SUPPLEMENTARY INFORMATION

The Motivational Determinants of Human Action, Their Neural Bases and Functional Impact in Adolescents With Obsessive-Compulsive Disorder

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[1] Full experimental methods including participant instructions, data handling, data analysis and imaging procedures

Design

We conducted a case-control cross-sectional study using associative learning paradigms, gold-standard clinical phenotyping, and multimodal magnetic resonance imaging. This study had approval (number 2012/2284) from The University of Sydney Human Research Ethics Committee.

Participants

21 healthy adolescents (control group) and 20 adolescents with a lifetime DSM-5 diagnosis of OCD (OCD group) were included in analysis. We included cases that were currently subclinical (following treatment) in that this would give a greater range of OCD symptom severity, accounting for the fact that extreme symptoms would likely preclude invited patients from participating in our research protocol; this approach strengthened symptom correlation analysis and state v trait insights. The sample size was based on power analysis drawn from a similar study in our lab(1) that stipulated a minimum sample size of n=16 to achieve 80% statistical power at an alpha of 0.05. There were no group demographic differences (Table 1). We adhered with the HREC-approved protocol and government legislation in NSW by obtaining parental consent with participant assent for those aged under 16 years and participant consent with parent assent for participants aged 16-17 years.

General inclusion criteria were: (1) age 12 – 18 years at time of testing, (2) no current DSM-5 eating disorder, (3) no DSM-5 intellectual disability, (4) no severe acquired brain injury, (5)
no history of central nervous system infection, (6) no current substance use more frequent than once per month, (7) no food allergies, (8) no MRI contraindications (e.g., full dental braces, other metallic implants). Co-morbid psychiatric diagnosis was allowed in the OCD group to improve external validity. Specific inclusion criteria for controls were: (1) no previously diagnosed DSM 5 disorder (past adjustment disorders and past or present elimination disorders were allowed), (2) no lifetime treatment with psychotropic medication, (3) no first-degree relative with OCD. General exclusion criteria were: (1) structural central nervous system abnormalities, (2) > 2 mm head movement during the scan, (3) failure to comprehend or recall the task instructions. Adolescents with OCD were recruited from 107 consecutive presentations (11/03/2008-09/03/2015) to an OCD clinic freely accessible to the public for children and adolescents residing in a geographical area within Sydney, Australia. Having excluded patients outside the age inclusion criterion at time of the study (n=45) or with a diagnosis of intellectual disability (n=2), 60 candidate participants remained. Telephone contact was attempted with 46, 20 of whom declined to participate, 2 had limited English language proficiency, and 3 had MRI contraindications. The remaining 21 attended for testing, one participant was exluded because the semi-structured clinical assessment excluded OCD. A child and adolescent psychiatrist clinically determined caseness. Recruitment of controls occurred through advertisement, convenience, ‘snowball’, and a research volunteer registry.

Telephone screening for inclusion criteria and recruitment was undertaken – refer Supplementary Table S1. Participants completed self-report questionnaires that recorded demographics (age, gender, ethnicity, language, and education), medications (agent, dose, and duration), and the Depression Anxiety and Stress Scale [DASS](2). Pre-morbid intelligence was assessed with the Weschler Ranging Assessment Test [WRAT](3).

All participants in both groups were assessed using the Schedule for Affective Disorders and Schizophrenia for School-Aged (K-SADS –PL 2013). OCD symptom measures(4) were completed for the clinical group. To optimize standardization, all assessments were completed a child and adolescent psychiatry registrar (IEP) who interviewed the participant and one or both parents. A child and adolescent psychiatrist (PLH) provided training and supervision of diagnostic interviews. All clinical assessment data was collected within 24 hours of behavioural experiments.

**Behavioral stimuli, outcomes & equipment.**

Outcomes consisted of five different sweet or salty foods, commercially named: Arnott’s Chocolate Tiny Teddy® Biscuits 250g, Doritos® Cheese Supreme Corn Chips 114g, Cheezels® Cheese Snacks 114g, Arnott’s BBQ Shapes® 250g, Milk Chocolate M&M’S® 49g. Task design, stimulus presentation and response recording was controlled by PsychoPy© software (v1.82.00) running on a MacBook© (Apple, CA) computer. Visual stimuli during scanning were displayed a projector placed behind the MRI scanner. A Lumina© MRI-compatible two-button response pad (Cedrus©, California) detected responses. Participants viewed a reflection of the projected image (800 x 600 pixels) in a mirror attached to the scanner headcoil.

**Procedure & setting.**

Participants abstained from eating for three hours prior to the experiment. Before training,
participants were asked “On a scale of 1 to 10, how hungry are you right now?”. Sealed commercial packages of the five foods were opened onto individual plates in front of participants in order to assuage any concerns about contamination (Arnott’s Chocolate Tiny Teddy® Biscuits 250g, Doritos® Cheese Supreme Corn Chips 114 g, Cheezels® Cheese Snacks 114 g, Arnott’s BBQ Shapes® 250 g, Milk Chocolate M&M’S® 49 g). Participants tasted and rated each food on a 7-point Likert scale (“Very Unpleasant” to “Very Pleasant”).

Instrumental and Pavlovian conditioning were conducted in an interview room. Participants were verbally asked 6 open questions assessing their knowledge of the instrumental and Pavlovian associations; if an answer was incorrect then the participant was asked “Could it have been something else?”, if all questions were answered correctly then a positive affirmation was given. The Pavlovian-instrumental transfer and outcome devaluation behavioural tests were completed during fMRI data acquisition. Written instructions were shown to participants on the computer monitor. Throughout the task, a virtual ‘snack vending machine’ image was intermittently presented on the screen. Participants learned how to acquire food rewards from this vending machine. Verbal instruction in response to questions from participants was limited to generic responses such as “Tip the machine to learn how to earn the snacks”. To improve reliability, one researcher (IEP) conducted all clinical assessments and behavioural experiments.

Behavioral Methods.

**Instrumental conditioning.** Left (A1) and right (A2) button presses were reinforced on a variable-ratio schedule (VR5) with a specific food, counterbalanced, dependent upon each participant’s three highest rated foods (Figure 1). The plate of snacks (O1) associated with A1 was placed on the desk on the left-hand side of the participant and the plate of snacks (O2) associated with A2 was placed on the right-hand side of the participant. As each outcome was earned, an image of that food appeared on the screen for 1 second and participants were invited to eat one piece of the relevant food. The following instructions were presented on screen: “You can get free snacks from our vending machine. Tip the machine with the left or right arrows. Learn how to get the different snacks. Press any key to begin”. After every third outcome participants were asked: “Which direction did you tilt to get (the outcome)”. Feedback was provided (“correct” or “Oops! That was wrong”). Instrumental conditioning ceased after a participant registered six consecutive correct answers.

**Pavlovian conditioning.** Prior to the start of conditioning the button box was removed. The three plates holding all three food rewards (O1, O2, O3) involved in Pavlovian conditioning were placed on the desk. Four stimuli (S1, S2, S3, S4) were paired with four outcomes (O1, O2, O3, Ø) (Figure 1). Two stimuli (S1, S2) were paired with two outcomes from instrumental conditioning; i.e., ensuring that S1-O1 and S2-O2 were distinct pairs. One of the stimuli (S3) was paired with an outcome (O3) that was not included in instrumental training stage. The fourth and final stimuli (S4) was paired with the word ‘EMPTY’ indicating that no food was available. The following instructions were presented on screen: “The vending machine cannot be tipped now. But, free snacks will sometimes fall out. Coloured lights will appear on the machine before a snack falls out. Watch the lights and learn which snack will fall out. Questions will test what you learn”. Stimuli were presented for 5 seconds, after which the image of the food outcome appeared beneath the stimuli (coloured vending machine) for 1 second — a total of six seconds. The inter-trial-interval (ITI) was 10 (+/-5) s and during the ITI the vending machine was shown without either stimuli (colour) or
outcome (food). After every block of four stimuli-outcome trials a multiple-choice question “Which snack will fall out?” appeared on the screen with a stimulus (coloured vending machine), if participants answered this question correctly then they were invited to eat one piece of the relevant outcomes. Pavlovian conditioning ceased after a participant registered six consecutive correct answers.

**Pavlovian-instrumental transfer test.** For this test the button box was returned and the four stimuli were presented individually for 6 seconds every 18 seconds (0-4 second random jitter). Each stimulus was presented 12 times in random order. Participants were able to tilt the vending machine during stimulus presentation and when the vending machine was unlit during the intertrial interval, providing an active baseline measure (Figure 1). This transfer phase was conducted in extinction, i.e., no outcomes, to ensure that responding was not influenced by change in the incidence of outcome delivery during the test. The following instructions were presented on screen: “The vending machine will now sometimes give free snacks. You will see coloured lights on the machine again. You can tip the machine at any time. No snacks will appear on the screen, but the snacks you earn will be recorded. Remember what you learned before to get all the snacks that you want!” Pavlovian-instrumental transfer data for one participant from each group was missing due to a data recording error, leaving OCD \( n = 19 \) and controls \( n = 20 \).

**Outcome devaluation procedure and test (Figure 2).** Participants were first shown the following statement on screen: “Now you’ll see what has happened to one of the snacks!” After this statement they were shown a 4-minute video of cockroaches crawling on one of the foods (counterbalanced between O1 and O2) they had learned to earn during instrumental conditioning. After the video presentation the following instructions were presented on screen: “You return to the vending machine you saw before. You can tip the machine at any time. No coloured lights or snacks will appear, but a tally will be kept of the snacks you get. Get all the snacks that you want!” The blank vending machine then appeared for 30 trials of 12 seconds each. Before each trial, a fixation cross was presented for 18 (±6) seconds. Participants could tilt the machine or fixation cross at any time. No outcomes were presented during the devaluation test.

**Recall test (post-test questionnaires).** After the devaluation test, whilst still in the scanner, participants rated the desirability of O1 and O2 on a scale of Likert scale 1 to 7. After exiting the scanner participants re-completed the self-report hunger and food pleasantness scales that were first completed at the start of the behavioural experiments. They also completed a self-report six-item multiple-choice test of their ability to recall of the instrumental (e.g., ‘What snack was associated with the LEFT key?’) and Pavlovian (e.g., ‘What snack was associated with the BLUE light?’) contingencies.

**Imaging methods.**

Scanning occurred in a 3T GE Discovery with a 32-channel head coil (GE Healthcare, UK).

A T1-weighted high-resolution was acquired for each participant for registration and anatomical screening: 7200-msec repetition time; 2700-msec echo time; 176 slices in the sagittal plane; 1-mm slice thickness (no gap); 256-mm field of view; and 256 x 256 matrix.

We acquired 300 T2*-weighted whole-brain echo planar images with a 2910-msec repetition time (TR); 20-msec echo time; 90-degree flip angle; 240-mm field of view; and
Each volume consisted of 52 axial slices (2-mm thick) with a 0.2-mm gap. Whole brain diffusion-weighted images were acquired using an echo planar imaging sequence with the following parameters: TR=8250ms; TE=85ms; number of slices=55 thickness=2mm-thick axial slices; matrix size, 128 x 128; in-plane resolution, 1.8 x 1.8mm²; 69 gradient directions. Eight images without gradient loading (B0 s.mm-2) were acquired prior to the acquisition of 69 images with uniform gradient loading (B0=1000s.mm-2).

Data Analysis.

Descriptive statistics were calculated and two-tailed t-tests were used for continuous variables and chi-squared for categorical variables. Selective serotonin reuptake inhibitor (SSRI) medication doses were standardized mg equivalents for fMRI analysis.

**Pavlovian-instrumental transfer (predicted value).** Outcome-specific PIT was determined by a comparison of the rate of the ‘same’ action and the ‘different’ action during the S1 and S2 stimulus trials. During S1 trials, the ‘same’ action was A1 and the ‘different’ action was A2. During S2 trials, the reverse was true: the ‘same’ action was A2 and the ‘different’ action was A1. The number of same and different actions was calculated per trial for each participant. For group differences in behaviour, the average ‘same’ and ‘different’ action rates were summarised per person and included in a 2 (group) x 2 (action) mixed ANOVA, where the interaction determined whether specific PIT was aberrant in OCD. For the fMRI analysis, the difference between the rate of the ‘same’ action less the ‘different’ action per trial was calculated, for each person. This was used as a parametric task regressor for specific PIT in the fMRI analysis (described below). For the tractography correlation analysis, this average difference was included as a covariate to determine tract weights related to specific PIT.

**General transfer** was determined by subtracting the rate of actions during S4 from the rate of action during S3 stimuli. The action rates (aggregate button-presses) were calculated per trial for each person. For group differences in behaviour, the average S3 and S4 response rates were summarised per person and included in a 2 (group) by 2 (stimulus) mixed ANOVA, where the interaction determined whether general-transfer behavior was aberrant in OCD. For the fMRI analysis, the vector of these rates minus baseline was used as a parametric task regressor for general PIT. Baseline rates were calculated as the total number of button presses per second during presentation of the ‘blank’ vending machine, and average group differences were tested with a 2-sample t-test.

**Outcome devaluation (experienced value).** The effect of the outcome devaluation procedure was determined by the change in food preference ratings across the battery of experiments, i.e., Δ value = pre-rating – post-rating. The interaction in a 2 (group) x 2 (pre-post) mixed ANOVA on the change scores indicated whether desire was aberrant in OCD. The effect of devaluation on behaviour was determined by the rate of actions for the still-valued food was calculated per trial, for each person. Group differences in goal-directed behaviour were tested in a 2 (group) x 2 (action) x 5 (trial bin) mixed ANOVA on the average still-valued and devalued action rates per person, where a significant interaction between group and action (valued vs devalued) indicated aberrant goal-directed behaviour in OCD. Valued-devalued action rates per trial were included as a parametric task regressor in the
fMRI analysis. The average difference in valued action rates less devalued rates for each person was also included in the tractography analyses to determine tract weights related to goal-directed behaviour.

**Magnetic Resonance Imaging – Functional (fMRI).** The data from each test were analyzed separately using SPM8 (Wellcome Department of Imaging Neuroscience). Structural images were manually inspected for anatomical abnormalities and co-registered to the mean functional image. Functional images were realigned, slice-time corrected, normalized to the Montreal Neurological Institute (MNI) template space, interpolated to 2 x 2 x 2 mm voxels and smoothed with a Gaussian filter (8-mm full width-half maximum). To correct for movement on image analysis we distinguished inter-subject motion and task-correlated motion. Subject motion can produce image artifacts (e.g., banding) which increases the error term in the statistical model and reduces the likelihood of correctly detecting a significant effect. To address this, we screened each run after movement correction and normalization (i.e., post-processing) for image artefacts using the Artifact Detection Tool from Susan Whitfield-Gabrielli (web.mit.edu/swg/software.htm). For each participant, outlier images were identified using the scan-to-scan differences in movement (mm) and rotation (degree) with default thresholds of 2 mm and 0.2 degrees, respectively. These points were used to construct an outlier regressor for each individual to be added as a covariate in the first-level analysis (see below). This resulted in the exclusion of 2.6 percent of data in the OCD group (highest percent from any single participant was 21.3 percent) while 0.4 percent of data was excluded among the control group. Using the same Artifact Detection Tool, we also manually screened each run for task-correlated motion which will increase the false positive error rate. There were no substantial correlations with any task regressor in our sample, mean r=0.08 (highest r=.19). The six movement regressors from realignment were also included as regressors-of-no-interest in each GLM (described below).

The fMRI analyses were conducted in a two-level manner, where the first-level specified a general linear model (GLM) for each participant, and the second-level included the first-level parameters as random effects. The first-level GLM for the Pavlovian-instrumental transfer test modelled conditioned stimuli as a boxcar function with separate regressors for specific- (S1, S2) and general- (S3, S4) stimuli. We modelled response times as stick functions in a separate regressor of no interest. Following Prevost et al 2012, a parametric regressor modulated the S1 and S2 stimulus blocks by a vector of the difference between `same` and `different` action rates per stimulus as the trial-wise task regressor for specific transfer. The S3 and S4 stimulus blocks were parametrically modulated by the vector of total response rates per stimulus, which served as the (trial-wise) task regressor for general transfer. The first-level GLM for the devaluation test included trials as a boxcar function and a regressor-of-no-interest modelling response times as a stick function. A parametric regressor modulated the trial blocks by the number of valued responses over devalued responses, which served as the (trial-wise) task regressor for choices driven by experienced value (1). Each task regressor was convolved with the canonical haemodynamic response function (after high-pass filtering with a cut-off of 128 s to remove drifts within sessions).

The resulting parameter estimates (betas) for the task regressors were entered into second-level t-tests in SPM8 to generate population-level effect statistics. BOLD activity tracking each task regressor were tested in planned whole-brain one-sample SPM t-tests of betas from healthy adolescents, while aberrant BOLD activity in OCD was tested in planned whole-brain two-sample SPM t-tests of betas from both groups. Significant regions in each whole-
brain analysis, exceeding a voxel level false-discovery rate FDR \( q = 0.05 \) are reported here (cluster size threshold \( k = 5 \)). Follow-up region-of-interest (ROI) analyses comparing groups in regions implicated by the task regressor in health adolescents were also performed when the planned group comparison was null, and results exceeding a small-volume corrected family-wise error rate \( p = 0.05 \) are reported. We also performed ROI analyses for correlations with obsessions (e.g., contamination, disgust, or symmetry) or compulsions, training performance, age, WRAT scores (IQ proxy), handedness, and SSRI medication dose.

**Diffusion Imaging and Tractography.** Diffusion data was first eddy-current corrected using FMRIB Diffusion Toolbox to align all images to a reference b0 image and linearly transform them, brains were extracted, and diffusion tensors fitted. Diffusion probabilistic tractography was then performed using the FDT Diffusion Toolbox. We determined seed masks using clusters of significant activation from the preceding fMRI analysis. For each participant, tractography was performed from every voxel within the seed mask to build up a connectivity distribution. We fitted a three-fibre orientation diffusion model to estimate probability distributions on the direction of fibre populations at each brain voxel in the diffusion space of each participant. To interpret the probabilistic tractography in standard space, we used standard-to-diffusion matrices and the corresponding inverted matrices. We generated 5000 samples from each seed voxel with a curvature threshold of 0.2 and no waypoint or termination masks. Tracking occurred in diffusion space, with results transformed back to MNI space. To visualize tracts efferent and afferent to the seed mask, individual participant 3D files were thresholded to the top 0.02% of tracts and binarized, before being concatenated into a 4D file. This showed the average connectivity, across all participants, for each seed region. FSL (FMRIB Software Library) tools ([www.fmrib.ox.ac.uk](http://www.fmrib.ox.ac.uk)) were used in all diffusion analyses (version 5.0.1).

We tested for group differences in the estimated strength of tracts efferent and afferent to our seed regions using nonparametric voxelwise statistical testing, and assessed the relationship between tract strength and the behavioural covariates (average rate of specific transfer from the task regressor, and the difference between valued and devalued press rates in the first minute of test, for PIT and outcome devaluation, respectively) with the tract values at each voxel, independently for each of the seed regions.

After group comparisons and voxelwise correlations against the behavioural regressors, the model fit was tested by permutation testing (FSL Randomize), using 25 000 random permutations. Threshold-free cluster enhancement (TFCE) was used to boost signal in areas that exhibit spatial clustering. To protect against false positives, we restricted the analysis to those voxels in which at least half of the participants (n=19) had tracts from the seed mask. In addition, only clusters of at least 20 contiguous voxels are reported.

Resulting statistical maps were thresholded at \( p = 0.05 \) family-wise error corrected (FWE). A significant relationship between white matter tractography values and behavioural regressors at a particular voxel implies variable white matter architecture between (some part of) the seed region and the voxel in question.
Supplementary Results

OCD symptom severity (CY-BOCS score) was distributed across subclinical (score 0-7; n=3), mild (score 8-15; n=4), moderate (score 16-23; n=8), severe (score 24-31; n=5) and extreme (score 32-40; n=0).

The influence of Pavlovian conditioning on specific PIT and the deficit in OCD:
To investigate whether the degree of Pavlovian conditioning influenced specific PIT, we conducted a post-hoc analysis of participants who remembered all Pavlovian and instrumental contingencies at the end of the experiment excluding participants with a post-test memory score less than 100 percent (2 controls and 5 OCD) leaving OCD n=14 and controls n=18 in each group for this analysis. The mean response rates among these subgroups of ‘complete learners’ confirmed that the marked deficit in specific transfer remained in the OCD relative to the control group (see Figure 2A inset, group interaction $F_{1,30}=5.23, p=.029, \eta^2_p=.15$), alongside intact stimulus-elicited arousal during general transfer (Figure 2B inset, main effect of cue $F_{1,30}=9.93, p=.004, \eta^2_p=.25$; group interaction $F < 1$).

Covariate analyses of specific PIT test:
An analysis including age or WRAT score as a covariate did not change the pattern of results between groups (e.g., largest group difference in medial OFC remained: BA11: MNI: -4,50,-20, $F_{2,36}=32.30$, pFDR < .001 after controlling for age). Likewise, excluding three left-handed OCD participants did not alter the pattern of significant results between groups (e.g., largest group difference remained in left MOrG (BA11: MNI: -6,46,-24, $F_{2,34}=32.47$, pFDR < .001). An analysis limited to the OCD group and including antidepressant dose (fluoxetine equivalent dose) as a covariate did not reveal any significant effects of medication (pFDR=.873).

Covariate analyses of outcome devaluation:
The majority of the OCD group had obsessions with contamination or disgust obsessions (n=16; 80%). The effect of revaluation in this subgroup was significant ($p=.007$, Cohen’s $d=0.77$, corrected for dependence between means) and the effect size was similar or larger than that among the total OCD group (i.e., Cohen’s $d=0.52$, corrected). However, the correlation between symptom severity and choices or ratings after revaluation in this subgroup were small and non-significant ($r_s < .361$).

Covariate analyses of the choice devaluation effect:
Analysis including age or WRAT score as a covariate did not change the significant group difference in the correlation with Anterior PFC activity: BA10: MNI: 2,50,10, $F_{2,38} = 9.04$, pFWE = .035, svc, after controlling for age whereas $F_{2,38}=9.82$, pFWE=.024, svc, after controlling for WRAT. Likewise, excluding three left-handed OCD participants did not alter the significant result (MNI: 2,50,10, $F_{2,36}=8.75$, pFWE=.044, svc). A further analysis limited to the OCD group and including antidepressant dose (fluoxetine equivalent dose) as a covariate again failed to reveal any significant effects of medication (pFDR=.279).
Tractography:

Specific PIT
Although the tractography analysis supported the cortical network implicated in the influence of predicted value, we found no significant differences in tract strength when we used the largest between-group differences in the fMRI results for specific transfer as seed regions. Figure S1A shows a significant negative correlation with the average rate of specific transfer and the tract strength between the left lateral OFC and the middle frontal gyrus (peak voxel -28 10 24, pFWE=.047, cluster size 286 voxels). In other words, across both groups, the stronger the OFC–MFG tract connection the weaker the influence of predicted values on choice during outcome-specific PIT. Figures S1B and S1C show the raw tractography thresholded at the top 0.02% of efferent and afferent tracts from the medial OFC and right lateral OFC, respectively, across all participants.

Outcome Devaluation
Using the hypoactive anterior PFC/dorsal ACC region identified in our analysis of OFC vs. HA in outcome devaluation as a seed region, tractography analysis compared afferent and efferent tracts between groups to investigate neural disconnection as a contributing factor to task performance. This analysis revealed a lower tract strength in the projection to the caudate nucleus (peak MNI coordinates: 6,18,-6; cluster size: 56 voxels) in adolescents with OCD relative to healthy controls (pFWE=.008; Supplementary Figure S2A). See Supplementary Figure S2A and Supplementary Figure S2B.
Table S1. Recruitment flowchart


- Not 12-18 years of age (n=5)
- No OCD diagnosis (n=3)
- Intellectual disability (n=2)

Telephone contact list (n=60)

- Uncontactable (n=6)
- Not required, sample size recruited (n=8)

Telephone contact made (n=46)

- Declined (n=20)
- Limited English language proficiency (n=2)
- MRI Contraindications (n=3)

Recruited and tested (n=21) (09/04/2015-28/01/2016)

- Diagnosed as no OCD (n=1)

Included in analysis (n=20)
Figure S1: Tractography in Specific PIT test

(A) We found a significant negative correlation between tract strength between the left lateral OFC and the middle frontal gyrus and the average rate of specific transfer (peak voxel -28 10 24, cluster size: 286 voxels). Raw tractography thresholded at the top 0.02% of efferent and afferent tracts from (B) medial OFC, and (C) right lateral OFC across all participants. There were no between-group differences in tract strength with any of the seed regions tested.
We found significantly lower anterior PFC/anterior cingulate complex-to-head of caudate (peak MNI coordinates: 6, 18, -6, cluster size: 56 voxels) tract strength in adolescents with OCD relative to healthy controls. The voxels with strongest connectivity, across all participants, to the BA10/32 seed mask (top 0.02% of tracts sent from this seed mask).
Supplementary References