

# Package ‘RVIpkg’

March 11, 2025

**Title** Regional Vulnerability Index

**Version** 0.3.3

**Description** The Regional Vulnerability Index (RVI), a statistical measure of brain structural abnormality, quantifies an individual's similarity to the expected pattern (effect size) of deficits in schizophrenia (Kochunov P, Fan F, Ryan MC, et al. (2020) <[doi:10.1002/hbm.25045](https://doi.org/10.1002/hbm.25045)>).

**License** GPL (>= 2)

**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 7.3.2

**Depends** R (>= 2.10)

**Imports** stats

**NeedsCompilation** no

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Ave_func	<i>Optimizing data from UK Biobank</i>
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### Description

The Ave\_func() can optimize data from UK Biobank(UKB). It will rename field IDs of regional neuroimaging traits to abbreviation names, and then average data of left and right hemispheres of the same field.

### Usage

```
Ave_func(resp.range, type = "all", data)
```

### Arguments

resp.range	a numeric vector specifying column range of regional neuroimaging traits.
type	a character string specifying data types of regional neuroimaging traits(i.e. All traits(type='all'), White matter(type='WM'),Gray matter(type='GM') or Subcortical(type='Subcortical'))
data	a data frame contains regional neuroimaging traits with field IDs from UKBB. Default(type='all')

### Value

a dataframe of regional neuroimaging traits with abbreviated field names.

### Note

The Ave\_func() function is developed at the Maryland Psychiatric Research Center, Department of Psychiatry, University of Maryland School of Medicine. This project is supported by NIH R01 EB015611 grant. Please cite our funding if you use this software.

### References

Kochunov P, Fan F, Ryan MC, et al. Translating ENIGMA schizophrenia findings using the regional vulnerability index: Association with cognition, symptoms, and disease trajectory (2020). Hum Brain Mapp. 2020;10.1002/hbm.25045. doi:10.1002/hbm.25045

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.

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data	<i>Simulated volumes of subcortical structures</i>
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### Description

Simulated volumes of subcortical structures of Schizophrenia spectrum disorder are used as an example for this function. You can calculate RVI for this dataset

### Usage

data

### Format

A data frame with 196 rows and 12 variables:

**ID** subjects' ID

**DX** indicators of control group

**Age** subjects' age

**Sex** subjects' gender

**Lateral.Ventricle** simulated volumes of lateral Ventricle

**Thalamus** simulated volumes of Thalamus

**Caudate** simulated volumes of Caudate

**Putamen** simulated volumes of Putamen

**Pallidum** simulated volumes of Pallidum

**Hippocampus** simulated volumes of Hippocampus

**Amygdala** simulated volumes of Amygdala

**Left.Accumbens.area** simulated volumes of left Accumbens

### Source

The 'data' dataset is from Maryland Psychiatric Research Center, Department of Psychiatry, University of Maryland School of Medicine.

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 EP.GM

*Expected patterns of gray matter*


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### Description

the expected patterns of gray matter in schizophrenia derived from large-scale meta-analyses by the ENIGMA.

### Usage

EP.GM

### Format

A data frame with 33 rows and 13 variables:

**GM** grey matter thickness

**SSD** the expected pattern of Schizophrenia Spectrum Disorder ([doi:10.1016/j.biopsych.2018.04.023](https://doi.org/10.1016/j.biopsych.2018.04.023) table S4a)

**MDD** the expected pattern of Major Depressive Disorder ([doi:10.1038/mp.2016.60](https://doi.org/10.1038/mp.2016.60) table 1)

**AD\_ADNI** the expected pattern of Alzheimer's Disease ([doi:10.1016/j.nicl.2021.102574](https://doi.org/10.1016/j.nicl.2021.102574) table S1)

**AD\_ADNIOSYRIX** the expected pattern of Alzheimer's Disease Neuroimaging Initiative + OSIRIX

**BD** the expected pattern of Bipolar Disorder ([doi:10.1038/mp.2017.73](https://doi.org/10.1038/mp.2017.73) table 1)

**PD** the expected pattern of Parkinson's disease

**Diabetes** the expected pattern of Diabetes

**HighBP** the expected pattern of Hypertension

**HighLipids** the expected pattern of Hyperlipidemia

**MET** the expected pattern of Metabolic diseases (Diabetes, Hypertension and Hyperlipidemia)

**DS\_22q** the expected pattern of 22q11.2 deletion syndrome ([doi:10.1038/s4138001800785](https://doi.org/10.1038/s4138001800785) table S10a)

**Suicide** the expected pattern of suicidal ideation ([doi:10.1101/2021.09.27.21264068](https://doi.org/10.1101/2021.09.27.21264068) table S8)

**OCD\_pediatric** the expected pattern of Obsessive-compulsive disorder in pediatric subjects ([doi:10.1176/appi.ajp.2017.17050485](https://doi.org/10.1176/appi.ajp.2017.17050485) table S6)

**OCD\_adult** the expected pattern of Obsessive-compulsive disorder in adults ([doi:10.1176/appi.ajp.2017.17050485](https://doi.org/10.1176/appi.ajp.2017.17050485) table S4)

**AN** the expected pattern of Anorexia Nervosa

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EP.Subcortical                      *Expected patterns of subcortical*

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### Description

the expected patterns of subcortical in schizophrenia derived from large-scale meta-analyses by the ENIGMA.

### Usage

EP.Subcortical

### Format

A data frame with 8 rows and 13 variables:

**Subcortical** subcortical grey matter volume

**SSD** the expected pattern of Schizophrenia Spectrum Disorder ([doi:10.1038/mp.2015.63](https://doi.org/10.1038/mp.2015.63) table 1)

**MDD** the expected pattern of Major Depressive Disorder ([doi:10.1038/mp.2015.69](https://doi.org/10.1038/mp.2015.69) table 1)

**AD\_ADNI** the expected pattern of Alzheimer's Disease ([doi:10.1016/j.nicl.2021.102574](https://doi.org/10.1016/j.nicl.2021.102574) table S1)

**AD\_ADNIOSYRIX** the expected pattern of Alzheimer's Disease Neuroimaging Initiative + OSIRIX

**BD** the expected pattern of Bipolar Disorder ([doi:10.1038/mp.2015.227](https://doi.org/10.1038/mp.2015.227) table 1)

**PD** the expected pattern of Parkinson's disease

**Diabetes** the expected pattern of Diabetes

**HighBP** the expected pattern of Hypertension)

**HighLipids** the expected pattern of Hyperlipidemia

**MET** the expected pattern of Metabolic diseases (Diabetes, Hypertension and Hyperlipidemia)

**DS\_22q** the expected pattern of 22q11.2 deletion syndrome ([doi:10.1176/appi.ajp.2019.19060583](https://doi.org/10.1176/appi.ajp.2019.19060583) table S14a)

**Suicide** the expected pattern of suicidal ideation ([doi:10.1101/2021.09.27.21264068](https://doi.org/10.1101/2021.09.27.21264068) table S8)

**OCD\_pediatic** the expected pattern of Obsessive-compulsive disorder in pediatric subjects ([doi:10.1176/appi.ajp.2016.16020201](https://doi.org/10.1176/appi.ajp.2016.16020201) table S2)

**OCD\_adult** the expected pattern of Obsessive-compulsive disorder in adults ([doi:10.1176/appi.ajp.2016.16020201](https://doi.org/10.1176/appi.ajp.2016.16020201) table 3)

**AN** the expected pattern of Anorexia Nervosa

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 EP.WM

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*Expected patterns of white matter*


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### Description

the expected patterns of white matter in schizophrenia derived from large-scale meta-analyses by the ENIGMA.

### Usage

EP.WM

### Format

A data frame with 24 rows and 14 variables:

**WM** white matter fractional anisotropy

**SSD** the expected pattern of Schizophrenia Spectrum Disorder ([doi:10.1038/mp.2017.170](https://doi.org/10.1038/mp.2017.170) table 1; [doi:10.1002/hbm.24998](https://doi.org/10.1002/hbm.24998) table 2)

**MDD** the expected pattern of Major Depressive Disorder ([doi:10.1038/s4138001904772](https://doi.org/10.1038/s4138001904772) Table S4; [doi:10.1002/hbm.24998](https://doi.org/10.1002/hbm.24998) table 2)

**AD\_ADNI** the expected pattern of Alzheimer's Disease ([doi:10.1016/j.nicl.2021.102574](https://doi.org/10.1016/j.nicl.2021.102574) table S1)

**AD\_ADNIOSYRIX** the expected pattern of Alzheimer's Disease Neuroimaging Initiative + OSIRIX

**BD** the expected pattern of Bipolar Disorder ([doi:10.1002/hbm.24998](https://doi.org/10.1002/hbm.24998) table 2)

**Diabetes** the expected pattern of Diabetes

**HighBP** the expected pattern of Hypertension

**HighLipids** the expected pattern of Hyperlipidemia

**MET** the expected pattern of Metabolic diseases (diabetes, hypertension and hyperlipidemia)

**DS\_22q** the expected pattern of 22q11.2 deletion syndrome ([doi:10.1002/hbm.24998](https://doi.org/10.1002/hbm.24998) table 2; [doi:10.1038/s4138001904500](https://doi.org/10.1038/s4138001904500) table S6)

**PTSD** the expected pattern of Post-traumatic stress disorder ([doi:10.1002/hbm.24998](https://doi.org/10.1002/hbm.24998) table 2)

**TBI** the expected pattern of Traumatic brain injury ([doi:10.1002/hbm.24998](https://doi.org/10.1002/hbm.24998) table 2)

**OCD\_pediatric** the expected pattern of Obsessive-compulsive disorder in pediatric subjects ([doi:10.1038/s4139802101276z](https://doi.org/10.1038/s4139802101276z) table 4)

**OCD\_adult** the expected pattern of Obsessive-compulsive disorder in adults ([doi:10.1038/s41398-02101276z](https://doi.org/10.1038/s41398-02101276z) table 3)

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RVI\_func                      *Regional Vulnerability Index*

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## Description

The Regional Vulnerability Index (RVI), a statistical measure of brain structural abnormality, quantifies an individual's similarity to the expected pattern (effect size) of deficits seen in schizophrenia derived from large-scale meta-analyses by the ENIGMA consortium. This package outputs the inverse-normal transformed (INT) residuals, z-normalized INT residuals, RVI and Alignment Vulnerability Index (AVI).

## Usage

```
RVI_func(
  ID,
  DXcontrol,
  covariates = NULL,
  resp.range,
  EP,
  sign = FALSE,
  fisherZ = FALSE,
  data
)
```

## Arguments

ID	a column name of subject IDs in data.
DXcontrol	a character string specifying control subset(i.e. DXcontrol='DX==0' or DXcontrol='DX=="CN"'). Mean and standard deviation of z-normalization should be calculated in healthy controls.
covariates	an optional character vector specifying column names of covariates (i.e. Age, Sex). If covariates=NULL (the default), residuals will not be adjusted for any covariate. If covariates are specified (i.e. covariates=c('Age','Sex')), residuals will be adjusted for covariates.
resp.range	a numeric vector specifying column indices of regional neuroimaging traits.
EP	a numeric vector specifying an expected pattern of regional neuroimaging traits. The expected patterns(EP.WM, EP.GM and EP.Subcortical) for white matter fractional anisotropy (FA), cortical matter thickness and subcortical volume are included in the package (Note: If you use an expected pattern, you need to make sure the order of regional neuroimaging traits in your data match up the corresponding order of the expected pattern). The patterns can be extract in the package (i.e. RVIpkg::EP.WM\$SSD, RVIpkg::EP.WM\$MDD, RVIpkg::EP.WM\$AD, RVIpkg::EP.WM\$BD ,RVIpkg::EP.WM\$PD .etc.). They were developed using neuroimaging data of UK Biobank (UKBB).
sign	a logical value indicating whether the AVI use signs from RVI.

fisherZ	a logical value indicating whether the result should generate fisher-z transformed RVI.
data	a data frame contains a column of subject IDs, a column of controls, columns of covariates, columns of responses.

### Details

The RVI is developed as a simple measure of agreement between an individual's pattern of regional neuroimaging traits and the expected pattern of schizophrenia. First, all observations of each regional neuroimaging trait are regressed out optional covariates using linear regression, and then residuals are extracted from the model after removing effects of the optional covariates. The optional covariates could be age, sex, intracranial brain volume and/or .etc in the data. After that the residuals are inverse-normal transformed based on residuals' ranks, and then the INT residuals are z-normalized/standardized using mean and standard deviation of healthy controls to get z-normalized INT residuals. For each subject, the RVI is then calculated as a Pearson correlation coefficient between the z-normalized INT residuals of the traits and corresponding expected pattern of the traits and the AVI is the dot product of the z-normalized INT residuals of the traits and corresponding expected pattern of the traits. These expected patterns include cortical thickness, subcortical volume, and white matter FA for mental illnesses and metabolic diseases.

### Value

A list with the following elements:

i.norm.resid	INT residuals
z.norm.resid	z-normalized/standardized INT residuals
RVI	RVI: the Pearson correlation coefficient between the z-normalized INT residuals and corresponding expected pattern; AVI: the dot product of the z-normalized INT residuals and corresponding expected pattern; RVI.fisherz: Fisher z-transformed RVI

### Note

The RVI\_func() function is developed at the Maryland Psychiatric Research Center, Department of Psychiatry, University of Maryland School of Medicine. This project is supported by NIH R01 EB015611 grant. Please cite our funding if you use this software.

### References

- Kochunov P, Fan F, Ryan MC, et al. Translating ENIGMA schizophrenia findings using the regional vulnerability index: Association with cognition, symptoms, and disease trajectory (2020). *Hum Brain Mapp.* 2020;10.1002/hbm.25045. doi:10.1002/hbm.25045
- R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.



**Examples**

```
EP1 <- c(-0.37,0.31,-0.02,-0.08,-0.21,0.46,0.31,0.25)
RVI1 <- RVI_func(ID='ID', DXcontrol='DX==0', covariates=c('Age','Sex'), resp.range=c(5:12),
EP=EP1, data=RVIpkg::data)
RVI2 <- RVI_func(ID='ID', DXcontrol='DX==0', covariates=NULL, resp.range=c(5:12),
EP=EP1, data=RVIpkg::data)
EP2 <- RVIpkg::EP.Subcortical$SSD
RVI3 <- RVI_func(ID='ID', DXcontrol='DX==0', covariates=c('Age','Sex'), resp.range=c(5:12),
EP=EP2, data=RVIpkg::data)
```

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