

2015

## **Update: Cognitive (brain-based) Intervention for Dyslexia in BC**

PI: Dr. Urs Ribary, Professor and BC LEEF Leadership Chair, Cognitive Neuroscience in Childhood Health and Development.

### ***Dyslexia: A widespread issue in need of support:***

Developmental dyslexia, the most common learning disability, affects approximately 5-10% of the population. It is defined as an unexpected difficulty in learning to read among children and adults who have received access to reasonable reading instruction and otherwise possess adequate intelligence and motivation to learn. Often first indicated in their school years by this pronounced difficulty in learning to read, write and spell, dyslexic children are often devastated by their poor performance. The social costs resulting from low self-esteem and failure to matriculate create enormous social and psychological costs for their families and for the public school system, as well as a large financial burden for the healthcare system and the government.

**Solutions:** At global issue, huge strides have been made internationally in dyslexia treatment with the implementation of interventional non-invasive brain training programs on over 2-million children in over 45 countries. Here in British Columbia, Dr. Ribary who contributed to the translation of these programs, has further collaborated with the BC school system to facilitate the implementation of such an interventional training platform in more than 119 schools across 21 school districts since 2008. "Fast ForWord" is a series of computer-delivered brain fitness exercises designed to produce dramatic language and reading improvements in children by improving memory, attention and processing skills. In addition to measurable gains in language, anecdotal evidence suggests that children who have completed the Fast ForWord Language program are better able to interact with parents, teachers and peers. As a result of this work, positive outcomes have already been seen in the more than 6,000 BC students who have received training, with an overall gain of 0.7-2.0 years in reading-grade level.

### ***Brain-Based Interventional Training Programs:***

In the early 90's the PI (Urs Ribary) was part of a distinguished scientific consortium effort that translated into a very successful cognitive brain-based interventional training program for learning disabilities, such as dyslexia. His collaborators (Merzenich and Tallal) came up with the computer-based training programs, called "FastForWord (FFW)", and based on two initial publications in the prestigious journal of "Science" in 1996, the company "Scientific Learning" was formed in San Francisco the same year. **As of today, more than 2 Million children have been very successfully trained in 45 countries!**

Scientific Learning's Website: [www.scientificlearning.com](http://www.scientificlearning.com)

Initial publications in Science:

- Merzenich MM, Jenkins WM, Johnston P, Schreiner C, Miller SL, Tallal P. (1996) Temporal processing deficits of language-learning impaired children ameliorated by training. *Science*, 271:77-81.

- Tallal P, Miller SL, Bedi G, Byma G, Wang X, Nagarajan SS, Schreiner C, Jenkins WM, Merzenich MM. (1996) Language comprehension in language-learning impaired children improved with acoustically modified speech. *Science*, 271:81-84.

Internationally over the past 20 years, there have been numerous research studies conducted using the FastForWord software products. Research studies indicated that specific aspects of the disrupted brain activation patterns can be remediated/recovered by following successful reading intervention. Some studies have used experimental designs, including the use of random assignment, while others have been intervention group studies or case studies. Some of the studies have had rapid follow-up showing that students start to reap the benefits in a few weeks while others have been longitudinal

and have shown that the benefits endure over years. Many studies have been published in the top peer-reviewed scientific journals such as "*Science*" and the "*Proceedings of the National Academy of Sciences USA*".

In addition to traditional journal-based peer-review, FastForWord software has been positively reviewed by the "What Works Clearinghouse", established in 2002 by the US Department of Education as a central and trusted peer-reviewed source of scientific evidence of what works in education. Their review included several independent studies on FastForWord products and found that studies meet the highest research standards of the Clearinghouse.

Finally, the results from numerous studies where schools or districts independently gather data and requested Scientific Learning's assistance on the analysis and reporting. These reports were reviewed for accuracy by educators at the district prior to being shared with others.

Across all the studies, data from more than 79,000 students at 860 schools have been analyzed and reported. Few studies manage to incorporate all the best attributes, but many studies incorporate each of the attributes.

The company's Scientific Learning website provides a link or direct access to more than 200 of these successful studies: [www.scientificlearning.com/results](http://www.scientificlearning.com/results)

### ***Outcome and Success of Training Programs in BC Schools:***

Dr. Ribary's previous brain imaging research was part of that initial consortium effort in the early 90's, facilitating the collaborators translation into these very successful cognitive interventional training programs for learning disabilities. On behalf of his tenure as the BC LEEF Chair here at SFU in Vancouver since 2007, he further facilitates these interventional programs in BC schools engaging at various levels, including past BC Ministers, BC-CASE (BC Council of Administrators of Special Education), BC school districts and BC schools (including teachers, staff and parents) by providing numerous scientific talks and scientific consulting.

In addition, Dr. Ribary together with his colleagues at the BC school system have further founded the "BC FastForWord Intervention Consortium" in 2008, a BC school interdistrict strategy to facilitate the knowledge and integration of brain-based interventional cognitive training programs for Learning Disabilities (dyslexia) across BC schools.

***The "BC FFW Intervention Consortium": Facilitating the integration of brain-based interventional cognitive programs for Learning Disabilities (Dyslexia) in BC schools.*** Dr. Ribary together with his colleagues at the BC school system (co-founders: Cairns, Chow, Hernandez, Todd, Collins and Ribary) have founded the "BC FastForWord Intervention Consortium" in 2008, a BC school interdistrict strategy to facilitate the knowledge and integration of brain-based interventional cognitive training programs for Learning Disabilities (dyslexia) in BC schools.

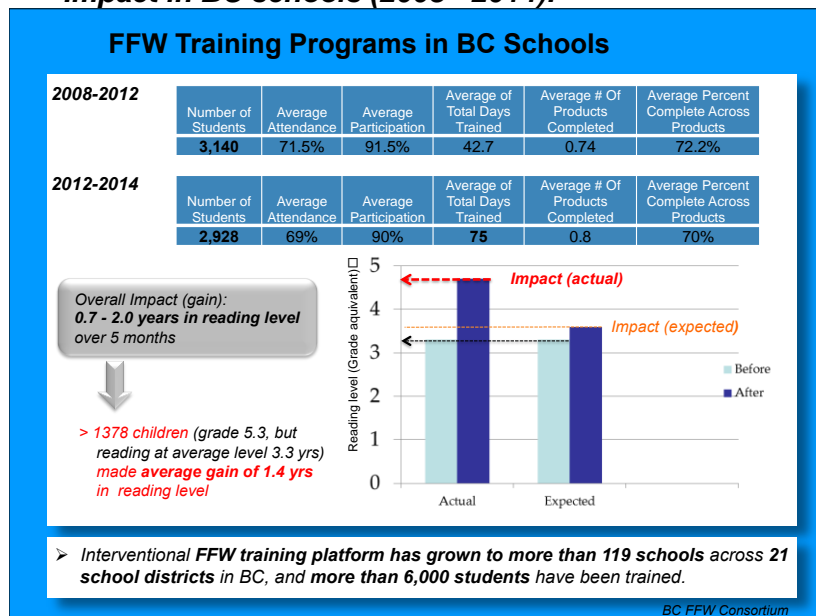
***Facts:*** Prior to founding the BC FFW Consortium during the 2007-2008 school year, fewer than 250 students used the FFW intervention in BC schools. Two years later, by the 2009-2010 school year, the number of students enrolled in FFW intervention had increased more than 400%/yr to a total of 1,208 students. As of 2012, more than 3,000 students have been successfully enrolled in FFW interventional training in BC over a five-year period, with average training of 43 days, average attendance of 72% and average participation of 92%. Students ranged from Kindergarten through High School, with an average grade level of early 5<sup>th</sup> grade. As of Dec/2014, the interventional FFW training platform has further grown; more than 6,000 students have been trained within 119 schools across 21 districts in BC with an overall gain of 0.7-2.0 years in reading level, including elementary and secondary schools. This is by far the largest effort across Canada with 51% training in BC alone, i.e. more training in BC than in all the other Provinces combined:

- Burnaby School District: more than 28 sites are up and running and more sites are in progress;
- Coquitlam: 8-16 schools are up and running and in progress to be setup;
- New Westminster: 8-10 schools are implemented and in progress;
- Surrey: 38 sites are up and running and about 25 students are in training daily;

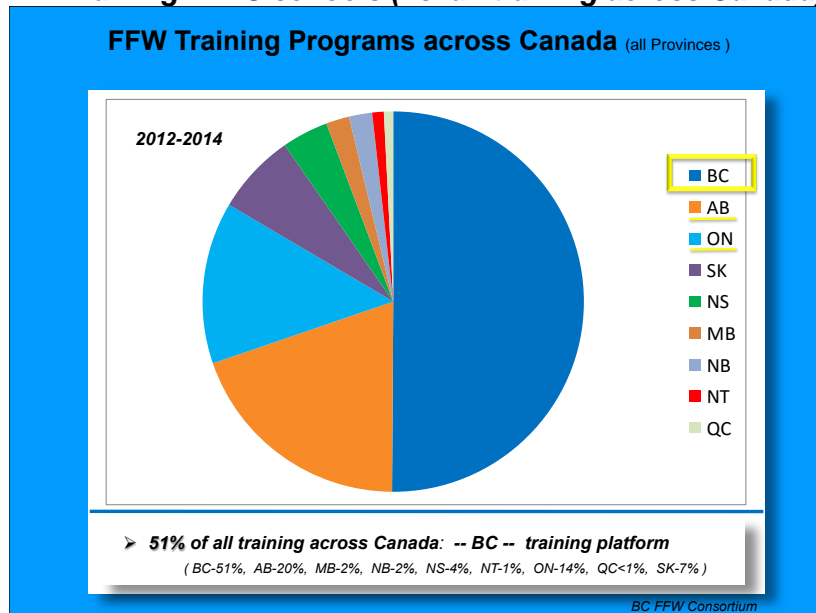
- Vancouver, West Vancouver, Richmond and other school districts, more and more sites are being setup and getting more and more support from their school districts.

"BC FFW Consortium" website: <http://bcfastforword.pbworks.com/w/page/6060644/FrontPage>

### - - - Impact in BC schools (2008 - 2014):



### - - - Training in BC schools (vs. all training across Canada):



### **Challenge and Need for Expansion in BC Schools:**

This interventional training project for child-dyslexia has already achieved change (i) internationally, with more than 2 Million children successfully trained in more than 45 countries world-wide, and (ii) in BC, with enormous impacts across the province now starting to run at 119 schools across 21 school districts, again by far the largest effort across Canada with 51% training in BC alone. While extreme

such success is reported across BC, the BC schools however lack the expertise and infrastructure of scientifically assessing, monitoring and evaluating the detailed and individual success of these interventions.

Therefore, Dr. Ribary's BCNI Institute at SFU, together with all his collaborators and his new addition of Dr. Dikla Ender-Fox, a psychologist and expert on brain plasticity and intervention, are now seeking appropriate funding to bring these interventional programs to the next level, by implementing and expanding assessments tools, publically increase awareness, amplify knowledge translation and implementation for intervention for learning disability (dyslexia) across entire BC, and possibly expanding across Canada (taking BC as a role-model). The impact will be in lives of thousands of children who will benefit from better assessment and reading enhancement intervention. From all the children across Canada about 5-10% from these children could benefit from these programs.

### ***Project-Plans for the next 3 years***

Over the next 3 years, Dr. Ribary's BCNI Institute together with all his colleagues in the Academia and the BC school system will (1) further expand and amplify access to these FastForWord programs, a life altering non-invasive dyslexia treatment for children across BC, as a role-model across Canada. In addition, (2) they will be expanding on these brain-based interventional training programs for child-dyslexia in BC schools, and adding training programs for adult dyslexia as well, boosting general cognitive and memory processing for the typical and atypical human brain, using existing and well-established brain-based cognitive interventional training programs and;

- **reduce increasing annual costs** to schools (and Government) by streamlining training platforms and implementing programs into school curriculum;
- **provide better assessment, intervention application and analysis of intervention outcome** in the school system, and enrich teachers with tools and guidelines for promoting children and adolescents with dyslexia within the class-room and beyond;
- **provide recommendations for further multidisciplinary research** to the Dyslexia Research Consortium (headed by the PI: Urs Ribary);
- **explore options for intervention at a younger age** as a result of increased diagnostic efficiencies;
- **reduce the social and economic burden** of dyslexia on individuals, families, and the health-care system by recommending individually targeted interventional programs to school districts, based on new research results;
- build foundational reading and language skills to **help special needs learners become successful learners** in the general classroom;

#### As a result we expect:

- To train at least 3,000 students/year in BC
- Expand training across BC and possibly to other provinces
- Have better-established guidelines for dyslexia-evaluation, intervention and outcome analysis for the school district and individual classrooms.

#### Follow-up plans:

The increase of awareness, assessment guidelines and research-based intervention, we allow thousands of children better reading skills and quality of life in the long run. The follow-up plans are providing independence to teachers and school districts to professionally implement better assessment and individualized intervention into the classroom, further based on increasing knowledge from brain imaging research continuously translated through workshops.

#### Other Organizations involved:

Among the organizations that will be collaborating on the project will be:

- BCNI Institute and associated teams (SFU, UBC, BC Children's Hospital or BCCH);
- International expert researchers in the field of dyslexia; i.e. Linda Siegel (National/International Language expert at UBC), Paula Tallal (International Language expert, UCSD), Mike Merzenich (Discoverer and World-expert on brain plasticity, UCSF);
- Dyslexia Research Consortium (PI: Urs Ribary with a larger team of expert researchers in language assessments, multimodal brain imaging, intervention and neuroethics including: Linda Siegel, Education-UBC; Alex Mackay, Physics and Radiology-UBC; Alex Rauscher, Pediatrics-UBC-BCCH; Debbie Giashi, Ophthalmology and Visual Sciences-UBC-BCCH; Lawrence Ward, Psychology-UBC; Tony Herdman, Audiology-UBC-SFU; Faisal Beg, Engineering-SFU; Judy Illes, Neurology and Neuroethics-UBC; Janet Chow, BC schools);
- The BC FastForward Intervention Consortium (at BC school);
- School District Boards across BC (with strong support from superintendents and technical directors);
- NeuroDevNet, a Canadian Network of Centres of Excellence (NCE), dedicated to understanding brain development and to helping children and their families overcome the challenges of neurodevelopmental disorders;

### ***Long-term Plans and Goals:***

We envision that in 3 years from now, we will be able to (1) use state-of-the-art assessment guidelines to the best ethical standards, (2) Have thousands of children across BC benefit from the reading intervention (3) Categorize various subtypes of reading disabilities and define the efficient intervention at lower age. (4) Recommend individually targeted and further advanced interventional programs to reorganize and overcome such difficulties, massively reducing the enormous social and economic burden (5) provide recommendations to the Dyslexia Research Consortium for further multidisciplinary research (expansion of assessment, multimodal brain imaging, knowledge translation, intervention), (6) explore funding opportunities from provincial/federal government and private sector to massively expanding training programs and implementation in all BC schools, and across Canada, (7) streamline training platforms and reducing annual costs to schools, by implementing programs into school curriculum and negotiating overall flat-implementation fees with the manufacturing company.

### ***Research Efforts in parallel (Ribary et al.):***

Dyslexia is a result of very complex integration problems at various levels in the human brain, and requires most comprehensive scientific expertise and evaluation. Therefore and in parallel, Dr. Ribary has put together a larger scientific research consortium including expert teams across SFU, BC Children Hospital, UBC, across Canada and the USA including the BC school system. Together with all his expert colleagues, he is approaching BrainCanada funding sources for 1.5M\$ to allow these teams working together:

- (1) to use multimodal brain imaging technologies and scientifically monitor and evaluate the detailed and individual success of these cognitive interventions in BC schools.*
- (2) to further add a needed research component of analyzing why some children benefit a 100% and some only 10-15%, by further exploring and advancing our current knowledge on the very detailed and complex integration problems at various levels in the dyslexic brain, towards individual neurodiagnostic, individual prognosis and expanded interventional therapies.*

The comprehensive research consortium includes behavioral assessments, multimodal brain imaging (MRI, fMRI, EEG, MEG and eye-tracking) applied before and following interventional training programs, and a neuroethics component in conjunction with children at BC schools towards a better

understanding of the underlying integration problems and brain network connectivity in language disabilities and its possible plastic restorations. In addition, using an evidence-based, pragmatic framework, guidelines will be developed to inform (i) better diagnostic evaluation criteria to educators as well as healthcare practitioners, (ii) utilization of criteria by the school system, and, (iii) for individual tailored prediction of outcome and interventional therapies.

*These research consortium efforts, happening in parallel to the facilitation of intervention at BC schools, will provide immense and comprehensive new discoveries, new behavioral and multimodal brain imaging findings, new applications and knowledge translation to further amplify the improving and facilitating of individual interventional training programs for learning disabilities (dyslexia).*

*Dr. Ribary's overall scientific and multidisciplinary consortium-projects will further generate synergy and research capacity building across disciplines and institutions (Simon Fraser University, University of British Columbia, BC Children's Hospital) including the BC school system, to assess, image and characterize child learning disabilities and re-normalization after intervention.*

The ultimate goal is to identify all 5-10% affected learning-disabled children at young pre-school age and start individually targeted intervention and restoration right away before they enter the school curriculum at a most cost-effective and streamlined manner.

### ***Additional international expert advisory teams:***

Dr. Ribary, the Principal Investigator, further includes international expert advisory teams, namely his former collaborators of previous and very successful consortium efforts, all prime international experts relating to language disabilities (Tallal, UCSD), brain plasticity (Merzenich, UCSF) and the neuroscience-based interventional training procedures (Scientific Learning, USA).

## ***Qualifications of PI (Urs Ribary):***

### **Selected PI's Relevant Scientific Publications:**

#### ***Related Papers in high-ranking Scientific and Medical Journals:***

- **U.Ribary**, A.A.Ioannides, K.D.Singh, R.Hasson, J.P.R.Bolton, F.Lado, A.Mogilner and R.Llinas. Magnetic Field Tomography (MFT) of coherent thalamo-cortical 40-Hz oscillations in humans. *Proc. Natl. Acad. Sci. USA*, 88, 11037-11041, 1991.  
**>> In 2003, the most cited research article in the field" (ISI SciSearch: 1970-2003) <<**
- R.Llinas and **U.Ribary**. Coherent 40-Hz oscillation characterizes dream state in humans. *Proc. Natl. Acad. Sci. USA*, 90, 2078-2081, 1993.  
**>> This research has been highlighted in The New York Times <<**  
**>> In 2003, #3 among the "10 most cited papers in the field" (ISI SciSearch: 1970-2003) <<**
- M.Joliot, **U.Ribary** and R.Llinas. Human oscillatory brain activity near 40 Hz coexists with cognitive temporal binding. *Proc. Natl. Acad. Sci. USA*, 91, 11748-11751, 1994.  
**>> In 2005, #10 among the "10 most cited papers in the field" (ISI SciSearch: 1970-2005) <<**
- R.Llinás, **U.Ribary**, and P.Tallal. Dyschronic language-based learning disability. In: *Basic Mechanisms in Cognition and Language*, C.VonEuler, I.Lundberg and R. Llinás, eds., Elsevier Science, New York, pp. 101-108, 1998.
- R.Llinás and **U.Ribary**. Temporal conjunction in thalamocortical transactions. In: *Consciousness: At the Frontiers of Neuroscience*, H.H.Jasper, L.Descarries, V.F.Castellucci, and S.Rossignol, eds., Lippincott-Raven Publishers, Series: Advances in Neurology, 77, 95-103, 1998.
- **U.Ribary**, J.Cappell, A.Mogilner, M.Hund, E.Kronberg and R.Llinas. Functional imaging of plastic changes in the human brain. *Advances in Neurology*, 81, 49-56, 1999.
- **U.Ribary**, M.Joliot, S.L.Miller, E.Kronberg, J.Cappell, P.Tallal, and R.Llinás. Cognitive temporal binding and its relation to 40Hz activity in humans: Alteration during dyslexia. In: *Biomag96*, C.Aine, Y.Okada, G.Stroink, S.Swithenby, and C.C.Wood, eds., Springer Verlag, pp. 971-974, 2000.
- **U.Ribary** and R.Llinás. Discrete time segments of thalamocortical oscillations underlies cognitive human brain function: The use of MEG. *Brain Topography*, 12, 297-298, 2000.
- **Ribary, U.** Dynamics of thalamo-cortical network oscillations and human perception. (Invited Review), *Progr. Brain Res.*, 150, 127-142, 2005.
- Bedo N, **Ribary U**, and Ward LM. Fast dynamics of cortical functional and effective connectivity during word reading. *PLoS ONE* 9(2): e88940, 2014.
- **Ribary U**, Doesburg SM, and Ward LM. Thalamocortical network dynamics: A framework for typical/atypical cortical oscillations and connectivity. In: *Magnetoencephalography*, S.Supek and C.J. Aine, eds, Springer Verlag Heidelberg, in press (2014).

#### ***Related Abstracts in high-ranking Journals and Conference Proceedings:***

- **U.Ribary**, M.Joliot, E.Kronberg and R.Llinas. Human oscillatory brain activity near 40Hz: Correlation with cognitive temporal binding and alteration during dyslexia. *Human Brain Mapping Suppl.* 1, 164, 1995.
- **U.Ribary**, S.L.Miller, M.Joliot, E.Kronberg, M.Rolli, J.Baskin, J.Cappell, P.Tallal and R.Llinás. Early auditory temporal processing and alteration during language-based learning disability. *Neuroimage*, 1997.
- **U.Ribary**, D.Jeanmonod, E.Kronberg, J.Schulman, K.Sauve, R.Ramirez, P.P.Mitra and R.Llinás. Thalamo-

- cortical spatio-temporal dynamics and its alterations in human brain pathology. *Neuroimage*, 11, S168, 2000.
- R.R.Ramirez, C.Horenstein, J.J.Schulman, R.Jagow, P.P.Mitra, E.Kronberg, **U.Ribary** and R.Llinás. Transient and steady-state visual activity in the human brain. *Neuroimage*, 11, S704, 2000.
  - Sauv  , K., Ramirez, R.R., Horenstein, C., Kronberg, E., **Ribary, U.**, and Llin  s, R. Binding across hemispheres: Gamma-band activity covaries with two-tap discrimination. *J.Cogn. Neurosci.*, 2001.
  - Ramirez, R.R., Horenstein, C., Kronberg, E., **Ribary, U.**, and Llin  s, R. Anatomically constrained iterative algorithm for MEG-based mapping of electrical activity in the time and frequency domains. *Neuroimage*, 13, 227, 2001.
  - Horenstein, C., Ramirez, R.R., Kronberg, E., **Ribary, U.**, and Llin  s, R. Neurobiological correlates of apparent motion perception in the human visual system using magnetoencephalography. *Neuroimage*, 13, 893, 2001.
  - Ramirez, RR, van Marle, H.J.F, Kronberg, E., **Ribary, U.** and Llinas R. Large-Scale Integration, Synchronization, and Coherent Brain Dynamics in Single Trials. *NeuroImage*, 19, S34 (505), 2003.
  - van Marle, H.J.F, Ramirez, RR, Kronberg, E., **Ribary, U.** Llinas, R. Event-Related Spectral Perturbations and Coherence During Multi-Modal Perception. *NeuroImage*, 19, S64 (1538), 2003.
  - Sauv  , K., Kronberg, E., **Ribary, U.** Llinas, R. Increasing gamma-band (20-80 Hz) signal-to-noise in MEG evoked responses: A comparison of Independent Component Analysis (ICA) and Principal Component Analysis (PCA). *NeuroImage*, 19, S64 (1515), 2003.
  - **Ribary, U.** Doesburg, S, Herdman, AT, Cheung, T, Mosieev, A, Weinberg, H, Liotti, M, Weeks, D, Grunau, RE. Increased long-range alpha-band phase synchronization during short-term memory retention in children. *Neuroimage*, 47, S144, 2009.
  - Sun, W, Mosieev, A, Beg, F, **Ribary, U.** Virji-Babul, N. Cortical dynamics underlying the visual perception of stationary and moving stimuli. *Biomag2010*, 17<sup>th</sup> International Conference on Biomagnetism, 2010.
  - Stephen JM, Braeutigam S, Furlong PL, **Ribary U.** Roberts TPL, and Virji-Babul N. Pediatric CNS Pathophysiology. *Biomag2010*, 17<sup>th</sup> International Conference on Biomagnetism, 2010.
  - **Ribary, U.** Brain Network Connectivity Dynamics towards Neurodiagnostic Markers and individual Interventional Therapies for Disabilities and Pathologies. *Neurotalk 2011*, pp 114, 2011.
  - **Ribary, U.** Brain Dynamics and Translation into Neurodiagnostic Markers. *IBMISPS*, <www.worldbrainmapping.org>, 2011.
  - Bedo N, **Ribary U.** and Ward LM. Spatio-temporal dynamics and interregional synchronization during letter- and word-reading. 52nd Annual Meeting of the Psychonomic Society, Seattle, USA, November, 2011.
  - Bedo N, **Ribary U.** and Ward LM. International meeting of the American Association for the Advancement of Science (AAAS), Vancouver, Canada, 2012.
  - Bedo N, **Ribary U.** and Ward LM. Connectivity in cortical networks during word-reading. *Cognitive Neuroscience Society*, Chicago, USA, March, 2012.
  - **Ribary U.** Imaging into the human brain: How we perceive and process the outside world, how the brain can reorganize itself, and how the brain alters in cognitive abnormalities and pathologies. *Teachers Educational Day*, West Vancouver, Canada, 2012.
  - **Ribary U.** Doesburg SM, Ward LM. Functional Connectivity Dynamics across the Entire Brain Space Relating to Cognition and Consciousness: Conceptual Perspective. 18<sup>th</sup> International Conference on Biomagnetism, Paris, France. *Biomag*, A-134, 2012.



- **Ribary U**, Doesburg SM, Ward LM. Functional connectivity and dynamics relating to cognition and consciousness: Conceptual perspective. International Human Brain Mapping Society (HBM), Seattle, USA. 2013.
- **Ribary U**. Window into the Human Brain: How we Perceive and Process the outside World, how the Brain can Reorganize itself, and how the Brain alters in Cognitive Abnormalities and Pathologies. BC School Special Education, SD-40, 2013.
- **Ribary U**. The Cognitive-Brain-Network in Health and Disease. International Health and Medical Research Conference, Gold Coast, Australia, 2013.
- **Ribary U**. The Behavioral and Cognitive Neuroscience Institute (BCNI): Establishment of Biomarkers for the Cognitive Human Brain Network in Health and Disease. SFU Health Research Day, 2014.
- **Ribary U**. The Behavioral and Cognitive Neuroscience Institute (BCNI): Neuromarkers at the Brink of Translational Technologies and further Basic/Clinical Brain Imaging Research. Fraser-Health and SFU Health Research Day, 2014.
- **Ribary U**. Neural Biomarkers for the Cognitive-Brain-Network in Health and Disease. Neurotalk, pp. 19-25, 2014.
- **U.Ribary**, R.Llinás, F.Lado, A.Mogilner, A.Ioannides, R.Jagow, M.Joliot and J.Volkman. Origin and characteristics of coherent thalamo-cortical 40-Hz oscillations in the human brain. Soc. Neurosci. Abstr., 18, 1420, 1992.
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- Ramirez, R., Jaramillo, S., Moran, K.A., **Ribary U.**, Llinas, R.R. Single trial neuromagnetic source dynamics. Soc. Neurosci. Abstr., 30, 2004 (on CD ROM).
- **Ribary U**, Doesburg SM, Ward LM. Functional connectivity dynamics across the entire brain space in health and disease: Conceptual perspective. Soc. Neurosci. Abstr., 2012 (on CD ROM).