_FA target image. The mean FA image was iteratively generated. Each group was then aligned to MNI 152 standard space using an affine transformation. An average white matter skeleton was then generated from the mean of all subjects’ transformed FA images at a threshold of 0.2, and each subject’s FA data was projected onto the white matter skeleton.

**Cortex-wise mediation analysis**

TFCE\_mediation performs cortex-wise mediation analysis with TFCE (threshold-free cluster enhancement)([Lett *et al*, 2017](#_ENREF_12)). Mediation models are statistically causal models that can determine the effect of an independent variable on two dependent variables ([Baron and Kenny, 1986](#_ENREF_2)). The effect of the independent variable on the dependent variable that is explained by a mediator variable is called the indirect effect. The most established method for assessing the significance of the indirect effect is through permutation testing ([Preacher and Hayes, 2008](#_ENREF_15)).

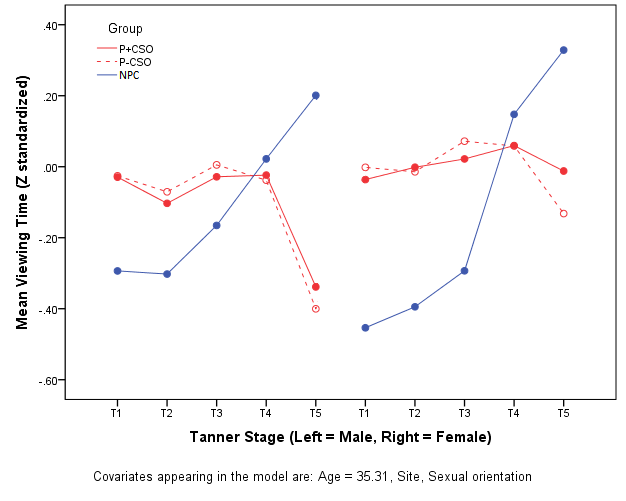
TFCE\_mediation applies a mediation model at all vertices or voxels (i.e., cortex-wise analysis) of a 4D image which then undergo TFCE and significance of the indirect model is assessed via permutation testing. There are three models of cortex-wise mediation that can be tested using TFCE\_mediation: (1), cortex-wise image as the independent variable; (2), cortex-wise image as the mediator variable, and (3) cortex-wise image as the dependent variable. Two sets of regression are performed to assess the indirect effect using the Aroian variant of the Sobel equation ([Mackinnon *et al*, 1995](#_ENREF_13); [Sobel, 1982](#_ENREF_25), [1986](#_ENREF_26)). The default version is the Aroian variant because it does not assume the product of Sa and Sb is small.

The unstandardized regression coefficients (betas: a and b) and the standard errors (Sa and Sb) from the independent variable are regressed on the mediator variable, and the mediator variable to the dependent variable while covarying for the independent variable to produce a z-value at each cortex-wise measure (above). TFCE\_mediation usesan equivalent Sobel equation using t-values (ta and tb) in order to vectorize the regression analyses (below).

Significant mediation is assessed using the maximum TFCE transformed z-value from each 10,000 permutations. TFCE transformed Sobel z-values that were greater than 95% of the maximum TFCE transformed z-values are deemed significant (i.e., pFWE-corrected<0.05). It should be noted that randomization strategies to assess significance of the Sobel equation are considered to be a better alternative than parameter tests that impose distribution assumptions ([Preacher *et al*, 2008](#_ENREF_15)).

**Table S1.** Diffusions tensor imaging acquisition parameters

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Dimension | Spatial Resolution | Slices | Gradient  Directions | b-value | TR | TE | Scanner |
| Charité Universitätsmedizin Berlin | 128x128x72 | 2mm3 | 72 | 60 | 1400 | 13800 ms | 90 ms | SIEMENS  MAGNETOM TrioTim |
| University of Duisburg-Essen | 128x128x72 | 2mm3 | 72 | 60 | 1000 | 12700 ms | 81 ms | Siemens Magnetom Skyra |
| Hannover  Medical School | 128x128x72 | 2mm3 | 72 | 60 | 1000 | 12700 ms | 81 ms | Siemens Magnetom Skyra or Siemens Magnetom Verio |
| University of Kiel | 128x128x72 | 2mm3 | 72 | 32 | 1000 | 13800 ms | 86 ms | Phillips Achieva 3-Tesla |
| University of Magdeburg | 128x128x72 | 2mm3 | 72 | 60 | 1400 | 13800 ms | 86 ms | Siemens Magnetom Verio |



**Figure S1.** Mean viewing time of images by Tanner stage interaction for P+CSO, P-CSO and NPC.P+CSO and P-CSO on average exhibited near identical preference for children, and NPC preferred adults. Mixed-model regression reveals a strong interaction among amount of viewing time and group (Tanner stage viewing time \* Group; F18,2322 = 24.7, p=4.1 x 10-75), as well as main effect of group (F2,258=29.2, p= 3.7 x 10-12). *Post hoc* analysis reveals the effect is consistent comparing P+CSO to NPC (main effect: F1,184=31.8, p = 6.2 x 10-8; interaction: F9,1728 = 27.1, p = 3.7x10-44), or P-CSO to NPC (main effect: F1,192=34.5, p = 1.9 x 10-8; interaction: F9,1728 = 47.1, p = 2.6x10-76), but not P+CSO versus P-CSO (main effect F1,133 = 0.29, p = 0.59; interaction: F9,1197 = 0.44, p = 0.91). Covariates include age, site, and sexual orientation.

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**Figure S2.** WAIS-R FSIQ score is associated with sexual offense of children by pedophiles.(**a**) Each circle represents a participant, and the mean and 95% confidence for each group is located immediately to the right, (**b**) Probability distribution and histogram of FSIQ predicted P+CSO (bottom) vs P-CSO (Wald Chi2=13.0, p=3.1 x 105), (**c**) Probability distribution and histogram of FSIQ predicted P+CSO (bottom) vs NPC (Wald Chi2 = 8.6, p= 0.003). FSIQ scores are corrected for age and site.

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**Figure S3.** P+CSO individuals compared to P-CSO have lower cortical thickness (CT) in the right motor and premotor cortices and the left temporal lobe (PFWE-corrected<0.05).Covariates include age, and scanner. (\*) *Post hoc* comparisons reveal that P+CSO have lower cortical thickness in the right motor region (A; 1383.0 mm2; lowest PFWE-corrected=0.008) as well as in the left temporal lobe (B; 2128.5 mm2; lowest PFWE-corrected=0.016). A, P+CSO versus P-CSO and mean cluster CT across the age-span of the sample. B, Meta-analysis of the association of P+CSO versus P-CSO and mean cluster CT stratified for each site.

**G:\Tris_Personal_2\active_manuscripts\NeMUP\Figures\new\Figure_NeMUP\Slide8.TIF Figure S4.** P+CSO individuals compared to NPC have lower cortical thickness (CT; PFWE-corrected<0.05).Covariates include age, and scanner. (\*) *Post hoc* comparisons reveal that P+CSO have lower cortical thickness in the right motor region (A; 865.8 mm2; lowest PFWE =0.02). A, P+CSO versus NPC and mean cluster CT across the age-span of the sample. B, Meta-analysis of the association of P+CSO versus NPC and mean cluster CT stratified for each site.

**G:\Tris_Personal_2\active_manuscripts\NeMUP\Figures\new\Figure_NeMUP\Slide5u.tif Figure S5.** P+CSO individuals compared to NPC have wide-spread and bilateral reduced surface area (SA) across the cortex (PFWE-corrected<0.05).Covariates include age, and scanner. (\*) *Post hoc* comparisons reveal that P+CSO have lower SA (49907.5 mm2; lowest PFWE-corrected=0.0006). (**a**) P+CSO versus NPC and mean cluster SA across the age-span of the sample. (**b**) Meta-analysis of the association of P+CSO versus NPC and mean cluster SA stratified for each site.

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**Figure S6.** P+CSO compared to NPC individuals have wide-spread reduced fractional anisotropy (FA) throughout the brain (PFWE-corrected<0.05).Covariates include age, and scanner. (\*) *Post hoc* comparisons reveal that P+CSO have lower FA primarily in the corpus callosum (11446 voxels, lowest PFWE-corrected=0.018). (**a**) P+CSO versus NPC and mean cluster FA across the age-span of the sample. (**b**) Meta-analysis of the association of P+CSO versus NPC and mean cluster FA stratified for each site.

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**Figure S7**. WAIS-R full scale IQ (FSIQ) score is associated with vertex-wise cortical thickness (CT), vertex-wise surface area (SA), and voxel-wise fractional anisotropy (FA) independent of group (NPC, P+CSO, P-CSO). Top and middle, the red and blue bars correspond to PFWE < 0.05 and lower on the midthickness projection of the ‘fsaverage’ surface. Bottom, Mean FA is transparent, and the red-yellow color bar represents significant (P<0.05) 1-PFWE values corresponding to each voxel. Top, CT in the prefrontal and right temporal regions was positively associated with FSIQ (PFWE<0.05). Middle, SA was positively associated with FSIQ throughout the cortex (PFWE<0.05). Bottom, white matter FA predominately in the body of the corpus callosum was positively associated with FSIQ (PFWE<0.05). Covariates included age, group, and scanner.

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**Figure S8.** The effect of vertex-wise surface area on P+CSO versus P-CSO pedophiles was strongly mediated by throughout the cortex (Sobel Z PFWE-corrected<0.05). Covariates include age, and scanner. (**a**) *post hoc* mediation model using with the mean surface area value of left hemisphere cluster (18681.5 mm2; lowest PFWE-corrected=0.002) as the independent variable, FSIQ performance as the mediator variable, and P+CSO versus NPC as the dependent variable. There was a significant indirect effect of the mean surface area on P+CSO versus P-CSO pedophiles (Sobel Z = 1.99, p=0.04). B, Beta; SE, Standard Error.

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**Figure S9.** Follow-up analysis in the P+CSO subgroup reveals a correlation between vertex-wise cortical thickness (CT) and the number of sexual offenses against children.Covariates include age, FSIQ, and scanner. *Post hoc* comparisons reveal that a small region within (**a)** the left precuneus (18.2 mm2; lowest PFWE=0.034) as well as within the right orbitofrontal region cortical thickness (**b**) were correlated with the number of offenses (49.0 mm2; lowest PFWE= 0.034).

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