Supplementary Information (SI) for

Genetic Underpinnings of Risky Behaviour Relate to Altered Neuroanatomy

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Supplementary Methods

1. Measures

1.1. Main risky behaviour measure

We closely follow the methods of ref 1 to derive a measure of risky behaviour based on participants' self-reports across the drinking, smoking, driving, and sexual domains.

Specifically, we use the following UK Biobank variables:

- Number of alcoholic drinks per week (Data-Fields: 1558, 1568, 1578, 1588, 1598, 1608, 5364, 4407, 4418, 4429, 4440, 4451, 4462)
- Ever smoking (Data-Field 20116, 1249, 1239)
- Frequency of driving faster than the motorway speed limit (Data-Field 1100)
- Lifetime number of sexual partners (Data-Field 2149)[1]

The full description of each Data-Field can be found in the online data showcase of the UKB (http://biobank.ctsu.ox.ac.uk/crystal/search.cgi). The annotated STATA code used to derive all behavioural phenotypes and control variables can be found in our pre-registered analysis plan (https://osf.io/qkp4g/).

All variables above were measured on at least one of 3 occasions: (1) the initial assessment visit, (2) the first repeat assessment visit, and (3) the imaging visit. Data from (2) and (3) are only available for a subset of the original sample. In cases where participants provided answers across more than one visit, we compute the average of their reports.

To obtain a measure that captures the common variance in risky behaviour shared across domains, we perform principal component analysis (PCA) on N = 315,855 UKB participants and extract the first principal component (PC) as our main outcome of interest for this study (referred to as "risky behaviour"). Compared to experimental procedures that elicit risk tolerance, self-reported measures exhibit higher external validity and test-retest reliability[3–5]. Furthermore, by

[1] Self-reports of the number of sexual partners have been implicated in risky behaviours related to alcohol abuse (i.e., binge drinking) and unprotected sex, specifically in young adults [2], irrespective of gender or sexual orientation.

extracting the first principal component of the four risky behaviours, we reduce measurement noise due to the aggregation of signals across various measures, while capturing behavioural tendencies across domains that are independent of idiosyncratic differences in the four specific behaviours. The PCA summary statistics are available in Supplementary Table 1, and the component loadings are available in Supplementary Table 2. The first PC explained about 37% of the variance in the different phenotypes of risky behaviours in the sample, and it was the only PC that positively loaded on all of four phenotypes. Data distribution was assumed to be normal but this was not formally tested.

While the GWAS by Linnér et al. (2019)[1], was primarily based on a meta-analysis of two very crude, noisy, single-item measures of risk taking that were available in the two largest samples (UKB and 23andMe, which had slightly different questions on risk taking), this choice (in the GWAS) was made to maximize the sample size for genetic discovery, following the logic outlined in ref 6, i.e., that in genetic discovery studies, sample size typically trumps phenotypic accuracy in terms of statistical power. (The supplementary material of ref 6 includes a mathematical derivation that illustrates this). In the current work, we also wanted to maximize statistical power, albeit the situation here is different, as the sample size was exogenously determined by the UKB. Thus, the only means to increase statistical power was via increasing the quality of the phenotypic measurement. We decided to focus on the first PC of the four risky behaviours introduced in Linnér et al. (2019) for the following reasons: (1) It is available for a large part of the scanned subsample. (2) Linnér et al. (2019) showed that this first PC has a higher SNP-based heritability than any of the general risk-taking measures or individual phenotypes, which is partly because the first PC is less affected by random measurement error than any input variable considered separately. (3) The high heritability of the first PC suggests that similar genetic factors influence risk taking across various domains, making this a promising trait to study in connection with other biomarkers such as brain anatomy. (4) This variable has been studied in the literature, limiting our degrees of freedom for the current study. (5) GWAS results for this variable were readily available.[6]

1.2 Control Variables

All of our analyses systematically control for several genetic, socio-demographic and anthropometric factors that could potentially confound the observed associations [e.g. sex[7], height[8] and genetic population structure[9]]. Specifically, we use the following control variables, as provided by the UKB:

- Age at the time of brain scan (Data-Field 21003)
- Birth year (Data-Field 33)
- Sex (self reported and genetically identified, Data-Fields 31 & 22001, dummy coded)
- Height (Data-Field 50)
- Handedness (Data-Field 1707, categorical variable: Right-handed, Left-handed, ambidextrous, N/A)
- Sex x birth year interactions (binned into fields containing at least 20 participants each)
- The first 40 PCs of the genetic data (Data-Field 22009)
- Total intracranial volume (TIV), derived using the CAT12 toolbox from T1 images.

We carry out an additional analysis that further controls for the following socio-economic and cognitive outcomes (provided by the UKB):

- Educational attainment (Data-Field 6138)
- A 13-item measure of fluid IQ (Data-Fields 20016 and 20191)
- Zip-code level measure of the Townsend social deprivation index (Data-Field 189)
- Household income (Data-Field 738)
- Number of household members (Data-Field 709)
- Place of birth, binned in 100 clusters based on North and East birth location coordinates (Data-Fields 129 and 130). Clusters were calculated using the *k*-means algorithm, which minimizes within-cluster variances (squared Euclidean distances) of *k* = 100 clusters with 10,000 iterations after random seeding.

The empirical distributions of the main variables used in our main analysis and the correlations between them are depicted in Figure 1B and Extended Data Figure 1 and 2. Data distributions were assumed to be normal but this was not formally tested.

1.3 Imaging-derived Phenotypes (IDPs)

1.3.1 T1 MRI Image Processing

Our voxel-level analysis uses T1-weighted structural brain MRI images in NIFTI format provided by the UKB (data field 20252). The images were acquired using 3-T Siemens Skyra scanners, with a 32-channel head coil (Siemens, Erlangen, Germany), with the following scanning parameters: repetition time = 2000 ms; echo time = 2.1 ms; flip angle = 8°; matrix size = 256 × 256 mm; voxel size = 1 × 1 × 1 mm; number of slices = 208.

We preprocessed the data using the Computational Anatomy Toolbox (CAT; www.neuro.uni-jena.de/cat/) for SPM (www.fil.ion.ucl.ac.uk/spm/software/spm12/), a fully automated toolbox for deriving neuroanatomical measurements at voxel and ROI levels. Image pre-processing used the default setting of CAT12 (accessible online at http://www.neuro.uni-jena.de/cat12/CAT12-Manual.pdf). Images were corrected for bias-field inhomogeneities, segmented into gray matter, white matter, and cerebrospinal fluid (CSF), spatially normalized to the MNI space using linear and non-linear transformations, and were modulated to preserve the total amount of signal in the original image during spatial normalization (the specific SPM-processing parameters can be found in the pre-registered document on OSF https://osf.io/qkp4g/). We applied spatial smoothing with 8-mm Full-Width-at-Half-Maximum (FWHM) Gaussian kernel for the segmented, modulated images for grey matter volume (GMV). Finally, to ensure that only voxels that likely contain grey matter enter the analyses, we constructed a brain mask based on the average of all GMV images. Specifically, following standard VBM procedures (see SPM/CAT12 http://www.neuro.uni-jena.de/cat12/CAT12-Manual.pdf) we thresholded the average of all brain images at 250 GMV intensity units. The resulting image was binarized and applied as a pre-mask to all individual images before running analyses. Additionally, on an individual level, we excluded all voxels that exhibited a lower grey matter volume than .1 from the analyses (see standard

parameters of SPM/CAT12 http://www.neuro.uni-jena.de/cat12/CAT12-Manual.pdf). Data distributions were assumed to be normal but this was not formally tested. To illustrate the results of the GMV analyses, we used a standard MNI brain template based on Fonov et al (2011)[10].

1.3.2 Region of interest (ROI)-level IDPs Processed by the UKB

We use all of the GMV IDPs that were processed and provided by the UKB [for details see ref 11]. These IDPs include GMV of 139 ROIs derived using parcellations from the Harvard-Oxford cortical and subcortical atlases, and Diedrichsen cerebellar atlas. Data distributions were assumed to be normal but this was not formally tested.

1.3.3 Additional ROI-level IDPs

Based on our voxel-level results (see 2.1), we extracted 5 additional ROI-level IDPs that quantified GMV in anatomical substructures that were not derived by the UKB. These ROIs were extracted bilaterally from unbiased masks and included the dorsolateral prefrontal cortex (dlPFC; BA 46), hypothalamus, posterior hippocampus, ventro-anterior insula and ventromedial prefrontal cortex (vmPFC). For the dlPFC, ventro-anterior insula and vmPFC masks, we used recent functional parcellations based on resting state data. The dlPFC mask was derived using the Sallet Dorsal Frontal resting state connectivity-based parcellation (cluster 7/BA46)[12]. Functionally, this area exhibits coupling with the frontal-parietal network (incl. anterior cingulate cortex, parietal cortex and inferior parietal lobe), as well as with the vmPFC. Anatomically, its boundaries show resemblance to BA 46 — an area functionally related to executive function that shows distinct cytoarchitectonic properties.

We extracted GMV from the vmPFC using a parcellation of the medial wall of the prefrontal cortex, based on resting state functional coupling[13]. Specifically, we extracted GMV from 14m — an area linked to cost-benefit integration in value-based decision-making[14–17], which maintains strong positive coupling with hypothalamus, ventral striatum, and amygdala[18]. The hypothalamus mask was derived from a high-resolution atlas of human subcortical brain nuclei[19]. The posterior hippocampus mask was derived according to recent recommendations for long-axis segmentation of the hippocampus in human neuroimaging[20]. We labeled hippocampal voxels

posterior to the coronal plane at *y* = -21 in MNI space (which corresponds to the uncal apex of the parahippocampal gyrus), as posterior hippocampus. To ensure spatial precision across participants, we used a minimum 80% likelihood of each voxel being in the anatomical structure for all of the aforementioned masks. The ventro-anterior insula mask was derived following a recent parcellation of the insula based on a resting state functional connectivity analysis by ref 21, which reported that this brain region showed functional coactivation with limbic areas including amygdala, ventral tegmental area (VTA), superior temporal sulcus, and posterolateral orbitofrontal cortex. The raw mask was thresholded at *z* = 10.

1.4 Polygenic Risk Score (PRS) for Risky behaviour

We use the genetic data provided by the UKB to construct a polygenic risk score (PRS) for risky behaviour. As a first step, we rerun the genome-wide association study (GWAS) of risky behaviour (the same measure used in the current study) as reported in ref 1 after excluding the 18,796 genotyped individuals with usable T1 NIFTI structural brain images (UKB field 20252) and all of their relatives up to the third degree (defined using the KING coefficient[22] based on a pairwise coefficient >0.0442). The final GWAS sample includes 297,025 individuals of European ancestry. We use BOLT-LMM version 2.3.2[23] to perform GWAS with linear mixed models (LMM), which outperforms linear regression in terms of statistical power and controlling for relatedness[24].

Next, we perform quality control (QC) of the GWAS results using a standardized QC protocol, described in detail in ref 1. This protocol removes rare and low-quality single-nucleotide polymorphisms (SNPs) based on minor allele frequency (MAF) < 0.001, imputation quality (INFO) < 0.7, and SNPs that could not be aligned with the Haplotype Reference Consortium (HRC) reference panel. After QC, a total of 11,514,220 SNPs remains in the GWAS summary statistics. Thereafter, we calculate for each participant *i* a PRS, S_i, by weighting his or her genotype across SNPs (*j*), g_{ij}, by the corresponding regression coefficients, β_j estimated in the GWAS described above. Thus, the PRS is a linear combination of genetic effects, calculated as:

$$S_i = \sum_{j=1}^{M} \beta_j g_{ij},$$

where the set of SNPs, *M*, is restricted to the consensus genotype set of 1.4 million SNPs established by the International HapMap 3 Consortium[25], which has been successfully employed for polygenic prediction in many previous studies. Furthermore, the PRS is constructed only with autosomal, bi-allelic SNPs with *MAF* > 0.01 and *INFO* > 0.9 in the UKB. The resultant PRS is based on a total of *M*=1,176,729 SNPs. The PRS is then standardized to mean zero and unit variance in the prediction sample. Data distribution was assumed to be normal but this was not formally tested.

1.5 Genetic Correlations of Risky behaviour

We rely on the results of the risky behaviour GWAS to estimate genetic correlations between this phenotype and 85 other traits, using bivariate LD Score regression[26]. The estimates are reported in Supplementary Table 3. For this purpose, we query the "GWAS ATLAS"[27] to identify publicly archived GWAS results that we consider relevant. We supplement the publicly available GWAS with a soon-to-be published GWAS on diet composition[28]. Notably, the collected traits span across many different outcomes, including the anthropometric, behavioural, cognitive, psychiatric, medical, and socioeconomic domains.

We find moderate to strong genetic correlations between our main measure and a range of phenotypes that are considered risky behaviours, including ever consuming cannabis (r_g = 0.72; *SE* = 0.03), self-employment (r_g = 0.52; *SE* = 0.30), and age at first sexual experience (r_g = –0.54; *SE* = 0.02). Our measure of risky behaviour is also genetically correlated with a range of mental disorders including bipolar disorder (r_g = 0.23; *SE* = 0.03), major depressive disorder (r_g = 0.22; *SE* = 0.03), and schizophrenia (r_g = 0.17; *SE* = 0.02). Finally, risky behaviour is genetically correlated in the expected direction with the personality traits of conscientiousness (r_g = –0.25; *SE* = 0.10) and extraversion (r_g = 0.34; *SE* = 0.05).

2. Pre-registration of Analysis Plan and Unplanned Deviations

We pre-registered our analysis plan on Open Science Framework (OSF, https://osf.io/qkp4g/). Our pre-registered plan specifies the construction of the dependent variable, the control variables, the inclusion criteria and quality controls, the VBM analyses and the main ROI-level analyses.

We deviated from the pre-registered plan in several cases, which are outlined in the following. These deviations occurred when the computational burden of following the pre-registered plan was unexpectedly high, and when alternative measures that we were not aware of at the time of the pre-registration were made available by the UKB. Specifically, we decided not to use alternative segmentations of the cortex (e.g. Hammer's atlas) as robustness checks for our ROI-level analysis because of the significant computational burden in deriving those measures. Instead, based on the voxel-level analysis, we derived additional ROIs only when they were not derived in sufficient granularity in the IDPs provided by the UKB (see 1.3.3).

Similarly, we did not derive cortical thickness (CT) measures because of the high computational burden using FreeSurfer, which is the gold standard in cortical thickness estimation. While other means to derive CT would have been available (e.g. CAT toolbox), they would provide relatively lower quality data and would not allow analyses of subcortical areas. Additionally, the UKB was expected to release CT measures derived from FreeSurfer before this work was finalized (see the UKB Data Showcase website for public announcements). The lack of CT measures has also led us to decide to postpone the conduct of an additional pre-registered multivariate analysis.

Finally, our pre-registered plan states that we would run additional robustness checks to control for potential neurotoxic effects of excessive alcohol intake. Upon examining the data for a different project that is focused on the effects of alcohol intake on the brain, we observed effects that were mainly driven by individuals who were heavy drinkers. We therefore decided to deviate from our original plan and exclude all participants who qualified as current or former regular heavy drinkers. However, we also provide additional analyses that include weekly alcohol intake and smoking habits as a covariate (see Extended Data Figure 6). Finally, the pre-registered

analysis of white-matter volume is not reported here, because we decided to focus our manuscript on GMV differences.

Supplementary Discussion

Our study highlights the importance of using large samples to study associations of neuroanatomy with complex behavioural traits. The largest effect we identify for the relationship between any cluster of voxels and risky behaviour is $\Delta R^2 = 0.6\%$ (see Supplementary Table 4). It would require more than 1,750 participants to have 90% statistical power at a liberal *p*-value threshold of 0.05 (uncorrected) to identify effects of this magnitude. This is a lower bound for the required sample size for such studies that does not reflect the upward bias in our effect size estimate due to the statistical "winner's curse", and the need to correct for multiple testing. Previous large-scale VBM studies ($N > 1000$) with other behavioural phenotypes[29] found effect sizes of similar magnitude and suggest that large samples are a prerequisite to detect such an association reliably. Of note, the largest previous study of risk tolerance employed a sample of 108 participants[30] and would have only 12% power to detect $\Delta R^2 = 0.6\%$ at $\alpha = 0.05$ (uncorrected).

A possible limitation of our study is that, the specific features of the component phenotypes (e.g., smoking) rather than their first PC (risky behaviour) could have driven the associations we report (quantified via standardized regression coefficients). To further investigate this possibility, we repeat our ROI-based analysis with the individual phenotypic measures (instead of their first PC) as outcome variables (see Supplementary Table 6). We find that 22 out of 23 ROIs are significantly associated with more than one phenotype (the exception is IX Cerebellum (r), which is significantly associated only with the number of sexual partners, yet the standardized coefficient denoting its relationship with the first PC is greater in magnitude than the coefficient denoting its relationship with the number of sexual partners). Furthermore, the standardized coefficients quantifying the relationships between the ROIs and the individual

phenotypes are either smaller than or at the same order of magnitude as the coefficients quantifying their relationship with the first PC.

While our study is larger and more representative than any previous investigation of the topic, and although we control for various potential confounds and replicate our findings in an independent sample, it was conducted in a population of UK individuals of European descent that were over 40 years old at the time of measurement, which limits the generalizability of our results to other populations. Moreover, our results do not exclude the possibility of bias due to other unobserved variables that our analyses do not account for. With the rise of large publicly available data sets [e.g. ref 31], we hope that future studies will be able to test the generalizability of our findings to populations of different ethnicities and age groups (e.g., adolescents).

Finally, while our analyses identify distinct brain areas that mediate gene-phenotype associations for risky behaviour (i.e., putamen, hypothalamus and dlPFC), they do not provide evidence for their causal relationship. For instance, it is possible that a person's genetic disposition would lead them to select into environments that influence both risky behaviour and features of brain anatomy.

Supplementary Table 1 | Eigenvalues of the four Principal Components of Risky Behaviours

Component	Eigenvalue	Cumulative Variance Explained
Component 1	1.474	0.3685
Component 2	0.975	0.6121
Component 3	0.819	0.817
Component 4	0.732	1

Supplementary Table 2 | Eigenvectors of the four Principal Components of Risky Behaviours

Variable	Comp1	Comp2	Comp3	Comp4
Speeding	0.4096	0.7643	0.1402	0.4779
Sexual behaviour	0.5543	0.1448	-0.6327	-0.5211
Drinking	0.5351	-0.1876	0.7339	-0.374
Smoking	0.4885	-0.5998	-0.2036	0.6002

Supplementary Table 3 | Genetic correlations (r_g) between risky behaviour (GWAS N = 297,025) and 85 traits, estimated using bivariate LD Score regression. All P values are based on two-sided statistical tests.

Trait	Category	Genetic correlation (r_g)	$SE(r_g)$	Z	P value
Number of sexual partners	Mental & Behavioral	0.807	0.009	87.168	<0.001
Smoking initiation	Mental & Behavioral	0.746	0.013	59.671	<0.001
Ever cannabis	Mental & Behavioral	0.721	0.025	29.382	<0.001
Drinks per week	Mental & Behavioral	0.698	0.016	44.726	<0.001
Alcohol dependence	Mental & Behavioral	0.613	0.063	9.668	<0.001
Maternal smoking around birth	Mental & Behavioral	0.581	0.026	22.676	<0.001
General risk tolerance	Mental & Behavioral	0.559	0.021	26.176	<0.001
Self-employment	Mental & Behavioral	0.517	0.304	1.703	0.089
Automobile speeding propensity	Mental & Behavioral	0.513	0.02	26.189	<0.001
Suicide attempt	Mental & Behavioral	0.473	0.069	6.857	<0.001
Antisocial behaviour	Mental & Behavioral	0.453	0.143	3.179	0.002
Cannabis use disorder	Mental & Behavioral	0.442	0.097	4.559	<0.001
Leisure/social activities: Pub or social club	Mental & Behavioral	0.433	0.028	15.272	<0.001
Own or rent accommodation lived in: Own with a mortgage	Mental & Behavioral	0.409	0.039	10.598	<0.001
Townsend deprivation index	Mental & Behavioral	0.401	0.046	8.793	<0.001
Own or rent accommodation lived in: Rent - from private landlord or letting agency	Mental & Behavioral	0.35	0.073	4.803	<0.001
Extraversion	Mental & Behavioral	0.338	0.054	6.284	<0.001
Stress-related disorder	Mental & Behavioral	0.308	0.043	7.084	<0.001
Psychiatric cross-disorder	Mental & Behavioral	0.256	0.036	7.121	<0.001
Bipolar disorder	Mental & Behavioral	0.226	0.027	8.348	<0.001
Post-traumatic stress disorder	Mental & Behavioral	0.198	0.052	3.805	0.0001
Smoking cessation	Mental & Behavioral	0.19	0.033	5.809	<0.001
Major depressive disorder	Mental & Behavioral	0.18	0.025	7.336	<0.001
Schizophrenia	Mental & Behavioral	0.167	0.021	7.979	<0.001
Anxiety Disorder Case-Control	Mental & Behavioral	0.163	0.082	1.989	0.047
Insomnia	Mental & Behavioral	0.149	0.027	5.612	<0.001
Leisure/social activities: Sports club or gym	Mental & Behavioral	0.143	0.034	4.188	<0.001

Anxiety Disorder FactorScore	Mental & Behavioral	0.116	0.087	1.331	0.183
Cigarettes per day	Mental & Behavioral	0.112	0.031	3.679	<0.001
Own or rent accommodation lived in: Rent - from local authority, local council, housing association	Mental & Behavioral	0.098	0.035	2.793	0.005
Openness	Mental & Behavioral	0.076	0.06	1.263	0.206
Autism spectrum disorder (ASD)	Mental & Behavioral	0.048	0.039	1.231	0.218
Intelligence	Mental & Behavioral	0.039	0.023	1.679	0.093
Household income	Mental & Behavioral	0.03	0.037	0.815	0.415
Neuroticism	Mental & Behavioral	-0.012	0.059	-0.21	0.834
Anorexia	Mental & Behavioral	-0.022	0.032	-0.698	0.485
Educational attainment	Mental & Behavioral	-0.028	0.02	-1.382	0.167
Tourette's syndrome	Mental & Behavioral	-0.03	0.042	-0.731	0.465
Friendships satisfaction	Mental & Behavioral	-0.057	0.034	-1.705	0.088
Leisure/social activities: Adult education class	Mental & Behavioral	-0.057	0.04	-1.414	0.157
Childhood intelligence	Mental & Behavioral	-0.073	0.056	-1.299	0.194
Sleep duration	Mental & Behavioral	-0.081	0.023	-3.579	<0.001
Obsessive compulsive disorder	Mental & Behavioral	-0.105	0.05	-2.103	0.036
Subjective well-being	Mental & Behavioral	-0.108	0.035	-3.06	0.002
Chronotype	Mental & Behavioral	-0.162	0.022	-7.357	<0.001
Family relationship satisfaction	Mental & Behavioral	-0.247	0.037	-6.728	<0.001
Leisure/social activities: Religious group	Mental & Behavioral	-0.251	0.026	-9.564	<0.001
Conscientiousness	Mental & Behavioral	-0.251	0.101	-2.497	0.013
Own outright (by you or someone in your household)	Mental & Behavioral	-0.365	0.028	-12.865	<0.001
Agreeableness	Mental & Behavioral	-0.386	0.399	-0.969	0.333
Age of smoking initiation	Mental & Behavioral	-0.401	0.029	-13.946	<0.001
Age at first sex	Mental & Behavioral	-0.536	0.018	-29.502	<0.001
Coronary artery disease	Circulatory	0.069	0.021	3.307	<0.001
Blood pressure	Circulatory	-0.06	0.02	-3.034	0.002
Heart rate	Circulatory	-0.074	0.019	-3.798	<0.001
Age of first facial hair (male)	Dermatologic	0.1	0.028	3.585	<0.001
Stomach or abdominal pain	Digestive	0.043	0.037	1.151	0.249
Fat (diet composition)	Digestive	0.009	0.038	0.221	0.825
Protein (diet composition)	Digestive	-0.016	0.039	-0.411	0.681
Sugar (diet composition)	Digestive	-0.327	0.032	-10.168	<0.001

Carbohydrates (diet composition)	Digestive	-0.53	0.028	-18.795	<0.001
Waist-to-hip ratio (WHR)	Endocrine & Metabolic	0.089	0.019	4.685	<0.001
Body mass index	Endocrine & Metabolic	0.066	0.019	3.424	<0.001
Type 2 diabetes	Endocrine & Metabolic	-0.017	0.022	-0.793	0.428
Chronic kidney disease	Endocrine & Metabolic	-0.157	0.066	-2.39	0.017
Age at menarche	Genitourinary	0.054	0.024	2.302	0.021
Age at menopause	Genitourinary	-0.084	0.028	-2.969	0.003
Mother's age at death	Longevity	-0.164	0.062	-2.645	0.008
Parental lifespan	Longevity	-0.169	0.029	-5.943	<0.001
Fathers age at death	Longevity	-0.188	0.038	-4.994	<0.001
Hip pain	Musculoskeletal	0.183	0.038	4.841	<0.001
Back pain	Musculoskeletal	0.173	0.028	6.095	<0.001
Knee pain	Musculoskeletal	0.143	0.028	5.038	<0.001
Neck or shoulder pain	Musculoskeletal	0.132	0.03	4.392	<0.001
Height	Musculoskeletal	0.065	0.014	4.633	<0.001
Infant birth weight	Musculoskeletal	0.053	0.025	2.133	0.033
Infant head circumference	Musculoskeletal	0.036	0.061	0.588	0.557
Rheumatoid arthritis	Musculoskeletal	-0.018	0.032	-0.547	0.585
Cancer (diagnosed by doctor)	Neoplasms	0.113	0.051	2.222	0.026
Alzheimer's disease	Neurological	0.032	0.042	0.749	0.454
Parkinson's disease	Neurological	-0.022	0.054	-0.395	0.693
Headache	Neurological	-0.085	0.03	-2.89	0.004
Asthma	Respiratory	0.074	0.024	3.111	0.002

Supplementary Table 4 | Association between risky behaviour and grey matter volumes (GMV) in clusters of voxels (N = 12,675). Depicted are the summarized regression statistics per cluster. ΔR^2 indicates the marginal increase in variance explained compared to a model that excludes GMV from the respective cluster. The corresponding coordinates of the peak activation in each cluster can be found in Extended Data Figure 3.

Cluster	β	95% CI	SE	P_{uncorr}	T(12,562)	R^2	ΔR^2
1	-0.115	[-0.14,-0.091]	0.013	1.15×10^{-19}	-9.089	0.048	0.006
2	-0.108	[-0.133,-0.084]	0.013	1.15×10^{-17}	-8.571	0.048	0.006
3	-0.064	[-0.082,-0.045]	0.010	3.01×10^{-11}	-6.652	0.045	0.003
4	-0.061	[-0.08,-0.042]	0.010	2.06×10^{-10}	-6.362	0.045	0.003
5	-0.078	[-0.098,-0.057]	0.011	3.66×10^{-13}	-7.275	0.046	0.004
6	-0.072	[-0.093,-0.051]	0.011	2.21×10^{-11}	-6.697	0.045	0.003
7	-0.054	[-0.073,-0.035]	0.010	1.46×10^{-08}	-5.670	0.044	0.002
8	-0.066	[-0.089,-0.042]	0.012	4.11×10^{-08}	-5.490	0.044	0.002
9	-0.066	[-0.087,-0.045]	0.011	7.64×10^{-10}	-6.157	0.045	0.003
10	-0.064	[-0.085,-0.043]	0.011	2.6×10^{-09}	-5.960	0.045	0.003
11	-0.066	[-0.088,-0.044]	0.011	4.50×10^{-09}	-5.869	0.045	0.003
12	-0.061	[-0.081,-0.04]	0.011	9.33×10^{-09}	-5.746	0.044	0.003
13	-0.057	[-0.077,-0.036]	0.010	4.77×10^{-08}	-5.463	0.044	0.002
14	-0.053	[-0.072,-0.033]	0.010	1.06×10^{-07}	-5.319	0.044	0.002
15	-0.054	[-0.074,-0.034]	0.010	1.14×10^{-07}	-5.306	0.044	0.002
16	-0.052	[-0.071,-0.032]	0.010	3.44×10^{-07}	-5.100	0.044	0.002

17	-0.051	[-0.071,-0.032]	0.010	3.42×10^{-07}	-5.102	0.044	0.002
18	-0.051	[-0.07,-0.031]	0.010	3.66×10^{-07}	-5.088	0.044	0.002
19	-0.050	[-0.07,-0.03]	0.010	6.84×10^{-07}	-4.969	0.044	0.002
20	-0.049	[-0.068,-0.03]	0.010	6.23×10^{-07}	-4.987	0.044	0.002
21	-0.049	[-0.068,-0.029]	0.010	1.19×10^{-06}	-4.870	0.044	0.002

Supplementary Table 5 | Effect sizes (standardized betas) and 95% confidence interval (uncorrected) of associations between risky behaviour and grey matter volumes (GMV) in 23 ROIs, with and without controlling for cognitive and socioeconomic outcomes (*N* = 11,864). Additional controls include education years, fluid IQ, zip-code level social deprivation, household income, number of household members, birth location. Both models include all standard controls. The sample size of the analysis with additional controls is reduced due to missing data for some variables. *FWE-rate of 5%; **FWE-rate of 1%.

ROI	Risky behaviour (with additional controls)	Risky behaviour (with standard controls)
vmPFC (l)	-0.055** [-0.081, -0.03] $t(11,647) = -4.27$ $p_{uncorr} = 2.01 \times 10^{-5}$	-0.056** [-0.08, -0.031] $t(12,562) = -4.44$ $p_{uncorr} = 8.88 \times 10^{-6}$
dlPFC (r) (BA46)	-0.065** [-0.087, -0.044] $t(11,647) = -5.98$ $p_{uncorr} = 2.29 \times 10^{-9}$	-0.065** [-0.086, -0.044] $t(12,562) = -6.15$ $p_{uncorr} = 7.91 \times 10^{-10}$
dlPFC (l) (BA46)	-0.044** [-0.066, -0.022] $t(11,647) = -3.93$ $p_{uncorr} = 8.64 \times 10^{-5}$	-0.048** [-0.069, -0.027] $t(12,562) = -4.44$ $p_{uncorr} = 8.96 \times 10^{-6}$
Precentral Gyrus (r)	-0.057** [-0.079, -0.036] $t(11,647) = -5.17$ $p_{uncorr} = 2.37 \times 10^{-7}$	-0.061** [-0.082, -0.04] $t(12,562) = -5.65$ $p_{uncorr} = 1.6 \times 10^{-8}$
Cuneal Cortex (l)	-0.031 [-0.051, -0.012] $t(11,647) = -3.18$ $p_{uncorr} = 1.46 \times 10^{-3}$	-0.038** [-0.057, -0.02] $t(12,562) = -4$ $p_{uncorr} = 6.48 \times 10^{-5}$
Hypothalamus	-0.066** [-0.087, -0.044] $t(11,647) = -6.02$ $p_{uncorr} = 1.84 \times 10^{-9}$	-0.068** [-0.089, -0.047] $t(12,562) = -6.41$ $p_{uncorr} = 1.53 \times 10^{-10}$
Putamen (l)	-0.057** [-0.076, -0.039] $t(11,647) = -6.06$ $p_{uncorr} = 1.4 \times 10^{-9}$	-0.061** [-0.079, -0.043] $t(12,562) = -6.67$ $p_{uncorr} = 2.69 \times 10^{-11}$
Putamen (r)	-0.055** [-0.073, -0.036] $t(11,647) = -5.79$ $p_{uncorr} = 7.34 \times 10^{-9}$	-0.055** [-0.073, -0.037] $t(12,562) = -5.98$ $p_{uncorr} = 2.34 \times 10^{-9}$
Amygdala (l)	-0.073** [-0.095, -0.051] $t(11,647) = -6.39$ $p_{uncorr} = 1.77 \times 10^{-10}$	-0.072** [-0.094, -0.051] $t(12,562) = -6.54$ $p_{uncorr} = 6.34 \times 10^{-11}$
Amygdala (r)	-0.066** [-0.089, -0.043] $t(11,647) = -5.73$ $p_{uncorr} = 1.01 \times 10^{-8}$	-0.073** [-0.095, -0.051] $t(12,562) = -6.58$ $p_{uncorr} = 4.85 \times 10^{-11}$
Ventral Striatum (l)	-0.045** [-0.066, -0.024] $t(11,647) = -4.23$ $p_{uncorr} = 2.31 \times 10^{-5}$	-0.048** [-0.068, -0.027] $t(12,562) = -4.61$ $p_{uncorr} = 4.16 \times 10^{-6}$
Ventral Striatum (r)	-0.052** [-0.072, -0.031] $t(11,647) = -4.81$ $p_{uncorr} = 1.5 \times 10^{-6}$	-0.053** [-0.074, -0.033] $t(12,562) = -5.12$ $p_{uncorr} = 3.17 \times 10^{-7}$
Brain-Stem	-0.035 [-0.055, -0.015] $t(11,647) = -3.43$ $p_{uncorr} = 6.11 \times 10^{-4}$	-0.041** [-0.061, -0.022] $t(12,562) = -4.15$ $p_{uncorr} = 3.4 \times 10^{-5}$
Crus I Cerebellum (l)	-0.039* [-0.059, -0.019] $t(11,647) = -3.89$ $p_{uncorr} = 9.88 \times 10^{-5}$	-0.04** [-0.059, -0.02] $t(12,562) = -4.05$ $p_{uncorr} = 5.2 \times 10^{-5}$
Crus II Cerebellum (l)	-0.041** [-0.06, -0.021] $t(11,647) = -4.13$ $p_{uncorr} = 3.59 \times 10^{-5}$	-0.038** [-0.057, -0.02] $t(12,562) = -4$ $p_{uncorr} = 6.45 \times 10^{-5}$
VIIb Cerebellum (l)	-0.055** [-0.074, -0.036] $t(11,647) = -5.71$ $p_{uncorr} = 1.17 \times 10^{-8}$	-0.054** [-0.072, -0.035] $t(12,562) = -5.72$ $p_{uncorr} = 1.12 \times 10^{-8}$

VIIb Cerebellum (r)	-0.044** [-0.063, -0.025] $t(11,647) = -4.48$ $p_{uncorr} = 7.67 \times 10^{-6}$	-0.042** [-0.06, -0.023] $t(12,562) = -4.4$ $p_{uncorr} = 1.08 \times 10^{-5}$
VIIIa Cerebellum (l)	-0.053** [-0.072, -0.034] $t(11,647) = -5.45$ $p_{uncorr} = 5.06 \times 10^{-8}$	-0.05** [-0.069, -0.032] $t(12,562) = -5.31$ $p_{uncorr} = 1.13 \times 10^{-7}$
VIIIa Cerebellum (r)	-0.052** [-0.071, -0.032] $t(11,647) = -5.31$ $p_{uncorr} = 1.15 \times 10^{-7}$	-0.048** [-0.067, -0.03] $t(12,562) = -5.13$ $p_{uncorr} = 2.99 \times 10^{-7}$
IX Cerebellum (r)	-0.038** [-0.056, -0.019] $t(11,647) = -4$ $p_{uncorr} = 6.43 \times 10^{-5}$	-0.036** [-0.054, -0.018] $t(12,562) = -3.92$ $p_{uncorr} = 8.93 \times 10^{-5}$
Ventroanterior Insula (r)	-0.079** [-0.104, -0.055] $t(11,647) = -6.29$ $p_{uncorr} = 3.34 \times 10^{-10}$	-0.079** [-0.103, -0.055] $t(12,562) = -6.43$ $p_{uncorr} = 1.34 \times 10^{-10}$
Ventroanterior Insula (l)	-0.068** [-0.093, -0.042] $t(11,647) = -5.24$ $p_{uncorr} = 1.66 \times 10^{-7}$	-0.065** [-0.09, -0.041] $t(12,562) = -5.24$ $p_{uncorr} = 1.65 \times 10^{-7}$
Planum Polare (l)	-0.039* [-0.06, -0.018] $t(11,647) = -3.68$ $p_{uncorr} = 2.36 \times 10^{-4}$	-0.043** [-0.063, -0.022] $t(12,562) = -4.13$ $p_{uncorr} = 3.68 \times 10^{-5}$

Supplementary Table 6 | Effect sizes (standardized betas) and the corresponding 95% confidence interval (uncorrected) of the associations between grey matter volumes in 23 ROIs and individual phenotypes of risky behaviour (*N*=12,675). Models include all of the standard control variables. *FWE-rate of 5 %; **FWE-rate of 1%.

ROI	Risky behaviour	Drinks Weekly	Speeding	# Lifetime sexual partners	Ever Smoked
vmPFC (l)	-0.056** [-0.08, -0.031] $t(12,562) = -4.44$ $p_{uncorr} = 8.88 \times 10^{-6}$	-0.062** [-0.086, -0.038] $t(12,562) = -5.12$ $p_{uncorr} = 3.08 \times 10^{-7}$	0.022 [-0.003, 0.046] $t(12,562) = 1.73$ $p_{uncorr} = 8.31 \times 10^{-2}$	-0.038* [-0.062, -0.014] $t(12,562) = -3.07$ $p_{uncorr} = 2.17 \times 10^{-3}$	-0.057** [-0.081, -0.032] $t(12,562) = -4.48$ $p_{uncorr} = 7.57 \times 10^{-6}$
dlPFC (r) (BA46)	-0.065** [-0.086, -0.044] $t(12,562) = -6.15$ $p_{uncorr} = 7.91 \times 10^{-10}$	-0.056** [-0.076, -0.036] $t(12,562) = -5.49$ $p_{uncorr} = 4.15 \times 10^{-8}$	-0.003 [-0.024, 0.017] $t(12,562) = -0.31$ $p_{uncorr} = 7.54 \times 10^{-1}$	-0.046** [-0.067, -0.026] $t(12,562) = -4.48$ $p_{uncorr} = 7.5 \times 10^{-6}$	-0.051** [-0.071, -0.03] $t(12,562) = -4.75$ $p_{uncorr} = 2.07 \times 10^{-6}$
dlPFC (l) (BA46)	-0.048** [-0.069, -0.027] $t(12,562) = -4.44$ $p_{uncorr} = 8.96 \times 10^{-6}$	-0.052** [-0.072, -0.031] $t(12,562) = -5$ $p_{uncorr} = 5.95 \times 10^{-7}$	0.005 [-0.016, 0.026] $t(12,562) = 0.49$ $p_{uncorr} = 6.23 \times 10^{-1}$	-0.032* [-0.053, -0.012] $t(12,562) = -3.05$ $p_{uncorr} = 2.26 \times 10^{-3}$	-0.038** [-0.06, -0.017] $t(12,562) = -3.53$ $p_{uncorr} = 4.1 \times 10^{-4}$
Precentral Gyrus (r)	-0.061** [-0.082, -0.04] $t(12,562) = -5.65$ $p_{uncorr} = 1.6 \times 10^{-8}$	-0.075** [-0.095, -0.054] $t(12,562) = -7.21$ $p_{uncorr} = 6.03 \times 10^{-13}$	0.013 [-0.008, 0.034] $t(12,562) = 1.19$ $p_{uncorr} = 2.32 \times 10^{-1}$	-0.029 [-0.05, -0.008] $t(12,562) = -2.72$ $p_{uncorr} = 6.48 \times 10^{-3}$	-0.062** [-0.083, -0.041] $t(12,562) = -5.7$ $p_{uncorr} = 1.21 \times 10^{-8}$
Cuneal Cortex (l)	-0.038** [-0.057, -0.02] $t(12,562) = -4$ $p_{uncorr} = 6.48 \times 10^{-5}$	-0.041** [-0.059, -0.022] $t(12,562) = -4.39$ $p_{uncorr} = 1.14 \times 10^{-5}$	-0.009 [-0.028, 0.01] $t(12,562) = -0.93$ $p_{uncorr} = 3.54 \times 10^{-1}$	-0.008 [-0.026, 0.011] $t(12,562) = -0.83$ $p_{uncorr} = 4.06 \times 10^{-1}$	-0.041** [-0.06, -0.022] $t(12,562) = -4.25$ $p_{uncorr} = 2.16 \times 10^{-5}$
Hypothalamus	-0.068** [-0.089, -0.047] $t(12,562) = -6.41$ $p_{uncorr} = 1.53 \times 10^{-10}$	-0.084** [-0.104, -0.064] $t(12,562) = -8.18$ $p_{uncorr} = 3 \times 10^{-16}$	-0.014 [-0.035, 0.007] $t(12,562) = -1.33$ $p_{uncorr} = 1.82 \times 10^{-1}$	-0.034* [-0.055, -0.014] $t(12,562) = -3.28$ $p_{uncorr} = 1.04 \times 10^{-3}$	-0.043** [-0.064, -0.022] $t(12,562) = -3.98$ $p_{uncorr} = 6.89 \times 10^{-5}$
Putamen (l)	-0.061** [-0.079, -0.043] $t(12,562) = -6.67$ $p_{uncorr} = 2.69 \times 10^{-11}$	-0.042** [-0.06, -0.025] $t(12,562) = -4.83$ $p_{uncorr} = 1.37 \times 10^{-6}$	-0.022 [-0.04, -0.004] $t(12,562) = -2.45$ $p_{uncorr} = 1.43 \times 10^{-2}$	-0.03* [-0.047, -0.012] $t(12,562) = -3.3$ $p_{uncorr} = 9.56 \times 10^{-4}$	-0.054** [-0.072, -0.036] $t(12,562) = -5.88$ $p_{uncorr} = 4.23 \times 10^{-9}$
Putamen (r)	-0.055** [-0.073, -0.037] $t(12,562) = -5.98$ $p_{uncorr} = 2.34 \times 10^{-9}$	-0.035** [-0.052, -0.017] $t(12,562) = -3.93$ $p_{uncorr} = 8.5 \times 10^{-5}$	-0.016 [-0.034, 0.002] $t(12,562) = -1.79$ $p_{uncorr} = 7.3 \times 10^{-2}$	-0.024 [-0.042, -0.006] $t(12,562) = -2.67$ $p_{uncorr} = 7.68 \times 10^{-3}$	-0.057** [-0.075, -0.039] $t(12,562) = -6.21$ $p_{uncorr} = 5.4 \times 10^{-10}$
Amygdala (l)	-0.072** [-0.094, -0.051] $t(12,562) = -6.54$ $p_{uncorr} = 6.34 \times 10^{-11}$	-0.05** [-0.071, -0.03] $t(12,562) = -4.73$ $p_{uncorr} = 2.28 \times 10^{-6}$	-0.006 [-0.028, 0.016] $t(12,562) = -0.53$ $p_{uncorr} = 5.95 \times 10^{-1}$	-0.056** [-0.078, -0.035] $t(12,562) = -5.2$ $p_{uncorr} = 2.06 \times 10^{-7}$	-0.057** [-0.079, -0.036] $t(12,562) = -5.15$ $p_{uncorr} = 2.62 \times 10^{-7}$
Amygdala (r)	-0.073** [-0.095, -0.051] $t(12,562) = -6.58$ $p_{uncorr} = 4.85 \times 10^{-11}$	-0.064** [-0.085, -0.043] $t(12,562) = -5.97$ $p_{uncorr} = 2.41 \times 10^{-9}$	-0.011 [-0.032, 0.011] $t(12,562) = -0.95$ $p_{uncorr} = 3.4 \times 10^{-1}$	-0.042** [-0.064, -0.021] $t(12,562) = -3.89$ $p_{uncorr} = 1.02 \times 10^{-4}$	-0.062** [-0.084, -0.04] $t(12,562) = -5.51$ $p_{uncorr} = 3.68 \times 10^{-8}$
Ventral Striatum (l)	-0.048** [-0.068, -0.027] $t(12,562) = -4.61$ $p_{uncorr} = 4.16 \times 10^{-6}$	-0.025 [-0.045, -0.005] $t(12,562) = -2.5$ $p_{uncorr} = 1.25 \times 10^{-2}$	-0.012 [-0.032, 0.009] $t(12,562) = -1.12$ $p_{uncorr} = 2.63 \times 10^{-1}$	-0.038** [-0.058, -0.018] $t(12,562) = -3.76$ $p_{uncorr} = 1.7 \times 10^{-4}$	-0.036** [-0.057, -0.016] $t(12,562) = -3.46$ $p_{uncorr} = 5.43 \times 10^{-4}$
Ventral Striatum (r)	-0.053** [-0.074, -0.033] $t(12,562) = -5.12$ $p_{uncorr} = 3.17 \times 10^{-7}$	-0.028 [-0.048, -0.008] $t(12,562) = -2.8$ $p_{uncorr} = 5.11 \times 10^{-3}$	-0.004 [-0.025, 0.016] $t(12,562) = -0.42$ $p_{uncorr} = 6.74 \times 10^{-1}$	-0.038** [-0.058, -0.018] $t(12,562) = -3.76$ $p_{uncorr} = 1.72 \times 10^{-4}$	-0.052** [-0.073, -0.032] $t(12,562) = -4.98$ $p_{uncorr} = 6.34 \times 10^{-7}$
Brain-Stem	-0.041** [-0.061, -0.022] $t(12,562) = -4.15$ $p_{uncorr} = 3.4 \times 10^{-5}$	-0.06** [-0.079, -0.041] $t(12,562) = -6.22$ $p_{uncorr} = 4.98 \times 10^{-10}$	-0.012 [-0.032, 0.007] $t(12,562) = -1.23$ $p_{uncorr} = 2.17 \times 10^{-1}$	-0.032* [-0.052, -0.013] $t(12,562) = -3.32$ $p_{uncorr} = 9.12 \times 10^{-4}$	-0.003 [-0.023, 0.017] $t(12,562) = -0.3$ $p_{uncorr} = 7.62 \times 10^{-1}$
Crus I Cerebellum (l)	-0.04** [-0.059, -0.02] $t(12,562) = -4.05$ $p_{uncorr} = 5.2 \times 10^{-5}$	-0.028 [-0.047, -0.01] $t(12,562) = -3$ $p_{uncorr} = 2.67 \times 10^{-3}$	0.002 [-0.017, 0.021] $t(12,562) = 0.22$ $p_{uncorr} = 8.26 \times 10^{-1}$	-0.03* [-0.049, -0.011] $t(12,562) = -3.12$ $p_{uncorr} = 1.83 \times 10^{-3}$	-0.037** [-0.056, -0.017] $t(12,562) = -3.71$ $p_{uncorr} = 2.1 \times 10^{-4}$
Crus II Cerebellum (l)	-0.038** [-0.057, -0.02] $t(12,562) = -4$ $p_{uncorr} = 6.45 \times 10^{-5}$	-0.017 [-0.035, 0.001] $t(12,562) = -1.86$ $p_{uncorr} = 6.34 \times 10^{-2}$	-0.012 [-0.03, 0.007] $t(12,562) = -1.21$ $p_{uncorr} = 2.28 \times 10^{-1}$	-0.03* [-0.048, -0.011] $t(12,562) = -3.17$ $p_{uncorr} = 1.53 \times 10^{-3}$	-0.03* [-0.049, -0.011] $t(12,562) = -3.13$ $p_{uncorr} = 1.78 \times 10^{-3}$
VIIb Cerebellum (l)	-0.054** [-0.072, -0.035] $t(12,562) = -5.72$ $p_{uncorr} = 1.12 \times 10^{-8}$	-0.028* [-0.046, -0.01] $t(12,562) = -3.08$ $p_{uncorr} = 2.07 \times 10^{-3}$	-0.017 [-0.036, 0.001] $t(12,562) = -1.85$ $p_{uncorr} = 6.43 \times 10^{-2}$	-0.039** [-0.057, -0.021] $t(12,562) = -4.23$ $p_{uncorr} = 2.3 \times 10^{-5}$	-0.042** [-0.06, -0.023] $t(12,562) = -4.4$ $p_{uncorr} = 1.08 \times 10^{-5}$

VIIb Cerebellum (r)	-0.042** [-0.06, -0.023] $t(12,562) = -4.4$ $p_{uncorr} = 1.08 \times 10^{-5}$	-0.018 [-0.036, 0] $t(12,562) = -2$ $p_{uncorr} = 4.51 \times 10^{-2}$	-0.012 [-0.031, 0.006] $t(12,562) = -1.29$ $p_{uncorr} = 1.96 \times 10^{-1}$	-0.032** [-0.05, -0.014] $t(12,562) = -3.45$ $p_{uncorr} = 5.7 \times 10^{-4}$	-0.034** [-0.053, -0.015] $t(12,562) = -3.55$ $p_{uncorr} = 3.84 \times 10^{-4}$
VIIIa Cerebellum (l)	-0.05** [-0.069, -0.032] $t(12,562) = -5.31$ $p_{uncorr} = 1.13 \times 10^{-7}$	-0.026 [-0.044, -0.008] $t(12,562) = -2.87$ $p_{uncorr} = 4.09 \times 10^{-3}$	-0.021 [-0.04, -0.003] $t(12,562) = -2.24$ $p_{uncorr} = 2.52 \times 10^{-2}$	-0.037** [-0.055, -0.019] $t(12,562) = -3.98$ $p_{uncorr} = 6.96 \times 10^{-5}$	-0.034** [-0.053, -0.016] $t(12,562) = -3.59$ $p_{uncorr} = 3.27 \times 10^{-4}$
VIIIa Cerebellum (r)	-0.048** [-0.067, -0.03] $t(12,562) = -5.13$ $p_{uncorr} = 2.99 \times 10^{-7}$	-0.019 [-0.037, -0.002] $t(12,562) = -2.14$ $p_{uncorr} = 3.2 \times 10^{-2}$	-0.016 [-0.034, 0.003] $t(12,562) = -1.67$ $p_{uncorr} = 9.43 \times 10^{-2}$	-0.033** [-0.051, -0.015] $t(12,562) = -3.56$ $p_{uncorr} = 3.66 \times 10^{-4}$	-0.044** [-0.062, -0.025] $t(12,562) = -4.62$ $p_{uncorr} = 3.81 \times 10^{-6}$
IX Cerebellum (r)	-0.036** [-0.054, -0.018] $t(12,562) = -3.92$ $p_{uncorr} = 8.93 \times 10^{-5}$	-0.016 [-0.033, 0.001] $t(12,562) = -1.79$ $p_{uncorr} = 7.31 \times 10^{-2}$	-0.024 [-0.042, -0.006] $t(12,562) = -2.65$ $p_{uncorr} = 8.03 \times 10^{-3}$	-0.028* [-0.046, -0.011] $t(12,562) = -3.19$ $p_{uncorr} = 1.42 \times 10^{-3}$	-0.016 [-0.034, 0.002] $t(12,562) = -1.76$ $p_{uncorr} = 7.8 \times 10^{-2}$
Ventroanterior Insula (r)	-0.079** [-0.103, -0.055] $t(12,562) = -6.43$ $p_{uncorr} = 1.34 \times 10^{-10}$	-0.068** [-0.091, -0.045] $t(12,562) = -5.73$ $p_{uncorr} = 1.03 \times 10^{-8}$	0.007 [-0.017, 0.031] $t(12,562) = 0.61$ $p_{uncorr} = 5.42 \times 10^{-1}$	-0.035* [-0.059, -0.011] $t(12,562) = -2.91$ $p_{uncorr} = 3.62 \times 10^{-3}$	-0.095** [-0.12, -0.071] $t(12,562) = -7.74$ $p_{uncorr} = 1.07 \times 10^{-14}$
Ventroanterior Insula (l)	-0.065** [-0.09, -0.041] $t(12,562) = -5.24$ $p_{uncorr} = 1.65 \times 10^{-7}$	-0.07** [-0.094, -0.047] $t(12,562) = -5.85$ $p_{uncorr} = 4.93 \times 10^{-9}$	0.026 [0.001, 0.05] $t(12,562) = 2.08$ $p_{uncorr} = 3.79 \times 10^{-2}$	-0.019 [-0.043, 0.005] $t(12,562) = -1.56$ $p_{uncorr} = 1.19 \times 10^{-1}$	-0.097** [-0.122, -0.072] $t(12,562) = -7.74$ $p_{uncorr} = 1.11 \times 10^{-14}$
Planum Polare (l)	-0.043** [-0.063, -0.022] $t(12,562) = -4.13$ $p_{uncorr} = 3.68 \times 10^{-5}$	-0.054** [-0.073, -0.034] $t(12,562) = -5.42$ $p_{uncorr} = 5.96 \times 10^{-8}$	0.009 [-0.011, 0.029] $t(12,562) = 0.9$ $p_{uncorr} = 3.68 \times 10^{-1}$	-0.014 [-0.034, 0.006] $t(12,562) = -1.36$ $p_{uncorr} = 1.75 \times 10^{-1}$	-0.05** [-0.07, -0.029] $t(12,562) = -4.78$ $p_{uncorr} = 1.74 \times 10^{-6}$

Supplementary Table 7 | Effect sizes (standardized betas) and the corresponding 95% confidence intervals (uncorrected) of the associations between risky behaviour and grey matter volume in 23 ROIs, with and without controlling for current drinking level (binned in deciles) and current smoking level (binned in 3 categories). Both models include all of our standard controls (N = 12,675). *FWE-rate of 5 %; **FWE-rate of 1%.

ROI	Risky behaviour (with drinking/smoking controls)	Risky behaviour (with standard controls)
vmPFC (l)	-0.015 [-0.036, 0.005] $t(12{,}551) = -1.45$ $p_{uncorr} = 0.15$	-0.056** [-0.08, -0.031] $t(12{,}562) = -4.44$ $p_{uncorr} = 8.88 \times 10^{-6}$
dlPFC (r) (BA46)	-0.029 [-0.047, -0.012] $t(12{,}551) = -3.32$ $p_{uncorr} = 9.03 \times 10^{-4}$	-0.065** [-0.086, -0.044] $t(12{,}562) = -6.15$ $p_{uncorr} = 7.91 \times 10^{-10}$
dlPFC (l) (BA46)	-0.016 [-0.033, 0.002] $t(12{,}551) = -1.76$ $p_{uncorr} = 7.83 \times 10^{-2}$	-0.048** [-0.069, -0.027] $t(12{,}562) = -4.44$ $p_{uncorr} = 8.96 \times 10^{-6}$
Precentral Gyrus (r)	-0.017 [-0.034, 0.001] $t(12{,}551) = -1.85$ $p_{uncorr} = 6.4 \times 10^{-2}$	-0.061** [-0.082, -0.04] $t(12{,}562) = -5.65$ $p_{uncorr} = 1.6 \times 10^{-8}$
Cuneal Cortex (l)	-0.012 [-0.028, 0.004] $t(12{,}551) = -1.49$ $p_{uncorr} = 0.14$	-0.038** [-0.057, -0.02] $t(12{,}562) = -4$ $p_{uncorr} = 6.48 \times 10^{-5}$
Hypothalamus	-0.017 [-0.034, 0.001] $t(12{,}551) = -1.88$ $p_{uncorr} = 6.05 \times 10^{-2}$	-0.068** [-0.089, -0.047] $t(12{,}562) = -6.41$ $p_{uncorr} = 1.53 \times 10^{-10}$
Putamen (l)	-0.034** [-0.049, -0.019] $t(12{,}551) = -4.46$ $p_{uncorr} = 8.15 \times 10^{-6}$	-0.061** [-0.079, -0.043] $t(12{,}562) = -6.67$ $p_{uncorr} = 2.69 \times 10^{-11}$
Putamen (r)	-0.031** [-0.046, -0.016] $t(12{,}551) = -4.09$ $p_{uncorr} = 4.39 \times 10^{-5}$	-0.055** [-0.073, -0.037] $t(12{,}562) = -5.98$ $p_{uncorr} = 2.34 \times 10^{-9}$
Amygdala (l)	-0.041** [-0.059, -0.023] $t(12{,}551) = -4.4$ $p_{uncorr} = 1.1 \times 10^{-5}$	-0.072** [-0.094, -0.051] $t(12{,}562) = -6.54$ $p_{uncorr} = 6.34 \times 10^{-11}$
Amygdala (r)	-0.032 [-0.05, -0.013] $t(12{,}551) = -3.39$ $p_{uncorr} = 6.95 \times 10^{-4}$	-0.073** [-0.095, -0.051] $t(12{,}562) = -6.58$ $p_{uncorr} = 4.85 \times 10^{-11}$
Ventral Striatum (l)	-0.032* [-0.049, -0.015] $t(12{,}551) = -3.66$ $p_{uncorr} = 2.56 \times 10^{-4}$	-0.048** [-0.068, -0.027] $t(12{,}562) = -4.61$ $p_{uncorr} = 4.16 \times 10^{-6}$
Ventral Striatum (r)	-0.033* [-0.05, -0.016] $t(12{,}551) = -3.79$ $p_{uncorr} = 1.53 \times 10^{-4}$	-0.053** [-0.074, -0.033] $t(12{,}562) = -5.12$ $p_{uncorr} = 3.17 \times 10^{-7}$
Brain-Stem	-0.014 [-0.031, 0.002] $t(12{,}551) = -1.71$ $p_{uncorr} = 8.73 \times 10^{-2}$	-0.041** [-0.061, -0.022] $t(12{,}562) = -4.15$ $p_{uncorr} = 3.4 \times 10^{-5}$
Crus I Cerebellum (l)	-0.017 [-0.033, -0.001] $t(12{,}551) = -2.11$ $p_{uncorr} = 3.45 \times 10^{-2}$	-0.04** [-0.059, -0.02] $t(12{,}562) = -4.05$ $p_{uncorr} = 5.2 \times 10^{-5}$
Crus II Cerebellum (l)	-0.027 [-0.043, -0.011] $t(12{,}551) = -3.39$ $p_{uncorr} = 6.98 \times 10^{-4}$	-0.038** [-0.057, -0.02] $t(12{,}562) = -4$ $p_{uncorr} = 6.45 \times 10^{-5}$
VIIb Cerebellum (l)	-0.035** [-0.05, -0.02] $t(12{,}551) = -4.44$ $p_{uncorr} = 9.08 \times 10^{-6}$	-0.054** [-0.072, -0.035] $t(12{,}562) = -5.72$ $p_{uncorr} = 1.12 \times 10^{-8}$
VIIb Cerebellum (r)	-0.03* [-0.045, -0.014] $t(12{,}551) = -3.75$ $p_{uncorr} = 1.76 \times 10^{-4}$	-0.042** [-0.06, -0.023] $t(12{,}562) = -4.4$ $p_{uncorr} = 1.08 \times 10^{-5}$
VIIIa Cerebellum (l)	-0.031** [-0.047, -0.016] $t(12{,}551) = -3.94$ $p_{uncorr} = 8.26 \times 10^{-5}$	-0.05** [-0.069, -0.032] $t(12{,}562) = -5.31$ $p_{uncorr} = 1.13 \times 10^{-7}$

VIIIa Cerebellum (r)	-0.033** [-0.048, -0.018] $t(12,551) = -4.21$ $p_{uncorr} = 2.63 \times 10^{-5}$	-0.048** [-0.067, -0.03] $t(12,562) = -5.13$ $p_{uncorr} = 2.99 \times 10^{-7}$
IX Cerebellum (r)	-0.023 [-0.038, -0.008] $t(12,551) = -3.04$ $p_{uncorr} = 2.4 \times 10^{-3}$	-0.036** [-0.054, -0.018] $t(12,562) = -3.92$ $p_{uncorr} = 8.93 \times 10^{-5}$
Ventroanterior Insula (r)	-0.033 [-0.053, -0.013] $t(12,551) = -3.21$ $p_{uncorr} = 1.32 \times 10^{-3}$	-0.079** [-0.103, -0.055] $t(12,562) = -6.43$ $p_{uncorr} = 1.34 \times 10^{-10}$
Ventroanterior Insula (l)	-0.018 [-0.039, 0.002] $t(12,551) = -1.76$ $p_{uncorr} = 7.79 \times 10^{-2}$	-0.065** [-0.09, -0.041] $t(12,562) = -5.24$ $p_{uncorr} = 1.65 \times 10^{-7}$
Planum Polare (l)	-0.011 [-0.028, 0.006] $t(12,551) = -1.24$ $p_{uncorr} = 0.22$	-0.043** [-0.063, -0.022] $t(12,562) = -4.13$ $p_{uncorr} = 3.68 \times 10^{-5}$

Supplementary Table 8 | Effect sizes (standardized betas) and the corresponding 95% confidence intervals (uncorrected) of the associations between risky behaviour and ROI-level imaging-derived phenotypes (IDPs) of grey matter volume (GMV) in the replication sample (*N* = 13,004) and original sample (*N*=12,675). All beta coefficients are consistently negative across samples and 21 of 23 ROIs identified in the original analysis replicate (corrected for multiple testing using a permutation test, see Methods). *FWE-rate of 5%; **FWE-rate of 1%.

ROI	Risky behaviour (Replication Sample)	Risky behaviour (Original Sample)
vmPFC (l)	-0.101** [-0.125, -0.077] $t(12,892) = -8.24$ $p_{uncorr} = 1.89 \times 10^{-16}$	-0.056** [-0.08, -0.031] $t(12,562) = -4.44$ $p_{uncorr} = 8.88 \times 10^{-6}$
dlPFC (r) (BA46)	-0.067** [-0.087, -0.046] $t(12,892) = -6.37$ $p_{uncorr} = 2.02 \times 10^{-10}$	-0.065** [-0.086, -0.044] $t(12,562) = -6.15$ $p_{uncorr} = 7.91 \times 10^{-10}$
dlPFC (l) (BA46)	-0.051** [-0.072, -0.03] $t(12,892) = -4.81$ $p_{uncorr} = 1.53 \times 10^{-6}$	-0.048** [-0.069, -0.027] $t(12,562) = -4.44$ $p_{uncorr} = 8.96 \times 10^{-6}$
Precentral Gyrus (r)	-0.073** [-0.094, -0.053] $t(12,892) = -7.03$ $p_{uncorr} = 2.17 \times 10^{-12}$	-0.061** [-0.082, -0.04] $t(12,562) = -5.65$ $p_{uncorr} = 1.6 \times 10^{-8}$
Cuneal Cortex (l)	-0.02 [-0.038, -0.001] $t(12,892) = -2.08$ $p_{uncorr} = 3.73 \times 10^{-2}$	-0.038** [-0.057, -0.02] $t(12,562) = -4$ $p_{uncorr} = 6.48 \times 10^{-5}$
Hypothalamus	-0.094** [-0.115, -0.074] $t(12,892) = -8.87$ $p_{uncorr} = 8.21 \times 10^{-19}$	-0.068** [-0.089, -0.047] $t(12,562) = -6.41$ $p_{uncorr} = 1.53 \times 10^{-10}$
Putamen (l)	-0.039** [-0.056, -0.021] $t(12,892) = -4.33$ $p_{uncorr} = 1.52 \times 10^{-5}$	-0.061** [-0.079, -0.043] $t(12,562) = -6.67$ $p_{uncorr} = 2.69 \times 10^{-11}$
Putamen (r)	-0.041** [-0.058, -0.023] $t(12,892) = -4.49$ $p_{uncorr} = 7.06 \times 10^{-6}$	-0.055** [-0.073, -0.037] $t(12,562) = -5.98$ $p_{uncorr} = 2.34 \times 10^{-9}$
Amygdala (l)	-0.037** [-0.059, -0.016] $t(12,892) = -3.41$ $p_{uncorr} = 6.52 \times 10^{-4}$	-0.072** [-0.094, -0.051] $t(12,562) = -6.54$ $p_{uncorr} = 6.34 \times 10^{-11}$
Amygdala (r)	-0.058** [-0.08, -0.036] $t(12,892) = -5.25$ $p_{uncorr} = 1.54 \times 10^{-7}$	-0.073** [-0.095, -0.051] $t(12,562) = -6.58$ $p_{uncorr} = 4.85 \times 10^{-11}$
Ventral Striatum (l)	-0.045** [-0.066, -0.025] $t(12,892) = -4.39$ $p_{uncorr} = 1.13 \times 10^{-5}$	-0.048** [-0.068, -0.027] $t(12,562) = -4.61$ $p_{uncorr} = 4.16 \times 10^{-6}$
Ventral Striatum (r)	-0.046** [-0.066, -0.025] $t(12,892) = -4.41$ $p_{uncorr} = 1.02 \times 10^{-5}$	-0.053** [-0.074, -0.033] $t(12,562) = -5.12$ $p_{uncorr} = 3.17 \times 10^{-7}$
Brain-Stem	-0.056** [-0.075, -0.037] $t(12,892) = -5.79$ $p_{uncorr} = 7.39 \times 10^{-9}$	-0.041** [-0.061, -0.022] $t(12,562) = -4.15$ $p_{uncorr} = 3.4 \times 10^{-5}$
Crus I Cerebellum (l)	-0.032** [-0.051, -0.013] $t(12,892) = -3.33$ $p_{uncorr} = 8.81 \times 10^{-4}$	-0.04** [-0.059, -0.02] $t(12,562) = -4.05$ $p_{uncorr} = 5.2 \times 10^{-5}$
Crus II Cerebellum (l)	-0.019 [-0.038, 0] $t(12,892) = -2.01$ $p_{uncorr} = 4.47 \times 10^{-2}$	-0.038** [-0.057, -0.02] $t(12,562) = -4$ $p_{uncorr} = 6.45 \times 10^{-5}$
VIIb Cerebellum (l)	-0.039** [-0.057, -0.02] $t(12,892) = -4.05$ $p_{uncorr} = 5.18 \times 10^{-5}$	-0.054** [-0.072, -0.035] $t(12,562) = -5.72$ $p_{uncorr} = 1.12 \times 10^{-8}$
VIIb Cerebellum (r)	-0.029* [-0.048, -0.01] $t(12,892) = -3.02$ $p_{uncorr} = 2.54 \times 10^{-3}$	-0.042** [-0.06, -0.023] $t(12,562) = -4.4$ $p_{uncorr} = 1.08 \times 10^{-5}$

VIIIa Cerebellum (l)	-0.039** [-0.058, -0.02] $t(12,892) = -3.98$ $p_{uncorr} = 7.02 \times 10^{-5}$	-0.05** [-0.069, -0.032] $t(12,562) = -5.31$ $p_{uncorr} = 1.13 \times 10^{-7}$
VIIIa Cerebellum (r)	-0.048** [-0.067, -0.029] $t(12,892) = -4.94$ $p_{uncorr} = 7.87 \times 10^{-7}$	-0.048** [-0.067, -0.03] $t(12,562) = -5.13$ $p_{uncorr} = 2.99 \times 10^{-7}$
IX Cerebellum (r)	-0.044** [-0.062, -0.026] $t(12,892) = -4.78$ $p_{uncorr} = 1.75 \times 10^{-6}$	-0.036** [-0.054, -0.018] $t(12,562) = -3.92$ $p_{uncorr} = 8.93 \times 10^{-5}$
Ventroanterior Insula (r)	-0.102** [-0.125, -0.078] $t(12,892) = -8.53$ $p_{uncorr} = 1.56 \times 10^{-17}$	-0.079** [-0.103, -0.055] $t(12,562) = -6.43$ $p_{uncorr} = 1.34 \times 10^{-10}$
Ventroanterior Insula (l)	-0.093** [-0.117, -0.069] $t(12,892) = -7.6$ $p_{uncorr} = 3.08 \times 10^{-14}$	-0.065** [-0.09, -0.041] $t(12,562) = -5.24$ $p_{uncorr} = 1.65 \times 10^{-7}$
Planum Polare (l)	-0.058** [-0.078, -0.038] $t(12,892) = -5.7$ $p_{uncorr} = 1.26 \times 10^{-8}$	-0.043** [-0.063, -0.022] $t(12,562) = -4.13$ $p_{uncorr} = 3.68 \times 10^{-5}$

Supplementary Table 9 | Summary of studies used for the meta-analysis of fMRI studies on risky behaviours (provided by Neurosynth). Neurosynth uses text mining techniques to search through published articles for certain keywords (here: 'risky') and then quantifies how important the keyword is in any particular published article, relative to all other searched articles. Specifically, Neurosynth uses a metric (i.e. 'loading') to quantify how often the key word (here: 'risky') was used in the respective article relative to all other articles in this meta-analysis. Its value ranges from 0 to 1 and increases proportionally with the number of times a word appears in the respective published article. Neurosynth typically uses a cutoff of .05 for articles to be included in the meta-analysis. For further information see ref 32.

Title	**Author**	**Journal**	**Loading**	**Sample Size (after exclusions)**
Adolescents' Neural Processing of Risky Decisions: Effects of Sex and behavioural Disinhibition.	Crowley TJ, Dalwani MS, Mikulich-Gilbertson SK, Young SE, Sakai JT, Raymond KM, McWilliams SK, Roark MJ, Banich MT	PloS one	0.678	81
Altered Functional Response to Risky Choice in HIV Infection.	Connolly CG, Bischoff-Grethe A, Jordan SJ, Woods SP, Ellis RJ, Paulus MP, Grant I	PloS one	0.622	40
Attenuated Neural Processing of Risk in Young Adults at Risk for Stimulant Dependence.	Reske M, Stewart JL, Flagan TM, Paulus MP	PloS one	0.576	208

Learning from other people's experience: a neuroimaging study of decisional interactive-learning.	Canessa N, Motterlini M, Alemanno F, Perani D, Cappa SF	NeuroImage	0.564	24
Children's brain activation during risky decision-making: A contributor to substance problems?	Crowley TJ, Dalwani MS, Sakai JT, Raymond KM, McWilliams SK, Banich MT, Mikulich-Gilbertson SK	Drug and alcohol dependence	0.52	58
Differences in neural activation as a function of risk-taking task parameters.	Congdon E, Bato AA, Schonberg T, Mumford JA, Karlsgodt KH, Sabb FW, London ED, Cannon TD, Bilder RM, Poldrack RA	Frontiers in neuroscience	0.49	23
Are risky choices actually guided by a compensatory process? New insights from FMRI.	Rao LL, Zhou Y, Xu L, Liang ZY, Jiang T, Li S	PloS one	0.442	23
Neural mechanisms of risky decision making in adolescents reporting frequent alcohol and/or marijuana use.	Claus ED, Feldstein Ewing SW, Magnan RE, Montanaro E, Hutchison KE, Bryan AD	Brain imaging and behaviour	0.435	189
Neural mechanisms of impulse control in sexually risky adolescents.	Goldenberg D, Telzer EH, Lieberman MD, Fuligni A, Galvan A	Developmental cognitive neuroscience	0.429	20

Neural Mechanisms Underlying Risk and Ambiguity Attitudes.	Blankenstein NE, Peper JS, Crone EA, van Duijvenvoorde ACK	Journal of cognitive neuroscience	0.414	50
Neural correlates of expected risks and returns in risky choice across development.	van Duijvenvoorde AC, Huizenga HM, Somerville LH, Delgado MR, Powers A, Weeda WD, Casey BJ, Weber EU, Figner B	Journal of neuroscience :	0.397	72
Learning to play it safe (or not): stable and evolving neural responses during adolescent risky decision-making.	Kahn LE, Peake SJ, Dishion TJ, Stormshak EA, Pfeifer JH	Journal of cognitive neuroscience	0.392	20
Risky decisions and their consequences: neural processing by boys with Antisocial Substance Disorder.	Crowley TJ, Dalwani MS, Mikulich-Gilbertson SK, Du YP, Lejuez CW, Raymond KM, Banich MT	PloS one	0.381	40
Adolescent neural response to reward is related to participant sex and task motivation.	Alarcon G, Cservenka A, Nagel BJ	Brain and cognition	0.38	167
The neural basis of social tactics: An fMRI study.	Fukui H, Murai T, Shinozaki J, Aso T, Fukuyama H, Hayashi T, Hanakawa T	NeuroImage	0.353	16
Neural mechanisms underlying urgent and evaluative behaviours: An fMRI study on	Megias A, Navas JF, Petrova D, Candido A, Maldonado A, Garcia-	Human brain mapping	0.348	57

the interaction of automatic and controlled processes.	Retamero R, Catena A			
Acute stress increases risky decisions and dampens prefrontal activation among adolescent boys.	Uy JP, Galvan A	NeuroImage	0.343	44
Is payoff necessarily weighted by probability when making a risky choice? Evidence from functional connectivity analysis.	Rao LL, Li S, Jiang T, Zhou Y	PloS one	0.335	18
The neural substrates of probabilistic and intertemporal decision making.	Weber BJ, Huettel SA	Brain research	0.333	23
Age-related differences in neural activities during risk taking as revealed by functional MRI.	Lee TM, Leung AW, Fox PT, Gao JH, Chan CC	Social cognitive and affective neuroscience	0.323	21
Neural mechanisms of risky decision-making and reward response in adolescent onset cannabis use disorder.	De Bellis MD, Wang L, Bergman SR, Yaxley RH, Hooper SR, Huettel SA	Drug and alcohol dependence	0.321	56
A cross-sectional and longitudinal analysis of reward-related brain activation: effects of age, pubertal stage, and	van Duijvenvoorde AC, Op de Macks ZA, Overgaauw S, Gunther Moor B, Dahl RE, Crone	Brain and cognition	0.319	33

reward sensitivity.	EA			
Effects of outcome on the covariance between risk level and brain activity in adolescents with internet gaming disorder.	Qi X, Yang Y, Dai S, Gao P, Du X, Zhang Y, Du G, Li X, Zhang Q	NeuroImage. Clinical	0.316	48
Risky decision making and the anterior cingulate cortex in abstinent drug abusers and nonusers.	Fishbein DH, Eldreth DL, Hyde C, Matochik JA, London ED, Contoreggi C, Kurian V, Kimes AS, Breeden A, Grant S	Brain research. Cognitive brain research	0.313	27
Neural mechanisms underlying context-dependent shifts in risk preferences.	Losecaat Vermeer AB, Boksem MA, Sanfey AG	NeuroImage	0.307	26
An event-related fMRI study on risk taking by healthy individuals of high or low impulsiveness.	Lee TM, Chan CC, Han SH, Leung AW, Fox PT, Gao JH	Neuroscience letters	0.295	18
Neural responses to emotional stimuli are associated with childhood family stress.	Taylor SE, Eisenberger NI, Saxbe D, Lehman BJ, Lieberman MD	Biological psychiatry	0.291	30
Neural correlates of Machiavellian strategies in a social dilemma task.	Bereczkei T, Deak A, Papp P, Perlaki G, Orsi G	Brain and cognition	0.276	27
Sex-related differences in	Lee TM, Chan CC, Leung	Cerebral	0.272	22

neural activity during risk taking: an fMRI study.	AW, Fox PT, Gao JH	cortex (New York, N.Y. : 1991)		
Neurocognitive mechanisms underlying identification of environmental risks.	Qin J, Han S	Neuropsychologia	0.249	14
Neural representation of subjective value under risk and ambiguity.	Levy I, Snell J, Nelson AJ, Rustichini A, Glimcher PW	Journal of neurophysiology	0.238	29
The influence of emotion regulation on decision-making under risk.	Martin LN, Delgado MR	Journal of cognitive neuroscience	0.238	30
Failure to retreat: Blunted sensitivity to negative feedback supports risky behaviour in adolescents.	McCormick EM, Telzer EH	NeuroImage	0.235	58
Pre-existing brain states predict risky choices.	Huang YF, Soon CS, Mullette-Gillman OA, Hsieh PJ	NeuroImage	0.234	14
Greater risk sensitivity of dorsolateral prefrontal cortex in young smokers than in nonsmokers.	Galvan A, Schonberg T, Mumford J, Kohno M, Poldrack RA, London ED	Psychopharmacology	0.232	43
Neuronal Correlates of Risk-Seeking Attitudes to	Worbe Y, Irvine M, Lange I, Kundu P, Howell NA,	Biological psychiatry	0.231	42

Anticipated Losses in Binge Drinkers.	Harrison NA, Bullmore ET, Robbins TW, Voon V			
Age differences in the impact of peers on adolescents' and adults' neural response to reward.	Smith AR, Steinberg L, Strang N, Chein J	Developmental cognitive neuroscience	0.228	40
Mothers know best: redirecting adolescent reward sensitivity toward safe behaviour during risk taking.	Telzer EH, Ichien NT, Qu Y	Social cognitive and affective neuroscience	0.206	25
Neural substrates of choice selection in adults and adolescents: development of the ventrolateral prefrontal and anterior cingulate cortices.	Eshel N, Nelson EE, Blair RJ, Pine DS, Ernst M	Neuropsychologia	0.202	30
The neural correlates of risk propensity in males and females using resting-state fMRI.	Zhou Y, Li S, Dunn J, Li H, Qin W, Zhu M, Rao LL, Song M, Yu C, Jiang T	Frontiers in behavioural neuroscience	0.198	289
Influence of dorsolateral prefrontal cortex and ventral striatum on risk avoidance in addiction: a mediation analysis.	Yamamoto DJ, Woo CW, Wager TD, Regner MF, Tanabe J	Drug and alcohol dependence	0.193	80
Lorazepam dose-dependently decreases risk-taking related	Arce E, Miller DA, Feinstein JS, Stein MB,	Psychopharmacology	0.192	15

activation in limbic areas.	Paulus MP			
Neural correlates of choice behaviour related to impulsivity and venturesomeness.	Hinvest NS, Elliott R, McKie S, Anderson IM	Neuropsychologia	0.188	34
Risk-Taking behaviour in a Computerized Driving Task: Brain Activation Correlates of Decision-Making, Outcome, and Peer Influence in Male Adolescents.	Vorobyev V, Kwon MS, Moe D, Parkkola R, Hamalainen H	PloS one	0.185	34
Risk-taking and social exclusion in adolescence: neural mechanisms underlying peer influences on decision-making.	Peake SJ, Dishion TJ, Stormshak EA, Moore WE, Pfeifer JH	NeuroImage	0.183	27
behavioural contagion during learning about another agent's risk-preferences acts on the neural representation of decision-risk.	Suzuki S, Jensen EL, Bossaerts P, O'Doherty JP	Proceedings of the National Academy of Sciences of the United States of America	0.178	24
Functional and structural neural indices of risk aversion in obsessive-compulsive	Admon R, Bleich-Cohen M, Weizmant R, Poyurovsky M, Faragian	Psychiatry research	0.175	26

disorder (OCD).	S, Hendler T			
Neural correlates of increased risk-taking propensity in sleep-deprived people along with a changing risk level.	Lei Y, Wang L, Chen P, Li Y, Han W, Ge M, Yang L, Chen S, Hu W, Wu X, Yang Z	Brain imaging and behaviour	0.17	37
Uncovering putative neural markers of risk avoidance.	Roy AK, Gotimer K, Kelly AM, Castellanos FX, Milham MP, Ernst M	Neuropsychologia	0.162	23
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Neural correlates of the impact of prior outcomes on subsequent monetary decision-making in frequent poker players.	Brevers D, He Q, Xue G, Bechara A	Biological psychology	0.161	28
Decision-making under risk: an fMRI study.	Hewig J, Straube T, Trippe RH, Kretschmer N, Hecht H, Coles MG, Miltner WH	Journal of cognitive neuroscience	0.158	17
Imbalanced neural responsivity to risk and reward indicates	Admon R, Lubin G, Rosenblatt JD, Stern O,	Cerebral cortex (New	0.156	24

stress vulnerability in humans.	Kahn I, Assaf M, Hendler T	York, N.Y. : 1991)		
Neural signatures of economic parameters during decision-making: a functional MRI (FMRI), electroencephalography (EEG) and autonomic monitoring study.	Minati L, Grisoli M, Franceschetti S, Epifani F, Granvillano A, Medford N, Harrison NA, Piacentini S, Critchley HD	Brain topography	0.152	22
Individual differences in risk preference predict neural responses during financial decision-making.	Engelmann JB, Tamir D	Brain research	0.151	10
Orbitofrontal reward sensitivity and impulsivity in adult attention deficit hyperactivity disorder.	Wilbertz G, van Elst LT, Delgado MR, Maier S, Feige B, Philipsen A, Blechert J	NeuroImage	0.149	56
A preliminary study of longitudinal neuroadaptation associated with recovery from addiction.	Forster SE, Finn PR, Brown JW	Drug and alcohol dependence	0.148	21
Neural correlates of anticipation risk reflect risk preferences.	Rudorf S, Preuschoff K, Weber B	Journal of neuroscience	0.147	56
behavioural and neural correlates of loss aversion and	Barkley-Levenson EE, Van Leijenhorst L, Galvan	Developmental cognitive	0.146	34

risk avoidance in adolescents and adults.	A	neuroscience		
Dopamine agonists and risk: impulse control disorders in Parkinson's disease.	Voon V, Gao J, Brezing C, Symmonds M, Ekanayake V, Fernandez H, Dolan RJ, Hallett M	Brain	0.142	44
Neural signatures of economic preferences for risk and ambiguity.	Huettel SA, Stowe CJ, Gordon EM, Warner BT, Platt ML	Neuron	0.126	13
Reduced cortical gray matter volume in male adolescents with substance and conduct problems.	Dalwani M, Sakai JT, Mikulich-Gilbertson SK, Tanabe J, Raymond K, McWilliams SK, Thompson LL, Banich MT, Crowley TJ	Drug and alcohol dependence	0.122	44
fMRI evidence for strategic decision-making during resolution of pronoun reference.	McMillan CT, Clark R, Gunawardena D, Ryant N, Grossman M	Neuropsychologia	0.12	16
Entering adolescence: resistance to peer influence, risky behaviour, and neural changes in emotion reactivity.	Pfeifer JH, Masten CL, Moore WE 3rd, Oswald TM, Mazziotta JC, Iacoboni M, Dapretto M	Neuron	0.118	38
The neural basis of financial risk taking.	Kuhnen CM, Knutson B	Neuron	0.116	19

Variables influencing the neural correlates of perceived risk of physical harm.	Coaster M, Rogers BP, Jones OD, Viscusi WK, Merkle KL, Zald DH, Gore JC	Cognitive, affective & behavioural neuroscience	0.116	19
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Individual differences in risk-taking tendencies modulate the neural processing of risky and ambiguous decision-making in adolescence.	Blankenstein NE, Schreuders E, Peper JS, Crone EA, van Duijvenvoorde ACK	NeuroImage	0.106	198
Morphometric correlation of impulsivity in medial prefrontal cortex.	Cho SS, Pellecchia G, Aminian K, Ray N, Segura B, Obeso I, Strafella AP	Brain topography	0.104	34

Processing of decision-making and social threat in patients with history of suicidal attempt: A neuroimaging replication study.	Olie E, Ding Y, Le Bars E, de Champfleur NM, Mura T, Bonafe A, Courtet P, Jollant F	Psychiatry research	0.102	73
Sleep deprivation is associated with attenuated parametric valuation and control signals in the midbrain during value-based decision making.	Menz MM, Buchel C, Peters J	Journal of neuroscience	0.101	22
Adaptive Adolescent Flexibility: Neurodevelopment of Decision-making and Learning in a Risky Context.	McCormick EM, Telzer EH	Journal of cognitive neuroscience	0.1	77
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How the risky features of previous selection affect	Dong G, Zhang Y, Xu J, Lin X, Du X	Frontiers in neuroscience	0.094	22

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Individualized relapse prediction: Personality measures and striatal and insular activity during reward-processing robustly predict relapse.	Gowin JL, Ball TM, Wittmann M, Tapert SF, Paulus MP	Drug and alcohol dependence	0.09	68
Reduced posterior mesofrontal cortex activation by risky rewards in substance-dependent patients.	Bjork JM, Momenan R, Smith AR, Hommer DW	Drug and alcohol dependence	0.089	34
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Increased activation in the right insula during risk-taking decision making is related to harm avoidance and neuroticism.	Paulus MP, Rogalsky C, Simmons A, Feinstein JS, Stein MB	NeuroImage	0.087	17
Neural activities underlying environmental and personal risk identification tasks.	Qin J, Lee TM, Wang F, Mao L, Han S	Neuroscience letters	0.086	14
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The functional and structural neural basis of individual differences in loss aversion.	Canessa N, Crespi C, Motterlini M, Baud-Bovy G, Chierchia G, Pantaleo G, Tettamanti M, Cappa SF	Journal of neuroscience	0.085	56
Developmental continuity in reward-related enhancement of cognitive control.	Strang NM, Pollak SD	Developmental cognitive neuroscience	0.085	65
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Neural activity associated with the passive prediction of ambiguity and risk for aversive events.	Bach DR, Seymour B, Dolan RJ	Journal of neuroscience	0.084	20
Gender differences in reward-related decision processing under stress.	Lighthall NR, Sakaki M, Vasunilashorn S, Nga L, Somayajula S, Chen EY, Samii N, Mather M	Social cognitive and affective neuroscience	0.083	47
Parsing neural mechanisms of social and physical risk identifications.	Qin J, Han S	Human brain mapping	0.082	14

Too little, too late or too much, too early? Differential hemodynamics of response inhibition in high and low sensation seekers	Collins HR, Corbly CR, Liu X, Kelly TH, Lynam D, Joseph JE	Brain research	0.082	40
Stress and decision making: neural correlates of the interaction between stress, executive functions, and decision making under risk.	Gathmann B, Schulte FP, Maderwald S, Pawlikowski M, Starcke K, Schafer LC, Scholer T, Wolf OT, Brand M	Experimental brain research	0.08	33
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The effect of age on neural processing of pleasant soft touch stimuli.	May AC, Stewart JL, Tapert SF, Paulus MP	Frontiers in behavioural neuroscience	0.076	58
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Neural sensitivity to absolute and relative anticipated reward in adolescents.	Vaidya JG, Knutson B, O'Leary DS, Block RI, Magnotta V	PloS one	0.075	36

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Neural correlates of stress and favorite-food cue exposure in adolescents: a functional magnetic resonance imaging study.	Hommer RE, Seo D, Lacadie CM, Chaplin TM, Mayes LC, Sinha R, Potenza MN	Human brain mapping	0.067	43
The neural basis of social risky decision making in females with major depressive disorder.	Shao R, Zhang HJ, Lee TM	Neuropsychologia	0.067	29
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Heightened activity in social reward networks is associated with adolescents' risky sexual behaviours.	Eckstrand KL, Choukas-Bradley S, Mohanty A, Cross M, Allen NB, Silk JS, Jones NP, Forbes EE	Developmental cognitive neuroscience	0.059	47
Neural correlates of high-risk behaviour tendencies and impulsivity in an emotional Go/NoGo fMRI task.	Brown MR, Benoit JR, Juhas M, Lebel RM, MacKay M, Dametto E, Silverstone PH, Dolcos F, Dursun SM, Greenshaw	Frontiers in systems neuroscience	0.054	19

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Supplementary Notes

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