**Supporting information - Shared genetic basis between genetic generalized epilepsy and background EEG oscillations**

Remi Stevelink, MD, MSc 1,2,\*, Jurjen J. Luykx MD, PhD3,4,5,\*,#, Bochao D. Lin, PhD3,4, Costin Leu, PhD6, Dennis Lal, PhD6, Alexander Smith, MA6, Dick Schijven, PhD3,4, Johannes A. Carpay, MD, PhD7, Koen Rademaker, BSc3, Roiza A. Rodrigues Baldez, MD8, Orrin Devinsky9, MD, Kees P.J. Braun MD, PhD2, Floor E. Jansen, MD, PhD2, ILAE Consortium on Complex Epilepsies, Epi25 Collaborative, Dirk Smit PhD10,@ & Bobby P.C. Koeleman, PhD1,@

1Department of Genetics, UMC Utrecht Brain Center, University Medical Center Utrecht, Utrecht University, Utrecht, the Netherlands

2Department of Neurology, UMC Utrecht Brain Center, University Medical Center Utrecht, Utrecht University, Utrecht, the Netherlands

3Department of Psychiatry, UMC Utrecht Brain Center, University Medical Center Utrecht, Utrecht University, Utrecht, the Netherlands;

4Department of Translational Neuroscience, UMC Utrecht Brain Center, University Medical Center Utrecht, Utrecht University, Utrecht, The Netherlands

5GGNet Mental Health, Apeldoorn, the Netherlands

6Broad Institute of Harvard and MIT, Cambridge, Massachussets, USA.

7Department of Neurology, Tergooi Hospital, Hilversum, the Netherlands

8 Clinical Research Laboratory on Neuroinfectious Diseases, Evandro Chagas Clinical Research Institute (IPEC), Fundação Oswaldo Cruz (FIOCRUZ), Rio de Janeiro, RJ, Brazil

9  Comprehensive Epilepsy Center, New York University School of Medicine, New York, NY 10016, USA.  
10 Psychiatry department, Amsterdam Neuroscience, Amsterdam University Medical Center, location AMC, The Netherlands.

\* These authors contributed equally to this work;

@ These authors jointly directed this work.

# To whom correspondence should be addressed at:

Jurjen Luykx, Department of Psychiatry, Brain Center Rudolf Magnus, University Medical Center Utrecht, Utrecht University, Utrecht, the Netherlands; Email: [J.Luykx@umcutrecht.nl](mailto:J.Luykx@umcutrecht.nl)

**Supporting materials**

**Supplementary Table 1**

**Number of SNPs tested per LDSC genetic correlation analysis.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Epilepsy phenotype | Alpha | Beta | Delta | Theta |
| ILAE focal | 842636 | 843077 | 842616 | 842616 |
| ILAE GGE | 842636 | 843077 | 842616 | 842616 |
| ILAE CAE | 864641 | 863614 | 863614 | 863614 |
| ILAE JAE | 864641 | 863614 | 863614 | 863614 |
| ILAE JME | 864641 | 863614 | 863614 | 863614 |
| ILAE GTCS | 864641 | 863614 | 863614 | 863614 |
| Epi25 focal | 288911 | 288902 | 288902 | 288902 |
| Epi25 GGE | 288911 | 288902 | 288902 | 288902 |

**Supplementary Table 2**

*How all EEG power spectra are correlated may be found in this correlation matrix of Spearman correlations (N=8,425). All p-values were well below e-17.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Delta | Theta | Alpha | Beta |
| Delta | 1 |  |  |  |
| Theta | 0.7002 | 1 |  |  |
| Alpha | 0.3004 | 0.5422 | 1 |  |
| Beta | 0.4232 | 0.5247 | 0.6252 | 1 |

**Supplemental Table 3**

*Summary table of LDSC genetic correlation analyses (p1=phenotype 1; p2=phenotype 2; rg=genetic correlation; se=standard error; z=z-score; p=p-value; h2\_obs, h2\_obs\_se=observed scale h2 for phenotype 2 and standard error; h2\_int, h2\_int\_se=single-trait LD Score regression intercept for phenotype 2 and standard error; gcov\_int\_se=cross-trait LD Score regression intercept and standard error. Note: Focal epilepsy showed low SNP heritability and z-score<2, which makes the genetic correlation estimates less reliable.*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| p1 | p2 | rg | se | z | p | h2\_obs | h2\_obs\_se | h2\_int | h2\_int\_se | gcov\_int | gcov\_int\_se |
| alpha | All epilepsy | 0.0591 | 0.1286 | 0.4595 | 0.6459 | 0.1327 | 0.0202 | 1.1693 | 0.0125 | 0.0032 | 0.007 |
| alpha | *Focal epilepsy* | *-0.1652* | *0.2784* | *-0.5934* | *0.5529* | *0.0356* | *0.0206* | *1.1704* | *0.0107* | *0.0008* | *0.0069* |
| alpha | GGE | 0.1569 | 0.107 | 1.4664 | 0.1426 | 0.323 | 0.033 | 1.1036 | 0.0134 | 0.005 | 0.0078 |
| alpha | CAE | 0.1274 | 0.1731 | 0.7361 | 0.4617 | 1.005 | 0.22 | 1.0724 | 0.0107 | 0.0106 | 0.007 |
| alpha | JAE | -0.041 | 0.22 | -0.1863 | 0.8522 | 1.1673 | 0.3377 | 1.0486 | 0.0094 | 0.0096 | 0.0074 |
| alpha | JME | 0.2879 | 0.1414 | 2.0358 | 0.0418 | 1.0461 | 0.1711 | 1.0551 | 0.0118 | -0.0031 | 0.0074 |
| alpha | GTCS | 0.0085 | 0.217 | 0.0391 | 0.9688 | 1.8076 | 0.5777 | 1.0297 | 0.0096 | 0.002 | 0.0064 |
| beta | All epilepsy | 0.3032 | 0.1895 | 1.5996 | 0.1097 | 0.1326 | 0.0202 | 1.1694 | 0.0125 | -0.0056 | 0.0075 |
| beta | *Focal epilepsy* | *0.1414* | *0.3661* | *0.3861* | *0.6994* | *0.0356* | *0.0206* | *1.1704* | *0.0107* | *-0.0052* | *0.0069* |
| beta | GGE | 0.4436 | 0.1766 | 2.5124 | **0.012** | 0.3229 | 0.033 | 1.1036 | 0.0134 | -0.004 | 0.0075 |
| beta | CAE | 0.3906 | 0.2376 | 1.6439 | 0.1002 | 1.0047 | 0.2197 | 1.0724 | 0.0107 | 0.0043 | 0.0065 |
| beta | JAE | 0.4928 | 0.304 | 1.6212 | 0.105 | 1.1689 | 0.3375 | 1.0485 | 0.0094 | -0.0038 | 0.0069 |
| beta | JME | 0.5568 | 0.2197 | 2.5341 | **0.0113** | 1.0463 | 0.1711 | 1.055 | 0.0118 | -0.0085 | 0.0071 |
| beta | GTCS | -0.0771 | 0.3153 | -0.2445 | 0.8068 | 1.8064 | 0.5784 | 1.0297 | 0.0096 | 0.0117 | 0.0067 |
| delta | All epilepsy | 0.1162 | 0.1604 | 0.7245 | 0.4688 | 0.1326 | 0.0202 | 1.1694 | 0.0125 | -0.009 | 0.0072 |
| delta | *Focal epilepsy* | *0.0798* | *0.3192* | *0.2498* | *0.8027* | *0.0356* | *0.0206* | *1.1704* | *0.0107* | *-0.0084* | *0.0071* |
| delta | GGE | 0.1392 | 0.1237 | 1.1256 | 0.2603 | 0.3229 | 0.033 | 1.1036 | 0.0134 | -0.0069 | 0.0074 |
| delta | CAE | 0.0007 | 0.1829 | 0.0041 | 0.9967 | 1.0047 | 0.2197 | 1.0724 | 0.0107 | -0.0019 | 0.0066 |
| delta | JAE | -0.0654 | 0.2071 | -0.3158 | 0.7521 | 1.1689 | 0.3375 | 1.0485 | 0.0094 | -0.0003 | 0.0068 |
| delta | JME | 0.2014 | 0.1579 | 1.2756 | 0.2021 | 1.0463 | 0.1711 | 1.055 | 0.0118 | -0.0071 | 0.0073 |
| delta | GTCS | 0.0742 | 0.2609 | 0.2843 | 0.7762 | 1.8064 | 0.5784 | 1.0297 | 0.0096 | -0.0055 | 0.0066 |
| theta | All epilepsy | 0.2269 | 0.1271 | 1.7848 | 0.0743 | 0.1326 | 0.0202 | 1.1694 | 0.0125 | -0.0099 | 0.007 |
| theta | *Focal epilepsy* | *0.0757* | *0.2926* | *0.2587* | *0.7958* | *0.0356* | *0.0206* | *1.1704* | *0.0107* | *-0.0073* | *0.0073* |
| theta | GGE | 0.2498 | 0.1058 | 2.36 | 0.0183 | 0.3229 | 0.033 | 1.1036 | 0.0134 | -0.0034 | 0.007 |
| theta | CAE | 0.2615 | 0.1874 | 1.3952 | 0.163 | 1.0047 | 0.2197 | 1.0724 | 0.0107 | -0.002 | 0.007 |
| theta | JAE | -0.0099 | 0.1943 | -0.0508 | 0.9595 | 1.1689 | 0.3375 | 1.0485 | 0.0094 | 0.0056 | 0.007 |
| theta | JME | 0.2838 | 0.1344 | 2.112 | 0.0347 | 1.0463 | 0.1711 | 1.055 | 0.0118 | -0.0082 | 0.0068 |
| theta | GTCS | 0.0438 | 0.2376 | 0.1842 | 0.8539 | 1.8064 | 0.5784 | 1.0297 | 0.0096 | 0.0017 | 0.0067 |

**Supplemental Table 4.**

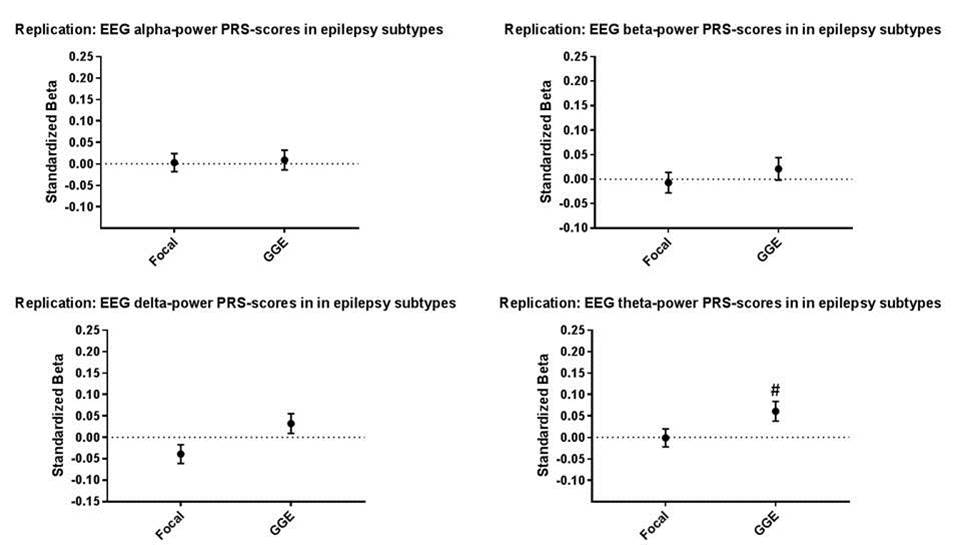
Mendelian Randomization results (in bold: significant results after multiple testing correction).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Outcome | Model | N instrument | N\* | OR (95%CI) | P |
| Alpha | IVW-fixed | 8 | 5 | 1.470(0.935-2.312) | 0.095 |
| Weighted median | 8 | 5 | 2.017(1.069-3.808) | 0.031 |
| MR egger | 8 | 5 | 0 (0-182.998) | 0.546 |
| MR egger (intercept) | 8 | 5 | 0.053 ± 0.068 | 0.487 |
| GSMR (r2<0.01) | 8 | 5 | 1.473 (0.927-2.339) | 0.101 |
| GSMR (r2<0.1) | 11 | 7 | 1.173(0.820-1.678) | 0.381 |
| GSMR (r2<0.15) | 12 | 8 | 1.238 (0.874-1.755) | 0.228 |
| GSMR (r2<0.2) | 14 | 9 | 1.346 (0.953-1.900) | 0.091 |
| Beta | IVW-fixed | 8 | 5 | 1.454 (0.925-2.286) | 0.105 |
| Weighted median | 8 | 5 | 1.270 (0.624-2.583) | 0.509 |
| MR egger | 8 | 5 | 0.003 (0-69.362) | 0.297 |
| MR egger (intercept) | 8 | 5 | 0.108 ± 0.089 | 0.269 |
| GSMR (r2<0.01) | 8 | 5 | 1.456 (0.920-2.303) | 0.108 |
| GSMR (r2<0.1) | 11 | 6 | 1.572 (1.049-2.355) | 0.028 |
| **GSMR (r2<0.15)** | **12** | **8** | **1.79 (1.189-2.707)** | **0.0052** |
| **GSMR (r2<0.2)** | **14** | **9** | **1.723 (1.180-2.516)** | **0.0048** |
| Delta | IVW-fixed | 8 | 5 | 1.387 (0.88292.181) | 0.156 |
| Weighted median | 8 | 5 | 1.064 (0.551-2.057) | 0.852 |
| MR egger | 8 | 5 | 0.035 (0-225.458) | 0.481 |
| MR egger (intercept) | 8 | 5 | 0.064± 0.077 | 0.441 |
| GSMR (r2<0.01) | 8 | 5 | 1.387 (0.882-2.181) | 0.156 |
| GSMR (r2<0.1) | 11 | 7 | 1.295 (0.906-1.849) | 0.154 |
| GSMR (r2<0.15) | 12 | 8 | 1.360 (0.958-1.931) | 0.085 |
| GSMR (r2<0.2) | 14 | 8 | 1.360 (0.958-1.932) | 0.085 |
| Theta | IVW-fixed | 8 | 6 | 1.322 (0.841-2.078) | 0.227 |
| Weighted median | 8 | 6 | 1.242 (0.707-2.181) | 0.450 |
| MR egger | 8 | 6 | 0.038 (0-25.341) | 0.363 |
| MR egger (intercept) | 8 | 6 | 0.061±0.057 | 0.324 |
| GSMR (r2<0.01) | 8 | 6 | 1.322 (0.839-2.082) | 0.228 |
| GSMR (r2<0.1) | 11 | 9 | 1.313 (0.917-1.881) | 0.137 |
| GSMR (r2<0.15) | 12 | 10 | 1.434 (1.006-2.045) | 0.046 |
| GSMR (r2<0.2) | 14 | 10 | 1.431 (1.010-2.027) | 0.044 |

Note: N\* is the number of instrumental SNPs have same direction of effects on both exposure (epilepsy) and outcome (EEG).

**Supplemental Figure 1**

*Polygenic risk score (PRS) analyses results in the Epi25 replication cohort. All directions of effect agreed with the PRS analyses in the discovery cohort. Theta-power PRSs were most strongly associated with GGE in this replication cohort (p=0.008).*



**Supplemental Figure 2**

*Scatter plot of instrumental SNPs associated with generalized epilepsy against EEG alpha, delta and theta oscillations. The instrumental variables passed the Heterogeneity in Dependent Instruments (HEIDI) testing for instrumental outliers from GSMR detection with multiple LD prune thresholds. Lines in red, yellow, light green and dark green represent β for fixed effect IVW, weighted median, MR Egger, and GSMR models using 8 instruments (r2<0.01). The lines in blue purple and pink represent βs from GSMR model with 11 (r2<0.1), 12 (r2<0.15)and 14 (r2<0.2) instruments in GSMR.* 



**Appendix**: ILAE consortium author names:

The International League Against Epilepsy Consortium on Complex Epilepsies

*Members listed in alphabetical order:*

Bassel Abou-Khalil1, Pauls Auce2, 3, Andreja Avbersek4, Melanie Bahlo5-7, David J Balding8, 9, Thomas Bast10, 11, Larry Baum12-14, Albert J Becker15, Felicitas Becker16, 17 Bianca Berghuis18, Samuel F Berkovic19, Katja E Boysen19, Jonathan P Bradfield20, 21, Lawrence C Brody22, Russell J Buono20, 23, 24, Ellen Campbell25, Gregory D Cascino26, Claudia B Catarino4, Gianpiero L Cavalleri27, 28, Stacey S Cherny13, 29, Krishna Chinthapalli4, Alison J Coffey30, Alastair Compston31, Antonietta Coppola32, 33, Patrick Cossette34, John J Craig35, Gerrit-Jan de Haan36, Peter De Jonghe37, 38, Carolien G F de Kovel39, Norman Delanty27, 28, 40, Chantal Depondt41, Orrin Devinsky42, Dennis J Dlugos43, Colin P Doherty28, 44, Christian E Elger45, Johan G Eriksson46, Thomas N Ferraro23, 47, Martha Feucht48, Ben Francis49, Andre Franke50, Jacqueline A French51, Saskia Freytag5, Verena Gaus52, Eric B Geller53, Christian Gieger54, 55, Tracy Glauser56, Simon Glynn57, David B Goldstein58, 59, Hongsheng Gui13, Youling Guo13, Kevin F Haas1, Hakon Hakonarson20, 60, Kerstin Hallmann45, 61, Sheryl Haut62, Erin L Heinzen58, 59, Ingo Helbig43, 63, Christian Hengsbach16, Helle Hjalgrim64, 65, Michele Iacomino33, Andrés Ingason66, Jennifer Jamnadas-Khoda4, 67, Michael R Johnson68, Reetta Kälviäinen69, 70, Anne-Mari Kantanen69, Dalia Kasperavičiūte4, Dorothee Kasteleijn-Nolst Trenite39, Heidi E Kirsch71, Robert C Knowlton72, Bobby P C Koeleman39, Roland Krause73, Martin Krenn74, Wolfram S Kunz45, Ruben Kuzniecky75, Patrick Kwan12, 76, 77, Dennis Lal78, Yu-Lung Lau79, Anna-Elina Lehesjoki80, Holger Lerche16, Costin Leu4, 78, 81, Wolfgang Lieb82, Dick Lindhout36, 39, Warren D Lo83, Iscia Lopes-Cendes84, 85, Daniel H Lowenstein71, Alberto Malovini86, Anthony G Marson2, Thomas Mayer87, Mark McCormack27, James L Mills88, Nasir Mirza2, Martina Moerzinger48, Rikke S Møller64, 65, 89, Anne M Molloy90, Hiltrud Muhle63, Mark Newton91, Ping-Wing Ng92, Markus M Nöthen93, Peter Nürnberg94, Terence J O’Brien76, 77, Karen L Oliver19, Aarno Palotie95, 96, Faith Pangilinan22, Sarah Peter73,Slavé Petrovski76, 97, Annapurna Poduri98, Michael Privitera99, Rodney Radtke100, Sarah Rau16, Philipp S Reif101, 102, Eva M Reinthaler74, Felix Rosenow101, 102, Josemir W Sander4, 36, 103, Thomas Sander52, 94, Theresa Scattergood104, Steven C Schachter105, Christoph J Schankin106, Ingrid E Scheffer19, 107, Bettina Schmitz52, Susanne Schoch15, Pak C Sham13, Jerry J Shih108, Graeme J Sills2, Sanjay M Sisodiya4, 103, Lisa Slattery109, Alexander Smith78, David F Smith3, Michael C Smith110, Philip E Smith111, Anja C M Sonsma39, Doug Speed8, 112, Michael R Sperling113, Bernhard J Steinhoff10, Ulrich Stephani63, Remi Stevelink39, Konstantin Strauch114, 115, Pasquale Striano116, Hans Stroink117, Rainer Surges45, K Meng Tan76, Liu Lin Thio118, G Neil Thomas119, Marian Todaro76, Rossana Tozzi120, Maria S Vari116, Eileen P G Vining121, Frank Visscher122, Sarah von Spiczak63, Nicole M Walley58, 123, Yvonne G Weber16, Zhi Wei124, Ruta Mameniskiene125, Judith Weisenberg118, Christopher D Whelan27, Peter Widdess-Walsh53, Markus Wolff125, Stefan Wolking16, Wanling Yang79, Federico Zara33, Fritz Zimprich74

1. Vanderbilt University Medical Center, Nashville, TN 37232, USA.

2. Department of Molecular and Clinical Pharmacology, University of Liverpool, Liverpool L69 3GL, UK.

3. The Walton Centre NHS Foundation Trust, Liverpool L9 7LJ, UK.

4. Department of Clinical and Experimental Epilepsy, UCL Institute of Neurology, Queen Square, London WC1N 3BG, UK.

5. Population Health and Immunity Divison, The Walter and Eliza Hall Institute of Medical Research, Parkville 3052, Australia.

6. Department of Biology, University of Melbourne, Parkville 3010, Australia.

7. School of Mathematics and Statistics, University of Melbourne, Parkville 3010, Australia.

8. UCL Genetics Institute, University College London, London WC1E 6BT, UK.

9. Melbourne Integrative Genomics, University of Melbourne, Parkville 3052, Australia.

10. Epilepsy Center Kork, Kehl-Kork 77694, Germany.

11. Medical Faculty of the University of Freiburg, Freiburg 79085, Germany.

12. Centre for Genomic Sciences, The University of Hong Kong, Hong Kong.

13. Department of Psychiatry, The University of Hong Kong, Hong Kong.

14. The State Key Laboratory of Brain and Cognitive Sciences, University of Hong Kong, Hong Kong, China.

15. Section for Translational Epilepsy Research, Department of Neuropathology, University of Bonn Medical Center, Bonn 53105, Germany.

16. Department of Neurology and Epileptology, Hertie Institute for Clinical Brain Research, University of Tübingen, Tübingen 72076, Germany.

17. Department of Neurology, University of Ulm, Ulm 89081, Germany.

18. Stichting Epilepsie Instellingen Nederland (SEIN), Zwolle 8025 BV, The Netherlands.

19. Epilepsy Research Centre, University of Melbourne, Austin Health, Heidelberg 3084, Australia.

20. Center for Applied Genomics, The Children's Hospital of Philadelphia, Philadelphia, PA 19104, USA.

21. Quantinuum Research LLC, San Diego, CA 92101, USA.

22. National Human Genome Research Institute, National Institutes of Health, Bethesda, MD 20892, USA.

23. Department of Biomedical Sciences, Cooper Medical School of Rowan University Camden, NJ 08103, USA.

24. Department of Neurology, Thomas Jefferson University Hospital, Philadelphia, PA 19107, USA.

25. Belfast Health and Social Care Trust, Belfast BT9 7AB, UK.

26. Division of Epilepsy, Department of Neurology, Mayo Clinic, Rochester, MN 55902, USA.

27. Department of Molecular and Cellular Therapeutics, The Royal College of Surgeons in Ireland, Dublin 2, Ireland.

28. The FutureNeuro Research Centre, Dublin 2, Ireland.

29. Department of Epidemiology and Preventive Medicine, School of Public Health, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv 6997801, Israel.

30. The Wellcome Trust Sanger Institute, Hinxton, Cambridge CB10 1SA, UK.

31. Department of Clinical Neurosciences, Cambridge Biomedical Campus, Cambridge CB2 0SL, UK.

32. Department of Neuroscience, Reproductive and Odontostomatological Sciences, University Federico II, Naples 80138, Italy.

33. Laboratory of Neurogenetics and Neurosciences, Institute G. Gaslini, Genova 16148, Italy.

34. Department of Neurosciences, Université de Montréal, Montréal, CA 26758, Canada.

35. Department of Neurology, Royal Victoria Hospital, Belfast Health and Social Care Trust, Grosvenor Road, Belfast BT12 6BA, UK.

36. Stichting Epilepsie Instellingen Nederland (SEIN), Heemstede 2103 SW, The Netherlands.

37. Neurogenetics Group, Center for Molecular Neurology, VIB and Laboratory of Neurogenetics, Institute Born-Bunge, University of Antwerp, Antwerp 2610, Belgium.

38. Department of Neurology, Antwerp University Hospital, Edegem 2650, Belgium.

39. Department of Genetics, University Medical Center Utrecht, Utrecht 3584 CX, The Netherlands.

40. Division of Neurology, Beaumont Hospital, Dublin D09 FT51, Ireland.

41. Department of Neurology, Hôpital Erasme, Université Libre de Bruxelles, Bruxelles 1070, Belgium.

42. Comprehensive Epilepsy Center, New York University School of Medicine, New York, NY 10016, USA.

43. Department of Neurology, The Children's Hospital of Philadelphia, Philadelphia, PA 19104, USA.

44. Neurology Department, St. James’s Hospital, Dublin D03 VX82, Ireland.

45. Department of Epileptology, University of Bonn Medical Centre, Bonn 53127, Germany.

46. Department of General Practice and Primary Health Care, University of Helsinki and Helsinki University Hospital, Helsinki 0014, Finland.

47. Department of Pharmacology and Psychiatry, University of Pennsylvania Perlman School of Medicine, Philadelphia, PA 19104, USA.

48. Department of Pediatrics and Neonatology, Medical University of Vienna, Vienna 1090, Austria.

49. Department of Biostatistics, University of Liverpool, Liverpool L69 3GL, UK.

50. Institute of Clinical Molecular Biology, Christian-Albrechts-University of Kiel, University Hospital Schleswig Holstein, Kiel 24105, Germany.

51. Department of Neurology, NYU School of Medicine, New York City, NY 10003, USA.

52. Department of Neurology, Charité Universitaetsmedizin Berlin, Campus Virchow-Clinic, Berlin 13353, Germany.

53. Institute of Neurology and Neurosurgery at St. Barnabas, Livingston, NJ 07039, USA.

54. Research Unit of Molecular Epidemiology, Helmholtz Zentrum München - German Research Center for Environmental Health, Neuherberg D-85764, Germany.

55. Institute of Epidemiology, Helmholtz Zentrum München - German Research Center for Environmental Health, Neuherberg D-85764, Germany.

56. Comprehensive Epilepsy Center, Division of Neurology, Cincinnati Children's Hospital Medical Center, Cincinnati, OH 45229, USA.

57. Department of Neurology, University of Michigan, Ann Arbor, MI 48109, USA.

58. Center for Human Genome Variation, Duke University School of Medicine, Durham, NC 27710, USA.

59. Institute for Genomic Medicine, Columbia University Medical Center, New York, NY 10032, USA.

60. Division of Human Genetics, Department of Pediatrics, The Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA 19104, USA.

61. Life and Brain Center, University of Bonn Medical Center, Bonn 53127, Germany.

62. Montefiore Medical Center, Bronx, NY 10467, USA.

63. Department of Neuropediatrics, University Medical Center Schleswig-Holstein (UKSH), Kiel 24105, Germany.

64. Danish Epilepsy Centre, Dianalund 4293, Denmark.

65. Institute of Regional Health Services Research, University of Southern Denmark, Odense 5000, Denmark.

66. deCODE genetics, Reykjavik IS-101, Iceland.

67. Department of Psychiatry and Applied Psychology, Institute of Mental Health University of Nottingham, Nottingham NG7 2TU, UK.

68. Faculty of Medicine, Imperial College London, London SW7 2AZ, UK.

69. Kuopio Epilepsy Center, Neurocenter, Kuopio University Hospital, Kuopio 70029, Finland.

70. Institute of Clinical Medicine, University of Eastern Finland, Kuopio 70029, Finland.

71. Department of Neurology, University of California, San Francisco, CA 94143, USA.

72. University of Alabama Birmingham, Department of Neurology, Birmingham, AL 35233, USA.

73. Luxembourg Centre for Systems Biomedicine, University of Luxembourg, Esch-sur-Alzette L-4362, Luxembourg.

74. Department of Neurology, Medical University of Vienna, Vienna 1090, Austria.

75. Department of Neurology, Zucker-Hofstra Northwell School of Medicine, NY 10075, USA.

76. Department of Medicine, University of Melbourne, Royal Melbourne Hospital, Parkville 3050, Australia.

77. Department of Neuroscience, Central Clinical School, Monash University, Melbourne 3004, Australia.

78. Stanley Center for Psychiatric Research, Broad Institute of Harvard and M.I.T., Cambridge, MA 02142, USA.

79. Department of Paediatrics and Adolescent Medicine, The University of Hong Kong, Hong Kong.

80. Folkhälsan Research Center and Medical Faculty, University of Helsinki, Helsinki 00290, Finland.

81. Genomic Medicine Institute, Lerner Research Institute, Cleveland Clinic, Cleveland, OH 44195, USA.

82. Institut für Epidemiologie Christian-Albrechts-Universität zu Kiel, Kiel 24105, Germany.

83. Department of Pediatrics and Neurology, Ohio State University and Nationwide Children's Hospital, Columbus, OH 43205, USA.

84. Department of Medical Genetics, School of Medical Sciences, University of Campinas (UNICAMP), Campinas, SP 13083-887, Brazil.

85. Brazilian Institute of Neuroscience and Neurotechnology (BRAINN), Campinas, SP 13083-970, Brazil.

86. Istituti Clinici Scientifici Maugeri, Pavia 27100, Italy.

87. Epilepsy Center Kleinwachau, Radeberg 01454, Germany.

88. Division of Intramural Population Health Research, Eunice Kennedy Shriver National Institute of Child Health and Human Development, National Institutes of Health, Bethesda, MD 20892, USA*.*

89. Wilhelm Johannsen Centre for Functional Genome Research, Copenhagen DK-2200, Denmark.

90. School of Medicine, Trinity College Dublin, Dublin 2, Ireland.

91. Department of Neurology, Austin Health, Heidelberg 3084, Australia.

92. United Christian Hospital, Hong Kong.

93. Institute of Human Genetics, University of Bonn Medical Center, Bonn 53127, Germany.

94. Cologne Center for Genomics, University of Cologne, Cologne 50931, Germany.

95. Institute for Molecular Medicine Finland (FIMM), University of Helsinki, Helsinki 0014, Finland*.*

96. The Broad Institute of M.I.T. and Harvard, Cambridge, MA 02142, USA.

97. AstraZeneca Centre for Genomics Research, Precision Medicine and Genomics, IMED Biotech Unit, AstraZeneca, Cambridge CB2 0AA, UK.

98. Department of Neurology, Boston Children's Hospital, Harvard Medical School, Boston, MA 02115, USA.

99. Department of Neurology, Neuroscience Institute, University of Cincinnati Medical Center, Cincinnati, OH 45220, USA.

100. Department of Neurology, Duke University School of Medicine, Durham, NC 27710, USA.

101. Epilepsy-Center Hessen, Department of Neurology, University Medical Center Giessen and Marburg, Marburg, Germany and Philipps-University Marburg, Marburg 35043, Germany.

102. Epilepsy Center Frankfurt Rhine-Main, Center of Neurology and Neurosurgery, Goethe University Frankfurt, Frankfurt 60528, Germany.

103. Chalfont Centre for Epilepsy, Chalfont-St-Peter, Buckinghamshire SL9 0RJ, UK.

104. Department of Endocrinology, Hospital of The University of Pennsylvania, Philadelphia, PA 19104, USA.

105. Departments of Neurology, Beth Israel Deaconess Medical Center, Massachusetts General Hospital, and Harvard Medical School, Boston, MA 02215, USA.

106. Department of Neurology, Inselspital, Bern University Hospital, University of Bern, Bern 3010, Switzerland.

107. Department of Neurology, Royal Children's Hospital, Parkville 3052, Australia.

108. Department of Neurosciences, University of California, San Diego, La Jolla, CA 92037, USA.

109. The Royal College of Surgeons in Ireland, Dublin D02 YN77, Ireland. *.*

110. Rush University Medical Center, Chicago, IL 60612, USA.

111. Department of Neurology, Alan Richens Epilepsy Unit, University Hospital of Wales, Cardiff CF14 4XW, UK.

112. Aarhus Institute of Advanced Studies (AIAS), Aarhus University, 8000 Aarhus, Denmark.

113. Department of Neurology and Comprehensive Epilepsy Center, Thomas Jefferson University, Philadelphia, PA 19107, USA.

114. Institute of Genetic Epidemiology, Helmholtz Zentrum München - German Research Center for Environmental Health, Neuherberg D-85764, Germany.

115. Chair of Genetic Epidemiology, IBE, Faculty of Medicine, LMU Munich 80539, Germany.

116. Pediatric Neurology and Muscular Diseases Unit, Department of Neurosciences, Rehabilitation, Ophthalmology, Genetics, Maternal and Child Health, G. Gaslini Institute, University of Genoa, Genova 16148, Italy.

117. CWZ Hospital, 6532 SZ Nijmegen, The Netherlands.

118. Department of Neurology, Washington University School of Medicine, St. Louis, MO 63110, USA*.*

119. Institute for Applied Health Research, University of Birmingham, Birmingham B15 2TT, UK.

120. C. Mondino National Neurological Institute, Pavia 27100, Italy.

121. Departments of Neurology and Pediatrics, The Johns Hopkins University School of Medicine, Baltimore, MD 21287, USA.

122. Department of Neurology, Admiraal De Ruyter Hospital, Goes 4462, The Netherlands.

123. Division of Medical Genetics, Department of Pediatrics, Duke University Medical Center, Durham, NC 27710, USA.

124. Department of Computer Science, New Jersey Institute of Technology, NJ 07102, USA.

125. Department of Pediatric Neurology and Developmental Medicine, University Children's Hospital, Tübingen 72076, Germany.

126. Department of Neurology, Institute of Clinical Medicine, Faculty of Medicine, Vilnius University, Vilnius, Lithuania.

**1. Epi25 Consortium**

**Epi25 sequencing, analysis, and project management at the Broad Institute**

Yen-Chen Anne Feng1-4, Daniel P. Howrigan1,3,4, Liam E. Abbott1,3,4, Katherine Tashman1,3,4, Felecia Cerrato3, Dennis Lal4,5, Costin Leu4,5, Claire Churchhouse1,3,4, Namrata Gupta3, Stacey B. Gabriel146, Mark J. Daly1,3,4, Eric S. Lander146,147,148, Benjamin M. Neale1,3,4

**Epi25 executive committee**

Samuel F. Berkovic 9, Holger Lerche8, David B. Goldstein 6, Daniel H. Lowenstein7

**Epi25 strategy, phenotyping, analysis, informatics, and project management committees**

Samuel F. Berkovic9, Holger Lerche8, David B. Goldstein6, Daniel H. Lowenstein7, Gianpiero L. Cavalleri67,70, Patrick Cossette106, Chris Cotsapas111, Peter De Jonghe12-14, Tracy Dixon-Salazar112, Renzo Guerrini82, Hakon Hakonarson101, Erin L. Heinzen6, Ingo Helbig28,29,102, Patrick Kwan10,11, Anthony G. Marson58, Slavé Petrovski11,116, Sitharthan Kamalakaran6, Sanjay M. Sisodiya57, Randy Stewart113, Sarah Weckhuysen12-14, Chantal Depondt15, Dennis J. Dlugos101, Ingrid E. Scheffer9, Pasquale Striano74, Catharine Freyer7, Roland Krause114, Patrick May114, Kevin McKenna7, Brigid M. Regan9, Susannah T. Bellows9, Costin Leu4,5,57

**Authors from individual Epi25 cohorts:**

**Australia: Melbourne (AUSAUS)**

Samuel F. Berkovic9, Ingrid E. Scheffer9, Brigid M. Regan9, Caitlin A. Bennett9, Susannah T. Bellows9, Esther M.C. Johns9, Alexandra Macdonald9, Hannah Shilling9, Rosemary Burgess9,

Dorien Weckhuysen9, Melanie Bahlo119,120

**Australia: Royal Melbourne (AUSRMB)**

Terence J. O'Brien10,11, Patrick Kwan10,11, Slavé Petrovski11,116, Marian Todaro10,11

**Belgium: Antwerp (BELATW)**

Sarah Weckhuysen12-14, Hannah Stamberger12-14, Peter De Jonghe12-14

**Belgium: Brussels (BELULB)**

Chantal Depondt15

**Canada: Andrade (CANUTN)**

Danielle M. Andrade16,17, Tara R. Sadoway17, Kelly Mo17

**Switzerland: Bern (CHEUBB)**

Heinz Krestel18, Sabina Gallati19

**Cyprus (CYPCYP)**

Savvas S. Papacostas20, Ioanna Kousiappa20, George A. Tanteles21

**Czech Republic: Prague (CZEMTH)**

Katalin Štěrbová22, Markéta Vlčková23, Lucie Sedláčková22, Petra Laššuthová22

**Germany: Frankfurt/Marburg (DEUPUM)**

Karl Martin Klein24,25, Felix Rosenow24,25, Philipp S. Reif24,25, Susanne Knake25

**Germany: Bonn (DEUUKB)**

Wolfram S. Kunz26,27, Gábor Zsurka26,27, Christian E. Elger27, Jürgen Bauer27, Michael Rademacher27

**Germany: Kiel (DEUUKL)**

Ingo Helbig28,29,102, Karl Martin Klein24,25, Manuela Pendziwiat29, Hiltrud Muhle29, Annika Rademacher29, Andreas van Baalen29, Sarah von Spiczak29, Ulrich Stephani29, Zaid Afawi30, Amos D. Korczyn31, Moien Kanaan32, Christina Canavati32, Gerhard Kurlemann33, Karen Müller-Schlüter34, Gerhard Kluger35,36, Martin Häusler37, Ilan Blatt31,115

**Germany: Leipzig (DEUULG)**

Johannes R. Lemke38, Ilona Krey38

**Germany: Tuebingen (DEUUTB)**

Holger Lerche8, Yvonne G. Weber8,151, Stefan Wolking8, Felicitas Becker8,39, Christian Hengsbach8, Sarah Rau8, Ana F. Maisch8, Bernhard J. Steinhoff40, Andreas Schulze-Bonhage41, Susanne Schubert-Bast42, Herbert Schreiber43, Ingo Borggräfe44, Christoph J. Schankin45, Thomas Mayer46, Rudolf Korinthenberg47, Knut Brockmann48, Gerhard Kurlemann33, Dieter Dennig49, Rene Madeleyn50

**Finland: Kuopio (FINKPH)**

Reetta Kälviäinen51, Pia Auvinen51, Anni Saarela51

**Finland: Helsinki (FINUVH)**

Tarja Linnankivi52, Anna-Elina Lehesjoki53

**Wales: Swansea (GBRSWU)**

Mark I. Rees54,55, Seo-Kyung Chung54,55, William O. Pickrell54, Robert Powell54,56

**UK: UCL (GBRUCL)**

Sanjay M. Sisodiya57, Natascha Schneider57, Simona Balestrini57, Sara Zagaglia57, Vera Braatz57

**UK: Imperial/Liverpool (GBRUNL)**

Anthony G. Marson58, Michael R. Johnson59, Pauls Auce60, Graeme J. Sills61

**Hong Kong (HKGHKK)**

Patrick Kwan10,11,62, Larry W. Baum117,118,63, Pak C. Sham117,118,63, Stacey S. Cherny64, Colin H.T. Lui65

**Croatia (HRVUZG)**

Nina Barišić66

**Ireland: Dublin (IRLRCI)**

Gianpiero L. Cavalleri67,70, Norman Delanty67,70, Colin P. Doherty68,70, Arif Shukralla69, Mark McCormack67, Hany El-Naggar69,70

**Italy: Milan (ITAICB)**

Laura Canafoglia71, Silvana Franceschetti71, Barbara Castellotti72, Tiziana Granata73

**Italy: Genova (ITAIGI)**

Pasquale Striano74, Federico Zara75, Michele Iacomino75, Francesca Madia75, Maria Stella Vari74, Maria Margherita Mancardi75, Vincenzo Salpietro74

**Italy: Bologna (ITAUBG)**

Francesca Bisulli76,77, Paolo Tinuper76,77, Laura Licchetta76,77, Tommaso Pippucci78, Carlotta Stipa79, Raffaella Minardi76

**Italy: Catanzaro (ITAUMC)**

Antonio Gambardella80, Angelo Labate80, Grazia Annesi81, Lorella Manna81, Monica Gagliardi81

**Italy: Florence (ITAUMR)**

Renzo Guerrini82, Elena Parrini82, Davide Mei82, Annalisa Vetro82, Claudia Bianchini82, Martino Montomoli82, Viola Doccini82, Carla Marini82

**Japan: RIKEN Institute (JPNRKI)**

Toshimitsu Suzuki83, Yushi Inoue84, Kazuhiro Yamakawa83

**Lithuania (LTUUHK)**

Birute Tumiene85,86

**New Zealand: Otago (NZLUTO)**

Lynette G. Sadleir87, Chontelle King87, Emily Mountier87

**Turkey: Bogazici (TURBZU)**

S. Hande Caglayan88, Mutluay Arslan89, Zuhal Yapıcı90, Uluc Yis91, Pınar Topaloglu90, Bulent Kara92, Dilsad Turkdogan93, Aslı Gundogdu-Eken88

**Turkey: Istanbul (TURIBU)**

Nerses Bebek94,95, Sibel Uğur-İşeri95, Betül Baykan94, Barış Salman95, Garen Haryanyan94, Emrah Yücesan149, Yeşim Kesim94, Çiğdem Özkara96

**USA: BCH (USABCH)**

Annapurna Poduri97,98

**USA: Philadelphia/CHOP (USACHP) and Philadelphia/Rowan (USACRW)**

Russell J. Buono99,100,101, Thomas N. Ferraro99,102, Michael R. Sperling100, Dennis J. Dlugos101,102, Warren Lo103, Michael Privitera104, Jacqueline A. French105, Patrick Cossette106, Steven Schachter107, Hakon Hakonarson101

**USA: EPGP (USAEGP)**

Daniel H. Lowenstein7, Ruben I. Kuzniecky108, Dennis J. Dlugos101,102, Orrin Devinsky105

**USA: NYU HEP (USAHEP)**

Daniel H. Lowenstein7, Ruben I. Kuzniecky108, Jacqueline A. French105, Manu Hegde7

**USA: Penn/CHOP (USAUPN)**

Ingo Helbig28,102, Pouya Khankhanian109,110, Katherine L. Helbig28, Colin A. Ellis110

Affiliations:

1. Analytic and Translational Genetics Unit, Department of Medicine, Massachusetts General Hospital and Harvard Medical School, Boston, MA 02114, USA
2. Psychiatric & Neurodevelopmental Genetics Unit, Department of Psychiatry, Massachusetts General Hospital and Harvard Medical School, Boston, MA 02114, USA
3. Program in Medical and Population Genetics, Broad Institute of Harvard and MIT, 7 Cambridge Center, Cambridge, MA 02142, USA
4. Stanley Center for Psychiatric Research, Broad Institute of Harvard and MIT, Cambridge, MA 02142, USA
5. Genomic Medicine Institute, Cleveland Clinic, Cleveland, OH 44195, USA
6. Institute for Genomic Medicine, Columbia University, New York, NY 10032, USA
7. Department of Neurology, University of California, San Francisco, CA 94110, USA
8. Department of Neurology and Epileptology, Hertie Institute for Clinical Brain Research, University of Tübingen, 72076 Tübingen, Germany
9. Epilepsy Research Centre, Department of Medicine, University of Melbourne, Victoria, Australia
10. Department of Neuroscience, Central Clinical School, Monash University, Alfred Hospital, Melbourne, Australia
11. Departments of Medicine and Neurology, University of Melbourne, Royal Melbourne Hospital, Parkville, Australia
12. Neurogenetics Group, Center for Molecular Neurology, VIB, Antwerp, Belgium
13. Laboratory of Neurogenetics, Institute Born-Bunge, University of Antwerp, Belgium
14. Division of Neurology, Antwerp University Hospital, Antwerp, Belgium
15. Department of Neurology, Université Libre de Bruxelles, Brussels, Belgium
16. Department of Neurology, Toronto Western Hospital, Toronto, ON M5T 2S8, Canada
17. University Health Network, University of Toronto, Toronto, ON, Canada
18. Departments of Neurology and BioMedical Research, Bern University Hospital and University of Bern, Bern, Switzerland
19. Institute of Human Genetics, Bern University Hospital, Bern, Switzerland
20. Neurology Clinic B, The Cyprus Institute of Neurology and Genetics, 2370 Nicosia, Cyprus
21. Department of Clinical Genetics, The Cyprus Institute of Neurology and Genetics, 2370 Nicosia, Cyprus
22. Department of Paediatric Neurology, 2nd Faculty of Medicine, Charles University and Motol Hospital, Prague, Czech Republic
23. Department of Biology and Medical Genetics, 2nd Faculty of Medicine, Charles University and Motol Hospital, Prague, Czech Republic
24. Epilepsy Center Frankfurt Rhine-Main, Center of Neurology and Neurosurgery, Goethe University Frankfurt, Frankfurt, Germany
25. Epilepsy Center Hessen-Marburg, Department of Neurology, Philipps University Marburg, Marburg, Germany
26. Institute of Experimental Epileptology and Cognition Research, University Bonn, 53127

Bonn, Germany

1. Department of Epileptology, University Bonn, 53127 Bonn, Germany
2. Division of Neurology, Children's Hospital of Philadelphia, Philadelphia, PA 19104, USA
3. Department of Neuropediatrics, Christian-Albrechts-University of Kiel, 24105 Kiel, Germany
4. Sackler School of Medicine, Tel-Aviv University, Ramat Aviv, Israel
5. Tel-Aviv University Sackler Faculty of Medicine, Ramat Aviv 69978, Israel
6. Hereditary Research Lab, Bethlehem University, Bethlehem, Palestine
7. Department of Neuropediatrics, Westfälische Wilhelms-University, Münster, Germany
8. Epilepsy Center for Children, University Hospital Neuruppin, Brandenburg Medical School, Neuruppin, Germany
9. Neuropediatric Clinic and Clinic for Neurorehabilitation, Epilepsy Center for Children and Adolescents, Vogtareuth, Germany
10. Research Institute Rehabilitation / Transition / Palliation, PMU Salzburg, Austria
11. Division of Neuropediatrics and Social Pediatrics, Department of Pediatrics, University Hospital, RWTH Aachen, Aachen, Germany
12. Institute of Human Genetics, Leipzig, Germany
13. RKU-University Neurology Clinic of Ulm, Ulm, Germany
14. Kork Epilepsy Center, Kehl-Kork, Germany
15. Epilepsy Center, University of Freiburg, Freiburg im Breisgau, Germany
16. Section Neuropediatrics and Inborn Errors of Metabolism, University Children's Hospital, Heidelberg, Germany
17. Neurological Practice Center & Neuropoint Patient Academy, Ulm, Germany.
18. Department of Pediatric Neurology and Developmental Medicine, LMU Munich, Munich, Germany
19. Department of Neurology, University of Munich Hospital-Großhadern, Munich, Germany
20. Saxonian Epilepsy Center Radeberg, Radeberg, Germany
21. Division of Neuropediatrics and Muscular Disorders, University Hospital Freiburg, Freiburg, Germany
22. University Children's Hospital, Göttingen, Germany
23. Private Neurological Practice, Stuttgart, Germany
24. Department of Pediatrics, Filderklinik, Filderstadt, Germany
25. Neurocenter, Kuopio University Hospital, Kuopio Finland and Institute of Clinical Medicine, University of Eastern Finland, Finland
26. Child Neurology, University of Helsinki and Helsinki University Hospital, Helsinki, Finland
27. Medicum, University of Helsinki, Helsinki, Finland and Folkhälsan Research Center, Helsinki, Finland
28. Neurology Research Group, Swansea University Medical School, Swansea University SA2 8PP, UK
29. Faculty of Medicine and Health, University of Sydney, Sydney, Australia
30. Department of Neurology, Morriston Hospital, Abertawe BroMorgannwg HealthBoard, Swansea, UK
31. Department of Clinical and Experimental Epilepsy, UCL Queen Square Institute of Neurology, London, UK and Chalfont Centre for Epilepsy, Chalfont St Peter, UK
32. Department of Molecular and Clinical Pharmacology, University of Liverpool, Liverpool, UK
33. Division of Brain Sciences, Imperial College London, London, UK
34. Department of Neurology, Walton Centre NHS Foundation Trust, Liverpool, UK
35. School of Life Sciences, University of Glasgow, Glasgow, UK
36. Department of Medicine and Therapeutics, Chinese University of Hong Kong, Hong Kong, China
37. Department of Psychiatry, University of Hong Kong, Hong Kong, China
38. Department of Epidemiology and Preventive Medicine and Department of Anatomy and Anthropology, Sackler Faculty of Medicine, Tel Aviv University, Israel
39. Department of Medicine, Tseung Kwan O Hospital, Hong Kong, China
40. Department of Pediatric University Hospital centre Zagreb, Croatia
41. The Department of Molecular and Cellular Therapeutics, The Royal College of Surgeons in Ireland, Dublin, Ireland
42. Neurology Department, St. James Hospital, Dublin, Ireland
43. The Department of Neurology, Beaumont Hospital, Dublin, Ireland
44. The FutureNeuro Research Centre, Ireland
45. Neurophysiopathology, Fondazione IRCCS Istituto Neurologico Carlo Besta, Milan, Italy
46. Unit of Genetics of Neurodegenerative and Metabolic Diseases, Fondazione IRCCS Istituto Neurologico Carlo Besta, Milan, Italy
47. Department of Pediatric Neuroscience, Fondazione IRCCS Istituto Neurologico Carlo Besta, Milan, Italy
48. Pediatric Neurology and Muscular Diseases Unit, Department of Neurosciences, Rehabilitation, Ophthalmology, Genetics, Maternal and Child Health, University of Genoa, "G. Gaslini" Institute, Genova, Italy
49. Laboratory of Neurogenetics, "G. Gaslini" Institute, Genova, Italy
50. IRCCS, Institute of Neurological Sciences of Bologna, Bologna, Italy
51. Department of Biomedical and Neuromotor Sciences, University of Bologna, Bologna, Italy
52. Medical Genetics Unit, Polyclinic Sant'Orsola-Malpighi University Hospital, Bologna, Italy
53. Department of Biomedical and Neuromotor Sciences, University of Bologna, Bologna, Italy
54. Institute of Neurology, Department of Medical and Surgical Sciences, University “Magna Graecia”, Catanzaro, Italy
55. Institute of Molecular Bioimaging and Physiology, CNR, Section of Germaneto, Catanzaro, Italy
56. Pediatric Neurology, Neurogenetics and Neurobiology Unit and Laboratories, Children's Hospital A. Meyer, University of Florence, Italy
57. Laboratory for Neurogenetics, RIKEN Center for Brain Science, Saitama, Japan
58. National Epilepsy Center, Shizuoka Institute of Epilepsy and Neurological Disorder, Shizuoka, Japan
59. Institute of Biomedical Sciences, Faculty of Medicine, Vilnius University, Vilnius, Lithuania
60. Centre for Medical Genetics, Vilnius University Hospital Santaros Klinikos, Vilnius, Lithuania
61. Department of Paediatrics and Child Health, University of Otago, Wellington
62. Department of Molecular Biology and Genetics, Bogaziçi University, Istanbul, Turkey
63. Department of Child Neurology, Gulhane Education and Research Hospital, Health Sciences University, Ankara, Turkey
64. Department of Child Neurology, Istanbul Faculty of Medicine, Istanbul University, Istanbul, Turkey
65. Department of Child Neurology, Medical School, Dokuz Eylul University, Izmir, Turkey
66. Department of Child Neurology, Medical School, Kocaeli University, Kocaeli, Turkey
67. Department of Child Neurology, Medical School, Marmara University, Istanbul, Turkey
68. Department of Neurology, Istanbul Faculty of Medicine, Istanbul University, Istanbul, Turkey
69. Department of Genetics, Aziz Sancar Institute of Experimental Medicine, Istanbul University, Istanbul, Turkey
70. Department of Neurology, Faculty of Medicine, Cerrahpaşa University Istanbul, Istanbul, Turkey
71. Epilepsy Genetics Program, Department of Neurology, Boston Children's Hospital, Boston, MA 02115, USA
72. Department of Neurology, Harvard Medical School, Boston, MA 02115, USA
73. Cooper Medical School of Rowan University, Camden, NJ 08103, USA
74. Thomas Jefferson University, Philadelphia, PA 19107, USA
75. The Children's Hospital of Philadelphia, Philadelphia, PA 19104, USA
76. Perelman School of Medicine, University of Pennsylvania, PA 19104, USA
77. Nationwide Children's Hospital, Columbus, OH 43205, USA
78. University of Cincinnati, Cincinnati, OH 45220, USA
79. Department of Neurology, New York University/Langone Health, New York, NY 10016, USA
80. University of Montreal, Montreal, QC H3T 1J4, Canada
81. Beth Israel Deaconess/Harvard, Boston, MA 02115, USA
82. Department of Neurology, Hofstra-Northwell Medical School, New York, NY 11549, USA
83. Center for Neuro-engineering and Therapeutics, University of Pennsylvania, Philadelphia, PA 19104

, USA

1. Department of Neurology, Hospital of University of Pennsylvania, Philadelphia, PA 19104, USA
2. School of Medicine, Yale University, New Haven, CT 06510, USA
3. LGS Foundation, NY 11716, USA
4. National Institute of Neurological Disorders and Stroke, MD 20852, USA
5. Luxembourg Centre for Systems Biomedicine, University Luxembourg, Esch-sur-Alzette, Luxembourg
6. Department of Neurology, Sheba Medical Center, Ramat Gan, Israel
7. Centre for Genomics Research, Precision Medicine and Genomics, IMED Biotech Unit, AstraZeneca, Cambridge, UK
8. The State Key Laboratory of Brain and Cognitive Sciences, University of Hong Kong, Hong Kong, China
9. Centre for Genomic Sciences, University of Hong Kong, Hong Kong, China
10. Population Health and Immunity Division, the Walter and Eliza Hall Institute of Medical Research, Parkville 3052, VIC, Australia
11. Department of Medical Biology, The University of Melbourne, Melbourne 3010, VIC, Australia