认知、情绪与社会行为的遗传基础及其神经相关物的研究进展

1875 Francis
Galton

“973”

300 Љ SNP Љ
ŋ Љ ᷾ Љ
ɱ ╤ ɱ ش haplotype ᷾
variable number of tandem repeats VNTR Ϛ ã ŋ
ã
ˊ ᷾ ẇ ῤ ⱺ Ẹ ‟ ͻ ╤
Ẹ Ϛ ═ e δ ⱺ ỵ
Ë υ П Ѝ ĕ Ẹ Ό 10% Љ e
Ẹ ŋ ã ˥
Ẹ ŋ δ ῢ
ⱺ Ϛ
ã δ Ӂ ã δ e δ ⱺ
W Ë
Љ ã Ë Ẹ υ
Ŀ gene set association analysis ◖ υ Ѝ ĕ
ĕ Ẃ ῢ δ ŋ
ش ῢ δ SNP ŋ ŋ
δ ã ² Ʒ ³ 5- ẹ
24 δ ˥ *HTR6* rs6658108 *HTR5A* rs732050
TPH2 rs1487275 *SLC6A4* rs8076005 ⱺ *HTR2C* rs2192371 ŋ δ
ڪ ã ⱺ ♯ Ό Ι ǎ Ë δ 19% ɱ
υ П Ѝ ĕ δ ῢ υ ш Ӂ
ŋ

Ã ã genome-wide association study GWAS Ã
SNP ⱺ
δ ⱺ υ ã CGAS ⱺ GWAS
Љ ã υ Љ CGAS ã ŋ GWAS e Ã
ệ δ ⱺ ã ͻ GWAS
ⱺ GWAS ŋ SNP
Ϛ copy number variation CNV GWAS ה
ⱺ Ḏ ῤ
GWAS ‟ ͻ ẇ Ã
˥ ŋ Љ ╞ ĕ ĕ

20% 30%

GWAS

J. Ott[6, 7]

[8, 9]

i-GSEA4GWAS ICSNPathway GWAS

imaging genetics

[10]

2000 [11]

1

[11~19] magnetic resonance imaging MRI fMRI VBM DTI MRS positron emission tomography PET single-photon emission computed tomography SPECT magnetoencephalography MEG

Lieber D. R. Weinberger[10]

3

GWAS

SNPs

case-control study

family study

animal study

knockout

δ ֺ ﱓ Ă ΰ e Ό ֺ δ

WË ˆ 1

			δ	95%CI
52	607 MZ 54% 218 DZ 55%	10 20 mean=15.47 SD=2.68	Ɽ	66% 41% 72% 43% 13% 64%
˂ ˩ 53	228 MZ 49% 84 DZ 40%	3 11 mean=6.71	Ό ֺ Ό Ό ֺ Ό	Ό 70% 61% 80% Ό 32% 15% 48% Ό 49% 27% 72%
22	102 MZ 71 DZ	7 19 mean=12.7 SD=2.48	Ό	Ό FRA 38.9% 20.1% 54.2% FIE 24.8% 5.9% 41.6% CFE 31% 10.6% 48.2%
54	520 MZ 53.5%	10 18 mean=13.86 SD=2.10	δ ã ֺ ʋ ã	δ ה ˅ Љ Ę ẃ ẹ Ϛ
23	697 MZ 52% 270 DZ 55% 214 ˭ ה	11 19 mean=12.17 SD=2.28		˅ 50% 32% 60% ˅ 51% 35% 69%
24	454 MZ 72% ֺ 152 DZ 61%	mean=13.27 SD=2.6; Ï mean=15.17 SD=2.6	♯ Ό I SLEs ֺ ˥ ɱ ♯ Ό	42% 12% 60% ; Ï 58% 36% 64% ; ♯ Ό I 33% 4% 56% ; ˥ 39% 10% 48%
25	439 MZ ֺ 235 DZ 53.7%	11 17 mean=14.03 SD=1.9	ֺ ˥ δ	˅ 50% 32% 60% ˅ 51% 35% 69% ; ˥ δ 24% 7% 39%
55	439 MZ ֺ 235 DZ 53.7%	11 17 mean=14.03 SD=1.9		31% 11% 45%
ˉ ẇ 56	795 MZ 52% ֺ 309 DZ 53%	8 19 mean=13.52 SD=2.57		˅ 50% 30% 60% ˅ 63% 47% 78%

δ ӎ δ ΰ Ό generalist genes
Ό ΰ Ж [22] ˥ Ό
Ό FRA FIE ˨ CFE
ΰ Ό ה ה ˓ ч
Ό Ό ˨ Ã Ό
ΰ щ Ë e Ό ΰ
˨ e ה
˨ Ë
ǎ Ц Ë ӎ υ ˥
[23] ã ӎ ♯ Ό I [24] ˨
δ [25]
ã ˨ П Й ĕ ΰ
ã *BDNF* Val66Met ŋ [26, 27] ˨ ♯ Ό I SLEs
ΰ П Ѝ ĕ *BDNF* Val ŋ Љ Met/Met ӎ
♯ Ό ΰ [28]

Ό e ˓ ∫ ˨ Ό e I
ã ˥ Ό ˥ Ό e ˨
ה Ό δ 30%
δ 50% Љ [29] ε щ Ό
Ό ĕ ˨ ˨
Ό Ë 2
ŋ Ό Ẹ ã Ë
˥ *SEMA5A* SNP rs42352 ŋ ה ӎ ã ӎ
RAPM ã [30] *GABRB1* rs7435958 ŋ ӎ ה
ӎ ã ה ӎ Ό ã [31] Ж
δ ã ĕ δ Ό ã
W Ë
ĕ ˨ Ë
˥ ã *COMT* *DRD2* *DRD3* *NTSR1*
BDNF ӎ ĕ ã [32~35] ˥ [35] *NTSR1* rs4334545 ŋ C
ŋ ŋ Ẹ ẹ ĕ rs4334545 ŋ
CT/TT ה ӎ ĕ ã CC
ã

30	*SEMA5A* 169 SNP	RAPM	*SEMA5A* SNP rs42352
31	*GABRB1* 49 SNP	WAIS-R	*GABRB1* rs7435958 GG
32	*COMT* Val158Met rs4680 COMT		*COMT* Met *COMT* Val 2-back
35	*NTSR1* 5 SNP		2-back rs4334545 C rs6090453 G rs4334545 CT/TT CC
33	*COMT* Val158Met *DRD1* 1403C/T -48A/G *DRD2* TaqIA Taq1B *DRD3* Ser9Gly *DRD4* -C521T -G809A *DAT1* VNTR		*DRD2* TaqIA TaqIB *DRD3* Ser9Gly *DRD2* TaqIA
34	*BDNF* Val166Met rs6265 5-		*BDNF* Val BDNF Met
42	*DDC* 7 DDC 5-		*DCC* SNP rs3887825 rs7786398 rs10499695 rs6969081 rs7786398 rs10499695 rs6969081 SNP G-A-T DDC
36	*BDNF* Val166Met rs6265 5-		*BDNF* Met e *BDNF* Val166Met

	ꞡ ⲁ ˊ	Ό	ɛ
ꟷ [37]	*DBH* -1021C/T ⺊ 19bp Ins/Del *MAOA* 30bp VNTR *MAOB* rs1799836 ⺊ ã̃	ᵥ	*DBH* -19bp Ins/Del ꞡ ⺊ *MAOA* VNTR ꞡ ᵥ ΰ̈ П Ѝ ĕ
[40]	*MAOA* VNTR ╤ A ⺊ 5-	Ό	Ṿ *MAOA* 4r/4r ﯾ Љ 3r/3r ⺊ 3r/4r ﯾ “ ” ῄ ʿ щ І щ ˥ Ё Ḙ Ό
e [39]	*ADRA2B* ╤ ɱ ﯾ e á ɱ ﯾ ɱ	˥	ǫ AAGG/AAGG ﯾ ǫ ˥ SSRT Stop-signal reaction time Љ CCAC/AAGG ⺊ CCAC/CCAC ﯾ AAGG/AAGG ﯾ Љ Ḛ ﯾ ẹ ˥ Ό
e [41]	*5-HTR2A* 30 SNP ꞡ 5- ɱ 2A		╤Ӂ ш щ ﻧﻬ ف̄ Ό̄1 Ɗ

ӎ ε σ ᵛ ჳ Ѝ͓ ش e ǎ ã̃ Ë ĕ [46-48] ⅎ
ˀ Ë *5-HT1A* ̂ ⅎ ĕ
ệ Ë ã̃ [49-51] Ж ﺶ Ë e Э
ⅎ δ Ë δ Э ⅎ δ ⅎ W Ë

	ӈ ჳ ´	δ	ε
3	127 SNP ⅎ 2 VNTR ӈ ჳ 5- ⅎ ӎ	ﻬ ã̃ ♯ Ό I δ ǚ	ˀ 8 5- ã̃ *TPH2* *MAOA* *MAOB* *SLC6A4* *HTR2A* *HTR2C* *HTR5A* ⅎ *HTR6* 12 SNP ӈ δ ε HTR6 rs6658108 HTR5A rs732050 TPH2 rs1487275 *SLC6A4* rs8076005 ⅎ *HTR2C* rs2192371 ӈ δ ﻬ ã̃ ⅎ ♯ Ό I Ë δ 19% ӎ
45	5- ӎ └ 5-HTTLPR 5- ӎ	ⅎ Э ã̃ ̂	5-HTTLPR ش ӎ l/l ش ӎ ⅎ Э ệ͈ ῷ ㅁ͈ └ ⅎ ã̃ Ӂ ˺ s/s ش ӎ
44	5- ӎ └ 5-HTTLPR 5- ӎ	ⅎ e ˥ ã̃	Љ 5-HTTLPR l/l s/s HA ῷ ⅎ ͈ ῷ 5-HTTLPR HA ǚ ͈ ῷ ц e
57	5- ӎ └ 5-HTTLPR 5- ӎ	5- ȯ Ḫ Ǎ ǚ	l/l ش ӎ Ǎ ﺶ Ë ʿ м ⅎ s/s ش ӎ ჳ Ặ ʿ 5- ȯ Ḫ ӎ ĕ W Ë
46	*OXTR* rs53576 ӈ ᵘ T ӎ	♦ ӎ ε σ ᵈ ⅎ	*OXTR* rs53576 ӈ A ӈ e ӎ ε σ ᵈ Ḥ *OXTR* rs53576 ӈ ц Ë ♦ ӎ ε σ ᵈ ã̃ ã̃ ӎ ε σ ᵈ ц Ë *OXTR* rs53576 ӈ ã̃ ã̃

	ŋ ʅ ˊ	δ	ε
47	*OXTR* rs53576 ŋ T ɱ	ệ	Љ A/A ش ɱ G/G ش ɱ ệ ẹ ῷ Љ G/G ش ɱ A/A ش ɱ ẹ ệ ῷ ɱ ệ ệ ẫ ɱ Ἐ ẫ
48	*OXTR* rs53576 ŋ T ɱ	Ѝ ش e ắ ắ ẫ	A/A ش ɱ G ŋ Ѝ ش e ắ ẫ e A/A ش ɱ G/G ش ɱ ᴍ ắ
43	ẫ 96 SNP ŋ 2		ŋ Ë 18% Ł ɱ Ł ɱ ĕ
58	5- ɱ 5-HTTLPR 5- ɱ	ỵ	5-HTTLPR IGT Ł LAT ΄O ΄O ẏ s ŋ l ŋ IGT ῷ 40 ẹ δ Ë ỵ ĕ
59	*COMT* Val158Met rs4680 COMT ε Ṿ	ỵ ẫ ♯ ΄O I	♯ ΄O I *COMT* Met ŋ IGT ẫ *COMT*Val/Val ش IGT
60	*SLC6A4* 5-HTTLPR STin2 7 SNP ŋ 5- ɱ	OCS	5-HTTLPR l/l l/s ش s/s OCS *SLC6A4* 6 SNP ŋ ɱ ش OCS ẫ CGAAGG/CGAAGG ش Љ Ẹ ش ẹ Ḫ OCS δ W Ë
51	*5-HT1A* C-1019G rs6295 5- ɱ 1A		ŋ ẫ ῷ *5-HT1A* C-1019G ŋ ẫ CC ش Љ CG/GG ش Љ

σ

BDNF [73, 74]

e BDNF Val66Met

BDNF Val Val/Val Val/Met Met/Met

[28, 75] [76] BDNF Val66Met GSK3B

rs6782799 I MDD

BDNF CRHR1 MDD BDNF NTRK2

MDD [77, 78]

5- SSRI

20 29 e 5-HTTLPR HTR1A rs6295 I MDD [79]

5-HTTLPR S [80] 5-HTTLPR T

[81, 82] e [44, 45]

e [83] fMRI 5-HTTLPR

δ W 2 TPH2

5- TPH2 rs4570625

MDD TPH2 MDD [84]

MAOA DRD DBH COMT MDD

3.

ғ Ë ě [90, 91] MIR206 rs16882131 ﻝ *BDNF* Val166Met ﻍ BPD-I ﻝ ғ ŭ П Й ě MIR206 T/T+TC ﻝ *BDNF* A/A ﺵ ﻡ Љ MIR206 CC ﻝ *BDNF* A/A+A/G ﺵ ﻍ MIR206 CC ﻝ *BDNF* G/G ﺵ Ë *BDNF* ã *COMT* Val158Met ﻍ Ϛ δ BPD ○ ﻝ┐ e [92] Ë ﻍ e BDP ŭ ┐ ﻍ Met ﻍ BDP ○ Ẃ 5-HTTLPR ﻍ S ﻍ Ϛ BDP ○ [93] Ë BDgene [94] δ W Ë BPD ﻍ Ẹ / П ב ﻝ ﻍ

ệ δ ⱺ Ḏ ˥ Ό ⱺ δ ג Ẹ
ẵ Ë ẳ ᵦ Ë ẹ ΰ Ό ĕ Ɽ [22]
ΰ 90
δ ⱺ Ḏ Љ ˥ ш
ẇ ẳ ⱺ ệ ε
Љ Ό Ë
Ẹ ⱺ Ë ẳ Ë [138] ệ
ệ ˥ ĕ δ e
Љ e ẵ δ ΐ ε σ
ệ ג Љ [139] ệ
Љ δ ẵ ω
Ẹ ╤ Ḏ ῷ e δ ɱ Ë
Ɽ Ẋ W. S. Kremen e [140, 141] Ḏ
˥ ˪ ˅ ג ɱ ⱺ
ΰ א J. L. Stein GWAS Ḏ
[142] ג Ẹ δ ΰ Љ
ệ 80% Ғ ẵ ⱺ δ ẵ Љ
Ẹ Ό
ỏ GWAS ╤ Ḩ GWAS
[143~145] ệ GWAS ╤ Ẵ ŋ δ
ẵ ˥ ẵ ŋ ⱺ
ĕ e δ
δ Ë e δ ג
Ë ĕ ENIGMA CHARGE IMAGEN [146] e
δ ⱺ Љ ĕ ῷ ệ ĕ
Ë

Ḏ
˥ e δ ⱺ ɱ П δ
e δ ⱺ W Ë ῷ ˥ ⱺ

δ ﾑ Ḏ ᄀ ‟ δ

1 δ ‟ p

Ό δ T Ë ⱱ Ặ ẫ

‟ Ϛ ﾑ ᄀ ệ ‟ Ë

ǎ 5 10 δ

ш

2 e δ ﾑ Ḏ

ﾑ GWAS Љ e δ ﾑ щ Ẫ

Ẹ ═ δ Ḏ Љ δ Ἃ

Ḏ δ ɛ GWAS δ δ ﾑ

W

3 ĕ ᆪ ĕ ẵ GWAS

ﾑ Ḏ ﾑ Ë ʋ

ĕ δ ﾑ ẫ Ẹ

ĕ ﾑ δ

ẫ ĕ

4 - П Й ĕ - П Й ĕ x Љ

- - - δ Ë e δ ﾑ

ʋ П Й ĕ ᆪ П Й ĕ Ꝣ

╞ e ╒ ΰ 147

ῳ ệ Љ ш ﾑ - П Й ĕ

- П Й ĕ x

5 ᆪ Ẹ ш Љ

δ Ë ⱶ щ δ

ᆪ П ῳ ệ ┘

Ḩ ɱ ɱ Љ ᆨ Љ

Љ e щ Ḑ ﾑ ῃ ĕ

ﾑ ш

δ ﾑ Ḏ ш Љ ᄀ

ω ệ

T Ë ΰ ệ ʋ ĕ ﾑ П Ϛ

5 10 П ב ﾑ ĕ

ﾑ ǎ Ό δ ﾑ Ḏ

2014–2015

genetic material	◖ Э υ RNA Ẹ Æ ᶾ Å̃ ẹ Ė ڨ DNA
heritability	δ ⩘
gene polymorphism	Љ ɱ ŋ 2 ڨ e ɱ δ
ŋ allele	ℵ ʄ Ж█ ɱ Ϛ
ڨ genotype	ℵ ڨ ɱ Å̃ ᥰ ɱ ◖ щ ה Э Å̃ ⩘
╤ ɱ ڨ haplotype	ŋ Љ ɱ └ Ѝ ã̃ ᵊ Љ ɱ ╤ ℵ ╤ ɱ ڨ ╤ Ẃ ڨ
copy number variation CNV	˥ δ 1 kb ڛ ʽ Ἐ ε δ E ⩘
variable number of tandem repeats VNTR	ℵ ▲ DNA DNA δ 10 10 1000
linkage	Љ ŋ Љ ɱ ẹ ᵊ ŋ
ڨ phenotype	ɱ ʹ Ό ν ◖ ɱ δ ⩘ ẹ δ
gene frequency	█ Å̃ ŋ
susceptibility	ỵ Ë ɱ ˥ ỵ ɱ δ

1 ╝ Ặ ה J Ч ┘ 2012 44 3 331-333.

2 De Quervain D J, Papassotiropoulos A. Identification of a genetic cluster influencing memory performance and hippocampal activity in humans J . Proc Natl Acad Sci U S A, 2006, 103 11 4270-4274.

3 Chen C, Liu C, Chen C, et al. Genetic variations in the serotoninergic system and environmental factors contribute to aggressive behavior in Chinese adolescents J . Physiol Behav, 2015, 138 62-68.

4 Lee S H, Wray N R, Goddard M E, et al. Estimating missing heritability for disease from genome-wide association studies J . The American Journal of Human Genetics, 2011, 88 3 294-305.

5 Casamassima F, Hay A C, Benedetti A, et al. L Ļ type calcium channels and psychiatric disorders A brief review J .

American Journal of Medical Genetics Part B Neuropsychiatric Genetics, 2010, 153 8 1373-1390.

6 Ott J, Kamatani Y, Lathrop M. Family-based designs for genome-wide association studies J . Nature reviews Genetics, 2011, 12 7 465-474.

7 Suo C, Toulopoulou T, Bramon E, et al. Analysis of multiple phenotypes in genome-wide genetic mapping studies J . BMC bioinformatics, 2013, 14 151.

8 Zhang K, Chang S, Cui S, et al. ICSNPathway identify candidate causal SNPs and pathways from genome-wide association study by one analytical framework J . Nucleic acids research, 2011, 39 Web Server issue W437-443.

9 Zhang K, Cui S, Chang S, et al. i-GSEA4GWAS a web server for identification of pathways/gene sets associated with traits by applying an improved gene set enrichment analysis to genome-wide association study J . Nucleic acids research, 2010, 38 Web Server issue W90-95.

10 Bigos K L, Weinberger D R. Imaging genetics--days of future past J . Neuroimage, 2010, 53 3 804-809.

11 Heinz A, Goldman D, Jones D W, et al. Genotype influences in vivo dopamine transporter availability in human striatum J . Neuropsychopharmacol, 2000, 22 2 133-139.

12 Bookheimer S Y, Strojwas M H, Cohen M S, et al. Patterns of brain activation in people at risk for Alzheimer's disease J . N Engl J Med, 2000, 343 7 450-456.

13 Egan M F, Goldberg T E, Kolachana B S, et al. Effect of COMT Val108/158 Met genotype on frontal lobe function and risk for schizophrenia J . Proc Natl Acad Sci U S A, 2001, 98 12 6917-6922.

14 Hariri A R, Mattay V S, Tessitore A, et al. Serotonin transporter genetic variation and the response of the human amygdala J . Science, 2002, 297 5580 400-403.

15 Meyer-Lindenberg A, Nichols T, Callicott J H, et al. Impact of complex genetic variation in COMT on human brain function J . Mol Psychiatry, 2006, 11 9 867-877, 797.

16 Potkin S G, Turner J A, Fallon J A, et al. Gene discovery through imaging genetics identification of two novel genes associated with schizophrenia J . Mol Psychiatry, 2009, 14 4 416-428.

17 Pezawas L, Meyer-Lindenberg A, Goldman A L, et al. Evidence of biologic epistasis between BDNF and SLC6A4 and implications for depression J . Mol Psychiatry, 2008, 13 7 709-716.

18 Esslinger C, Walter H, Kirsch P, et al. Neural mechanisms of a genome-wide supported psychosis variant J . Science, 2009, 324 5927 605.

19 Nicodemus K K, Law A J, Radulescu E, et al. Biological validation of increased schizophrenia risk with NRG1, ERBB4, and AKT1 epistasis via functional neuroimaging in healthy controls J . Arch Gen Psychiatry, 2010, 67 10 991-1001.

20 Huang Y, Collier D, Li T. A Prospective Twin Registry in Southwestern China TRiSC exploring the effects of genetic and environmental factors on cognitive and behavioral development and mental health wellbeing in children and adolescents J . Twin Res Hum Genet, 2009, 12 3 312-319.

21 Chen J, Li X, Zhang J, et al. The Beijing Twin Study BeTwiSt a longitudinal study of child and adolescent development J . Twin Res Hum Genet, 2013, 16 1 91-97.

22 Zhu Q, Song Y, Hu S, et al. Heritability of the specific cognitive ability of face perception J . Curr Biol, 2010, 20 2 137-142.

23 Chen J, Li X, Natsuaki M N, et al. Genetic and environmental influences on depressive symptoms in Chinese adolescents J . Behav Genet, 2014, 44 1 36-44.

24 Li X, Mcgue M, Gottesman, Ii. Two sources of genetic liability to depression interpreting the relationship between stress sensitivity and depression under a multifactorial polygenic model J . Behav Genet, 2012, 42 2 268-277.

25 Chen J, Li X. Genetic and environmental influences on adolescent rumination and its association with depressive symptoms J . J Abnorm Child Psychol, 2013, 41 8 1289-1298.

26 Greenberg M E, Xu B, Lu B, et al. New insights in the biology of BDNF synthesis and release implications in CNS function J . J Neurosci, 2009, 29 41 12764-12767.

27 Martinowich K, Manji H, Lu B. New insights into BDNF function in depression and anxiety J . Nat Neurosci, 2007, 10 9 1089-1093.

28 Chen J, Li X, Mcgue M. The interacting effect of the BDNF Val66Met polymorphism and stressful life events on adolescent depression is not an artifact of gene-environment correlation evidence from a longitudinal twin study J . J Child Psychol Psychiatry, 2013, 54 10 1066-1073.

29 Deary I J, Johnson W, Houlihan L M. Genetic foundations of human intelligence J . Hum Genet, 2009, 126 1 215-232.

30 Zhu B, Chen C, Xue G, et al. The SEMA5A gene is associated with hippocampal volume, and their interaction is associated with performance on Raven's Progressive Matrices J . Neuroimage, 2013, 88C 181-187.

31 Zhu B, Chen C, Xue G, et al. The GABRB1 gene is associated with thalamus volume and modulates the association between thalamus volume and intelligence J . Neuroimage, 2014, 102 Pt 2 756-763.

32 Wang Y, Li J, Chen C, et al. COMT rs4680 Met is not always the 'smart allele' Val allele is associated with better working memory and larger hippocampal volume in healthy Chinese J . Genes Brain Behav, 2013, 12 3 323-329.

33 Gong P, Zhang H, Chi W, et al. An association study on the polymorphisms of dopaminergic genes with working memory in a healthy Chinese Han population J . Cell Mol Neurobiol, 2012, 32 6 1011-1019.

34 Gong P, Zheng A, Chen D, et al. Effect of BDNF Val66Met polymorphism on digital working memory and spatial localization in a healthy Chinese Han population J . J Mol Neurosci, 2009, 38 3 250-256.

35 Li J, Chen C, Chen C, et al. Neurotensin receptor 1 gene NTSR1 polymorphism is associated with working memory J . PLoS One, 2011, 6 3 e17365.

36 Gong P, Xi S, Li S, et al. Effect of Val66Met polymorphism in BDNF on attentional bias in an extroverted Chinese Han population J . Acta Neurobiol Exp Wars , 2013, 73 2 280-288.

37 Gong P, Xi S, Shen G, et al. The effects of DBH, MAOA, and MAOB on attentional biases for facial expressions J . J Mol Neurosci, 2013, 49 3 606-613.

38 Gong P, Zheng Z, Chi W, et al. An association study of the genetic polymorphisms in 13 neural plasticity-related genes with semantic and episodic memories J . J Mol Neurosci, 2012, 46 2 352-361.

39 Lei X, Chen C, He Q, et al. Haplotype polymorphism in the alpha-2B-adrenergic receptor gene influences response inhibition in a large Chinese sample J . Neuropsychopharmacol, 2012, 37 5 1115-1121.

40 Zhang M, Chen X, Way N, et al. The association between infants' self-regulatory behavior and MAOA gene polymorphism J . Dev Sci, 2011, 14 5 1059-1065.

41 Zhu B, Chen C, Loftus E F, et al. True but not false memories are associated with the HTR2A gene J . Neurobiol Learn Mem, 2013, 106 204-209.

42 Zhu B, Chen C, Moyzis R K, et al. The DOPA decarboxylase DDC gene is associated with alerting attention J . Prog Neuropsychopharmacol Biol Psychiatry, 2013, 43 140-145.

43 Zhu B, Chen C, Moyzis R K, et al. Genetic variations in the dopamine system and facial expression recognition in healthy chinese college students J . Neuropsychobiology, 2012, 65 2 83-89.

44 Ma Y, Li B, Wang C, et al. 5-HTTLPR polymorphism modulates neural mechanisms of negative self-reflection J . Cereb Cortex, 2014, 24 9 2421-2429.

45 Ma Y, Wang C, Li B, et al. Does self-construal predict activity in the social brain network A genetic moderation effect J . Soc Cogn Affect Neurosci, 2014, 9 9 1360-1367.

46 Luo S, Han S. The association between an oxytocin receptor gene polymorphism and cultural orientations J . Culture and Brain, 2014, 2 1 89-107.

47 Luo S, Li B, Ma Y, et al. Oxytocin receptor gene and racial ingroup bias in empathy-related brain activity J . Neuroimage, 2015, 110 22-31.

48 Luo S, Ma Y, Liu Y, et al. Interaction between oxytocin receptor polymorphism and interdependent culture values on

human empathy J . Social cognitive and affective neuroscience, 2015, nsv019.

49 Gong P, Liu J, Li S, et al. Dopamine beta-hydroxylase gene modulates individuals' empathic ability J . Soc Cogn Affect Neurosci, 2014, 9 9 1341-1345.

50 Gong P, Liu J, Li S, et al. Serotonin receptor gene 5-HT1A modulates alexithymic characteristics and attachment orientation J . Psychoneuroendocrino, 2014, 50 274-279.

51 Liu J, Gong P, Zhou X. The association between romantic relationship status and 5-HT1A gene in young adults J . Sci Rep, 2014, 4 7049.

52 Li M, Chen J, Li N, et al. A twin study of problematic internet use its heritability and genetic association with effortful control J . Twin Res Hum Genet, 2014, 17 4 279-287.

53 Chow B W, Ho C S, Wong S W, et al. Generalist genes and cognitive abilities in Chinese twins J . Dev Sci, 2013, 16 2 260-268.

54 Hou J, Chen Z, Natsuaki M N, et al. A longitudinal investigation of the associations among parenting, deviant peer affiliation, and externalizing behaviors a monozygotic twin differences design J . Twin Res Hum Genet, 2013, 16 3 698-706.

55 Chen J, Li X. Genetic and environmental etiologies of adolescent dysfunctional attitudes a twin study J . Twin Res Hum Genet, 2014, 17 1 16-22.

56 Chen J, Yu J, Li X, et al. Genetic and environmental contributions to anxiety among Chinese children and adolescents - a multi-informant twin study J . J Child Psychol Psychiatry, 2014.

57 Ma Y, Li B, Wang C, et al. Allelic variation in 5-HTTLPR and the effects of citalopram on the emotional neural network J . The British Journal of Psychiatry, 2015, 206 5 385-392.

58 He Q, Xue G, Chen C, et al. Serotonin transporter gene-linked polymorphic region 5-HTTLPR influences decision making under ambiguity and risk in a large Chinese sample J . Neuropharmacology, 2010, 59 6 518-526.

59 He Q, Xue G, Chen C, et al. COMT Val158Met polymorphism interacts with stressful life events and parental warmth to influence decision making J . Sci Rep, 2012, 2 677.

60 Lei X, Chen C, He Q, et al. Sex determines which section of the SLC6A4 gene is linked to obsessive-compulsive symptoms in normal Chinese college students J . J Psychiatr Res, 2012, 46 9 1153-1160.

61 Wu N, Li Z, Su Y. The association between oxytocin receptor gene polymorphism OXTR and trait empathy J . J Affect Disord, 2012, 138 3 468-472.

62 Xia H, Wu N, Su Y. Investigating the genetic basis of theory of mind ToM the role of catechol-O-methyltransferase COMT gene polymorphisms J . PLoS One, 2012, 7 11 e49768.

63 Wood A C, Rijsdijk F, Saudino K J, et al. High heritability for a composite index of children's activity level measures J . Behav Genet, 2008, 38 3 266-276.

64 Gizer I R, Ficks C, Waldman I D. Candidate gene studies of ADHD a meta-analytic review J . Hum Genet, 2009, 126 1 51-90.

65 Guan L, Wang B, Chen Y, et al. A high-density single-nucleotide polymorphism screen of 23 candidate genes in attention deficit hyperactivity disorder suggesting multiple susceptibility genes among Chinese Han population J . Mol Psychiatry, 2009, 14 5 546-554.

66 Qian Q J, Yang L, Wang Y F, et al. Gene-gene interaction between COMT and MAOA potentially predicts the intelligence of attention-deficit hyperactivity disorder boys in China J . Behav Genet, 2010, 40 3 357-365.

67 Li H, Liu L, Tang Y, et al. Sex-specific association of brain-derived neurotrophic factor BDNF Val66Met polymorphism and plasma BDNF with attention-deficit/hyperactivity disorder in a drug-naive Han Chinese sample J . Psychiatry Res, 2014, 217 3 191-197.

68 Liu L, Guan L L, Chen Y, et al. Association analyses of MAOA in Chinese Han subjects with attention-deficit/hyperactivity disorder family-based association test, case-control study, and quantitative traits of impulsivity J .

Am J Med Genet B Neuropsychiatr Genet, 2011, 156B 6 737-748.

69 Li Y, Baker-Ericzen M, Ji N, et al. Do SNPs of DRD4 gene predict adult persistence of ADHD in a Chinese sample J . Psychiatry Res, 2013, 205 1-2 143-150.

70 Yang L, Qian Q, Liu L, et al. Adrenergic neurotransmitter system transporter and receptor genes associated with atomoxetine response in attention-deficit hyperactivity disorder children J . J Neural Transm, 2013, 120 7 1127-1133.

71 Wu J, Xiao H, Sun H, et al. Role of dopamine receptors in ADHD a systematic meta-analysis J . Mol Neurobiol, 2012, 45 3 605-620.

72 Sullivan P F, Neale M C, Kendler K S. Genetic epidemiology of major depression review and meta-analysis J . The American journal of psychiatry, 2000, 157 10 1552-1562.

73 Lu B, Gottschalk W. Modulation of hippocampal synaptic transmission and plasticity by neurotrophins J . Prog Brain Res, 2000, 128 231-241.

74 Nibuya M, Morinobu S, Duman R S. Regulation of BDNF and trkB mRNA in rat brain by chronic electroconvulsive seizure and antidepressant drug treatments J . J Neurosci, 1995, 15 11 7539-7547.

75 Chen J, Li X, Mcgue M. Interacting effect of BDNF Val66Met polymorphism and stressful life events on adolescent depression J . Genes, brain, and behavior, 2012.

76 Yang C, Xu Y, Sun N, et al. The combined effects of the BDNF and GSK3B genes modulate the relationship between negative life events and major depressive disorder J . Brain research, 2010, 1355 1-6.

77 Li Z, Zhang Y, Wang Z, et al. The role of BDNF, NTRK2 gene and their interaction in development of treatment-resistant depression data from multicenter, prospective, longitudinal clinic practice J . Journal of psychiatric research, 2013, 47 1 8-14.

78 Xiao Z, Liu W, Gao K, et al. Interaction between CRHR1 and BDNF genes increases the risk of recurrent major depressive disorder in Chinese population J . PloS One, 2011, 6 12 e28733.

79 Zhang K, Xu Q, Xu Y, et al. The combined effects of the 5-HTTLPR and 5-HTR1A genes modulates the relationship between negative life events and major depressive disorder in a Chinese population J . J Affect Disord, 2009, 114 1-3 224-231.

80 Gao Z, Yuan H, Sun M, et al. The association of serotonin transporter gene polymorphism and geriatric depression a meta-analysis J . Neurosci Lett, 2014, 578 148-152.

81 Fang J, Yan W, Jiang G X, et al. Serotonin transporter gene polymorphism in Chinese patients with poststroke depression a case-control study J . Stroke, 2011, 42 5 1461-1463.

82 Xu H, Zhang Q, Hou X, et al. The effect of the polymorphisms of 5-HTTLPR on new onset of depression in patients who underwent pacemaker implantation J . Psychiatr Genet, 2014, 24 2 70-74.

83 Fang Z, Zhu S, Gillihan S J, et al. Serotonin transporter genotype modulates functional connectivity between amygdala and PCC/PCu during mood recovery J . Front Hum Neurosci, 2013, 7 704.

84 Gao J, Pan Z, Jiao Z, et al. TPH2 gene polymorphisms and major depression--a meta-analysis J . PLoS One, 2012, 7 5 e36721.

85 Domschke K, Dannlowski U. Imaging genetics of anxiety disorders J . Neuroimage, 2010, 53 3 822-831.

86 Chi S, Teng L, Song J H, et al. Tryptophan hydroxylase 2 gene polymorphisms and poststroke anxiety disorders J . J Affect Disord, 2013, 144 1-2 179-182.

87 Long H, Liu B, Hou B, et al. The long rather than the short allele of 5-HTTLPR predisposes Han Chinese to anxiety and reduced connectivity between prefrontal cortex and amygdala J . Neurosci Bull, 2013, 29 1 4-15.

88 Zhang L, Liu L, Li X, et al. Serotonin transporter gene polymorphism 5Ļ HTTLPR influences trait anxiety by modulating the functional connectivity between the amygdala and insula in Han Chinese males J . Hum Brain Mapp, 2015.

89 Cadoret R J. Evidence for genetic inheritance of primary affective disorder in adoptees J . Am J Psychiatry, 1978, 135 4 463-466.

90 Xu J, Liu Y, Wang P, et al. Positive association between the brain-derived neurotrophic factor BDNF gene and bipolar disorder in the Han Chinese population J . Am J Med Genet B Neuropsychiatr Genet, 2010, 153B 1 275-279.

91 Wang Z, Li Z, Chen J, et al. Association of BDNF gene polymorphism with bipolar disorders in Han Chinese population J . Genes Brain Behav, 2012, 11 5 524-528.

92 Wang Z, Zhang C, Huang J, et al. MiRNA-206 and BDNF genes interacted in bipolar I disorder J . J Affect Disord, 2014, 162 116-119.

93 Jiang H Y, Qiao F, Xu X F, et al. Meta-analysis confirms a functional polymorphism 5-HTTLPR in the serotonin transporter gene conferring risk of bipolar disorder in European populations J . Neurosci Lett, 2013, 549 191-196.

94 Chang S H, Gao L, Li Z, et al. BDgene a genetic database for bipolar disorder and its overlap with schizophrenia and major depressive disorder J . Biological psychiatry, 2013, 74 10 727-733.

95 Li X, Hu Z, He Y, et al. Association analysis of CNTNAP2 polymorphisms with autism in the Chinese Han population J . Psychiatr Genet, 2010, 20 3 113-117.

96 Zhou X, Xu Y, Wang J, et al. Replication of the association of a MET variant with autism in a Chinese Han population J . PLoS One, 2011, 6 11 e27428.

97 Liu Y, Hu Z, Xun G, et al. Mutation analysis of the NRXN1 gene in a Chinese autism cohort J . J Psychiatr Res, 2012, 46 5 630-634.

98 Guo T, Chen H, Liu B, et al. Methylenetetrahydrofolate reductase polymorphisms C677T and risk of autism in the Chinese Han population J . Genet Test Mol Biomarkers, 2012, 16 8 968-973.

99 Bi C, Wu J, Jiang T, et al. Mutations of ANK3 identified by exome sequencing are associated with autism susceptibility J . Hum Mutat, 2012, 33 12 1635-1638.

100 Yang Y, Pan C. Role of metabotropic glutamate receptor 7 in autism spectrum disorders a pilot study J . Life Sci, 2013, 92 2 149-153.

101 Tian P. RELN gene polymorphisms and susceptibility to autism in Chinese Han population J . Neurol India, 2012, 60 6 581-584.

102 Wang L, Li J, Ruan Y, et al. Sequencing ASMT identifies rare mutations in Chinese Han patients with autism J . PLoS One, 2013, 8 1 e53727.

103 Shao S, Xu S, Yang J, et al. A commonly carried genetic variant, rs9616915, in SHANK3 gene is associated with a reduced risk of autism spectrum disorder replication in a Chinese population J . Mol Biol Rep, 2014, 41 3 1591-1595.

104 Xu X, Xiong Z, Zhang L, et al. Variations analysis of NLGN3 and NLGN4X gene in Chinese autism patients J . Mol Biol Rep, 2014, 41 6 4133-4140.

105 ys } / S /S /

1 i 4 asson :

1 4 5

1 4

109 Yang W, Liu J, Zheng F, et al. The evidence for association of ATP2B2 polymorphisms with autism in Chinese Han population J . PloS one, 2013, 8 4 e61021.

110 Xu L M, Li J R, Huang Y, et al. AutismKB an evidence-based knowledgebase of autism genetics J . Nucleic acids research, 2012, 40 Database issue D1016-1022.

111 Sullivan P F, Kendler K S, Neale M C. Schizophrenia as a complex trait evidence from a meta-analysis of twin studies J . Arch Gen Psychiat, 2003, 60 12 1187-1192.

112 Li M, Luo X J, Xiao X, et al. Allelic differences between Han Chinese and Europeans for functional variants in ZNF804A and their association with schizophrenia J . Am J Psychiatry, 2011, 168 12 1318-1325.

113 Li M, Shi C J, Shi Y Y, et al. ZNF804A and schizophrenia susceptibility in Asian populations J . Am J Med Genet B Neuropsychiatr Genet, 2012, 159B 7 794-802.

114 Li M, Zhang H, Luo X J, et al. Meta-analysis indicates that the European GWAS-identified risk SNP rs1344706 within ZNF804A is not associated with schizophrenia in Han Chinese population J . PLoS One, 2013, 8 6 e65780.

115 Yang Y, Li W, Yang G, et al. Evaluation of the relationship between the ZNF804A single nucleotide polymorphism rs1344706 A/C variant and schizophrenia subtype in Han Chinese patients J . Int J Psychiatry Med, 2013, 45 3 269-278.

116 Zhou D H, Yan Q Z, Yan X M, et al. The study of BDNF Val66Met polymorphism in Chinese schizophrenic patients J . Prog Neuropsychopharmacol Biol Psychiatry, 2010, 34 6 930-933.

117 Yi Z, Zhang C, Wu Z, et al. Lack of effect of brain derived neurotrophic factor BDNF Val66Met polymorphism on early onset schizophrenia in Chinese Han population J . Brain Res, 2011, 1417 146-150.

118 Lu W, Zhang C, Yi Z, et al. Association between BDNF Val66Met polymorphism and cognitive performance in antipsychotic-naive patients with schizophrenia J . J Mol Neurosci, 2012, 47 3 505-510.

119 Li W, Zhou N, Yu Q, et al. Association of BDNF gene polymorphisms with schizophrenia and clinical symptoms in a Chinese population J . Am J Med Genet B Neuropsychiatr Genet, 2013, 162B 6 538-545.

120 Zhai J, Yu Q, Chen M, et al. Association of the brain-derived neurotrophic factor gene G196A rs6265 polymorphisms and the cognitive function and clinical symptoms of schizophrenia J . Int J Clin Exp Pathol, 2013, 6 8 1617-1623.

121 Wang Y, Fang Y, Shen Y, et al. Analysis of association between the catechol-O-methyltransferase COMT gene and negative symptoms in chronic schizophrenia J . Psychiatry Res, 2010, 179 2 147-150.

122 Li W J, Kou C G, Yu Y, et al. Association of catechol-O-methyltransferase gene polymorphisms with schizophrenia and negative symptoms in a Chinese population J . Am J Med Genet B Neuropsychiatr Genet, 2012, 159B 4 370-375.

123 Liu X, Hong X, Chan R C, et al. Association study of polymorphisms in the alpha 7 nicotinic acetylcholine receptor subunit and catechol-o-methyl transferase genes with sensory gating in first-episode schizophrenia J . Psychiatry Res, 2013, 209 3 431-438.

124 Hui L, Zhang X, Huang X F, et al. The dopamine b-hydroxylase 19 bp insertion/deletion polymorphism was associated with first-episode but not medicated chronic schizophrenia J . J Psychiatr Res, 2012, 46 6 733-737.

125 Hui L, Zhang X, Yu Y Q, et al. Association between DBH 19 bp insertion/deletion polymorphism and cognition in first-episode schizophrenic patients J . Schizophr Res, 2013, 147 2-3 236-240.

126 Lai J H, Zhu Y S, Huo Z H, et al. Association study of polymorphisms in the promoter region of DRD4 with schizophrenia, depression, and heroin addiction J . Brain Res, 2010, 1359 227-232.

127 Zhang F, Fan H, Xu Y, et al. Converging evidence implicates the dopamine D3 receptor gene in vulnerability to schizophrenia J . Am J Med Genet B Neuropsychiatr Genet, 2011, 156B 5 613-619.

128 Xiao L, Shen T, Peng D H, et al. Functional -141C Ins/Del polymorphism in the dopamine D2 receptor gene

promoter and schizophrenia in a Chinese Han population J . J Int Med Res, 2013, 41 4 1171-1178.

129 Pan Y, Yao J, Wang B. Association of dopamine D1 receptor gene polymorphism with schizophrenia a meta-analysis J . Neuropsychiatr Dis Treat, 2014, 10 1133-1139.

130 Wei Y L, Li C X, Li S B, et al. Association study of monoamine oxidase A/B genes and schizophrenia in Han Chinese J . Behav Brain Funct, 2011, 7 42.

131 Sun Y, Zhang J, Yuan Y, et al. Study of a possible role of the monoamine oxidase A MAOA gene in paranoid schizophrenia among a Chinese population J . Am J Med Genet B Neuropsychiatr Genet, 2012, 159B 1 104-111.

132 Zhang R, Zhang H, Li M, et al. Genetic analysis of common variants in the CMYA5 cardiomyopathy-associated 5 gene with schizophrenia J . Prog Neuropsychopharmacol Biol Psychiatry, 2013, 46 64-69.

133 Gu L Z, Jiang T, Cheng Z H, et al. rs11098403 polymorphism near NDST3 is associated with a reduced risk of schizophrenia in a Han Chinese population J . Neurosci Lett, 2014, 581 42-45.

134 Luo X J, Li M, Huang L, et al. Convergent lines of evidence support CAMKK2 as a schizophrenia susceptibility gene J . Mol Psychiatry, 2014, 19 7 774-783.

135 Wong E H, So H C, Li M, et al. Common variants on Xq28 conferring risk of schizophrenia in Han Chinese J . Schizophr Bull, 2014, 40 4 777-786.

136 Zhang B, Xu Y H, Wei S G, et al. Association study identifying a new susceptibility gene AUTS2 for schizophrenia J . International journal of molecular sciences, 2014, 15 11 19406-19416.

137 Ji W, Li T, Pan Y, et al. CNTNAP2 is significantly associated with schizophrenia and major depression in the Han Chinese population J . Psychiatry research, 2013, 207 3 225-228.

138 Aimone J B, Li Y, Lee S W, et al. Regulation and function of adult neurogenesis from genes to cognition J . Physiol Rev, 2014, 94 4 991-1026.

139 Egan M F, Kojima M, Callicott J H, et al. The BDNF val66met polymorphism affects activity-dependent secretion of BDNF and human memory and hippocampal function J . Cell, 2003, 112 2 257-269.

140 Kremen W S, Prom-Wormley E, Panizzon M S, et al. Genetic and environmental influences on the size of specific brain regions in midlife the VETSA MRI study J . Neuroimage, 2010, 49 2 1213-1223.

141 Rimol L M, Panizzon M S, Fennema-Notestine C, et al. Cortical thickness is influenced by regionally specific genetic factors J . Biol Psychiatry, 2010, 67 5 493-499.

142 Stein J L, Medland S E, Vasquez A A, et al. Identification of common variants associated with human hippocampal and intracranial volumes J . Nat Genet, 2012, 44 5 552-561.

143 Chaste P, Klei L, Sanders S J, et al. A Genome-wide Association Study of Autism Using the Simons Simplex Collection Does Reducing Phenotypic Heterogeneity in Autism Increase Genetic Homogeneity? J . Biol Psychiatry, 2014,

144 Hibar D P, Stein J L, Kohannim O, et al. Voxelwise gene-wide association study vGeneWAS multivariate gene-based association testing in 731 elderly subjects J . Neuroimage, 2011, 56 4 1875-1891.

145 Yang J, Benyamin B, Mcevoy B P, et al. Common SNPs explain a large proportion of the heritability for human height J . Nat Genet, 2010, 42 7 565-569.

146 Medland S E, Jahanshad N, Neale B M, et al. Whole-genome analyses of whole-brain data working within an expanded search space J . Nat Neurosci, 2014, 17 6 791-800.

147 International Schizophrenia C, Purcell S M, Wray N R, et al. Common polygenic variation contributes to risk of schizophrenia and bipolar disorder J . Nature, 2009, 460 7256 748-752.