

## CURRICULUM VITAE

Name : **PATRICIO ORIO**  
Nationality: Chile  
Date of Birth: December 3, 1973  
Address: Centro de Neurociencias de Valparaíso  
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### Academic Positions

2012 - Associate Professor. Department of Neuroscience, Faculty of Sciences, University of Valparaiso, Chile.  
2007 - 2011 Auxiliary Professor. Department of Neuroscience, Faculty of Sciences, University of Valparaiso, Chile.

### EDUCATION

1998-2004 Ph.D. in Biological Sciences. Facultad de Ciencias, Universidad de Chile, Santiago, Chile.  
1992-1997 Biochemistry. Facultad de Ciencias Químicas y Farmacéuticas, Universidad de Chile, Santiago, Chile.

### Titles and Degrees

2004 Ph.D. in Biological Sciences. Facultad de Ciencias, Universidad de Chile, Santiago, Chile.  
2000 Biochemist. Facultad de Ciencias Químicas y Farmacéuticas, Universidad de Chile, Santiago, Chile.

## Research Experience

- 2007 - Modelling of stochastic and dynamical systems applied to neuroscience.
- 2005 - 2007 Electrophysiological Characterization and Quantitative Description of Cold-sensing Neurons. Sensory Transduction and Nociception Laboratory, Instituto de Neurociencias de Alicante (Universidad Miguel Hernández/CSIC), Alicante, Spain.
- 1999 – 2004 Function-Structure Relationships in the BK Potassium Channel and its Regulation by  $\beta$ -subunits. (PhD Thesis). Dr. Ramón Latorre, Laboratorio de Biofísica y Fisiología Molecular, Centro de Estudios Científicos (CECS), Valdivia, Chile.
- 1997 Functional and Molecular characterization of Gap Junctions in human circulating lymphocytes (Thesis for Biochemist title). Dr. Juan Carlos Sáez, P. Universidad Católica de Chile.

## Scientific Grants (last 10 years)

- 2018 – 2020 Fondecyt Grant 1181076 “Chaos versus Noise as drivers of Multistability in Neural Networks”. PI.
- 2017 – 2018 FONDEF-Idea Grant: “Dispositivo neuroingenieril para mejorar el control de la atención de trabajadores en minas a gran altura”. Investigador.
- 2014 – 2019 Basal Grant “Advanced Center for Electronic and Electrical Engineering”. Resarcher.
- 2013 – 2015 Fondecyt 1130862: Conductance-based modeling of the dynamic response of cold thermoreceptors. PI
- 2013 – 2015 Fondecyt 1131064: Cellular And Molecular Determinants of the Abnormal Cold Sensitivity of Primary Sensory Neurons in Response to Axonal Damage. Co-Inv
- 2013 – 2015 Anillo de Ciencia y Tecnología ACT-1113 “Estudio Del Papel Fisiológico De Los Canales TRP En La Termotransducción Y La Plasticidad Sináptica”. PI
- 2013 – 2015 Anillo de Ciencia y Tecnología ACT-1104 “Sensor de Voltage de Canales de Iones: Desde la Estructura a la Función”. Co-Inv.
- 2012 – 2013 ANR/CONICYT-47 “KEOpS: Algorithms for modelling the visual system: From natural vision to numerical applications.” Investigador Asociado.
- 2011 - 2013 INRIA Associated Team ‘Cortina’. (Chile-France).
- 2011 - 2021 Millenium Institute “Centro Interdisciplinario de Neurociencia de Valparaíso CINV”. Adjunt Researcher
- 2009 – 2011 Proyecto FONDECYT de Iniciación en Investigación. “Effect of stochastic channel gating and axonal geometry on sensory transduction and encoding in cold-sensitive nerve endings”. (PI)
- 2008 – 2009 DIPUV Grant (Dir. de Investigación Universidad de Valparaíso): “Modelos de respuesta dinámica en neuronas y terminaciones nerviosas sensibles a frío”. (PI)
- 2007 – 2009 Programa Bicentenario de Ciencia y Tecnología: Inserción de académicos en la Facultad de Ciencias de la Universidad de Valparaíso con perspectivas a la creación de un programa de Doctorado en Ciencias, mención Modelación Estocástica.

## Supervision of Thesis works

- Miguel Piñeiro, PhD thesis in Neuroscience, Universidad de Valparaíso. Finished May, 2018. “Estudio de las propiedades del circuito asociado a las neuronas CCAP AN1 – AN4 y motoneuronas durante la ecdisis a pupa en *Drosophila Melanogaster*”.
- Erick Olivares, PhD thesis in Neuroscience, Universidad de Valparaíso. Finished March, 2014. “Estudio a través de modelación matemática del rol de TRPM8 en el patrón de disparo de terminales nerviosos sensibles a frío.”
- Gaspar Herrera, PhD thesis in Neuroscience, Universidad de Valparaíso (*in progress*). “Injury-associated changes in the expression of KCNA genes in cold-sensitive DRG neurons and their impact on the detection threshold to cold of free nerve endings.”
- Samy Castro, Ph in Neuroscience, Universidad de Valparaíso (*in progress*). “Fluctuaciones Espontáneas en Actividad Neuronal Sostenida: Dinámica Multi-Estable en Modelo de Masas Neuronales

### Undergraduate students.

- Jean Paul Maidana, Mathematical Engineering, Universidad Técnica Federico Santa María. *Graduated December, 2015*. “Análisis matemático de spike-trains con aplicaciones en termorreceptores de frío”.
- Marilyn Gatica, Mathematical Engineering, Universidad de Santiago de Chile. *Graduated November 2014*. “Efecto del ruido multiplicativo en sistemas de ecuaciones diferenciales estocásticas aplicadas a la neurociencia”.
- Mauricio Caviedes, program in Physics, Universidad de Valparaíso. *Graduated August 2014*. “Análisis Geométrico de un modelo de excitabilidad neuronal”.

## Publications

- Orio P, Gatica M, Herzog R, Maidana J, Castro S, Xu K. (2018). Chaos versus Noise as drivers of multistability in neural networks. *Chaos* **28**:106321. doi: 10.1063/1.5043447.
- Xu K, Maidana JP, Castro S, Orio P. (2018) Synchronization transition in neuronal networks composed of chaotic or non-chaotic oscillators. *Sci Rep* **8**: 8370. doi: 10.1038/s41598-018-26730-9
- Richard A, Orio P, Tanré E. (2018) An integrate-and-fire model to generate spike trains with long-range dependence. *J Comput Neurosci* **44**: 297–312. doi: 10.1007/s10827-018-0680-1
- Xu K., Maidana JP, Caviedes M, Quero D, Aguirre P and Orio P. (2017). Hyperpolarization-activated current induces period-doubling cascades and chaos in a cold thermoreceptor model. *Front. Comput. Neurosci.* **11**:12. doi: 10.3389/fncom.2017.00012
- González A., Ugarte G., Restrepo C., Herrera G., Piña R., Gómez-Sánchez JA., Pertusa M., Orio P. and Madrid R. (2017). Role of the excitability brake potassium current IKD in cold allodynia induced by chronic peripheral nerve injury. *J Neurosci* **37**(12):3109-3126; doi:10.1523/JNEUROSCI.3553-16.2017
- González, A., Herrera, G., Ugarte, G., Piña, R., Pertusa, M., Orio, P. and Madrid, R. (2017) IKD current in cold transduction and damage-triggered cold hypersensitivity. *Adv. Exp. Med. Biol.* **1015**:265-277; doi: 10.1007/978-3-319-62817-2\_14.

- Olivares E, Salgado S, Maidana JP, Herrera G, Campos M, Madrid R, Orio P (2015). TRPM8-Dependent Dynamic Response in a Mathematical Model of Cold Thermoreceptor. *PLOS One* **10**:e0139314. doi: 10.1371/journal.pone.0139314
- Leiva V, Tejo M, Guiraud P, Schmachtenberg O, Orio P and Marmolejo-Ramos F (2015). Modeling neural activity with cumulative damage distributions. *Biol Cybern* **109**:421-433. doi: 10.1007/s00422-015-0651-9
- Pezo D, Soudry D and Orio P (2014). Diffusion approximation-based simulation of stochastic ion channels: which method to use?. *Front. Comput. Neurosci.* **8**:139. doi: 10.3389/fncom.2014.00139
- Escobar MJ, Pezo D, Orio P (2013), Mathematical Analysis and Modeling of Motion Direction Selectivity in the Retina. *J Physiol Paris*, **107**(5):349-359
- Boric K, Orio P, Vieville T, Whitlock K (2013). Quantitative analysis of cell migration using optical flow. *PLoS ONE* **8**(7): e69574.
- Orio P., Parra A., Madrid R., González O., Belmonte C., Viana F. (2012) Role of I<sub>h</sub> in the Firing Pattern of Mammalian Cold Thermoreceptors. *J Neurophysiol* **108**:3009-3023
- Orio P. and Soudry D. (2012) Simple and Fast Implementation of the Diffusion Approximation Algorithm for Stochastic Ion Channels with Multiple States. *PLoS ONE* **7**(5): e36670.
- Latorre R., Brauchi S., Madrid R., Orio P. (2011) A Cool Channel in Cold Transduction. *Physiology* **26**:273-285.
- Brauchi S., Orio P. (2011) Voltage Sensing in thermo-TRP channels. *Adv. Exp. Med. Biol.* **704**:517-530.
- Orio P., Madrid R., de la Peña E., Parra A., Meseguer V., Bayliss D.A., Belmonte C., Viana F. (2009) Characteristics and physiological role of hyperpolarization-activated current I<sub>h</sub> in mouse cold thermoreceptors. *J Physiol* **587**:1961-1976.
- González-Pérez V., Neely A., Tapia C., González-Gutiérrez G., Contreras G., Orio P., Lagos V., Rojas G., Estévez T., Stack K., Naranjo D. (2008) Slow inactivation in Shaker K channels is delayed by intracellular tetraethylammonium. *J. Gen. Physiol.* **132**:633-50.
- Orio P., Torres Y., Rojas P., Carvacho I., Garcia M.L., Toro L., Valverde M.A., Latorre R. (2006). Structural Determinants for Functional Coupling Between the  $\alpha$  and  $\beta$  Subunits in the Ca<sup>2+</sup>-activated K<sup>+</sup> (BK) Channel. *J. Gen. Physiol.* **127**:191-204.
- Orio, P., Latorre, R. (2005) Differential effect of  $\beta$ 1 and  $\beta$ 2 subunits on BK Channel Activity. *J. Gen. Physiol.* **125**:395-411.
- Brauchi, S., Orio, P., Latorre, R. (2004) Clues to understanding cold sensation. Thermodynamics and electrophysiological analysis of the cold receptor TRPM8. *Proc Natl Acad Sci USA.* **101**:15494-15499
- Fernández-Fernández, J.M., Tomás, M., Vázquez, E., Orio, P., Latorre, R., Sentí, M., Marrugat, J., Valverde, M.A. (2004). Gain-of-function mutation in the KCNMB1 potassium channel subunit associated with low prevalence of diastolic hypertension. *J. Clin. Invest.* **113**:1032-1039.
- Orio, P; Rojas, P; Ferreira, G; Latorre, R. (2002) New disguises for an old channel: MaxiK channel  $\beta$ -subunits. *Physiology* **17**:156-161
- Bravo-Zehnder, M.; Orio, P.; Norambuena, A.; Wallner, M.; Meera, P.; Toro, L.; Latorre, R.; González, A. (2000) Apical sorting of a voltage- and Ca<sup>2+</sup>-activated K<sup>+</sup> channel  $\alpha$ -subunit in Madin-Darby canine kidney cells is independent of N-glycosylation. *Proc Natl Acad Sci USA* **97**(24):13114-13119.
- Valverde, MA; Rojas, P; Amigo, J; Cosmelli, D; Orio, P; Bahamonde, MI; Mann, GE; Vergara, C; Latorre, R (1999) Acute activation of Maxi-K channels (hSlo) by estradiol binding to the  $\beta$  subunit. *Science* **285**:1929-1931.

- Bitran, M; Tapia, W; Eugenin, E; Orio, P; Boric, MP (1999) Neuropeptide Y Induced inhibition of noradrenaline release in rat hypothalamus: role of receptor subtype and nitric oxide. *Brain Res* **851**:87-93

## Book chapters

Olivares, E; Orio, Patricio. (2015) Mathematical Modeling of TRPM8 and the Cold Thermoreceptors. In: TRP Channels in Sensory Transduction. Madrid, R.; Bacigalupo, J., editors. Springer International Publishing.

Pertusa M, Moldenhauer H, Brauchi S, Latorre R, Madrid R, Orio P. (2012) Mutagenesis and Temperature-Sensitive Little Machines. In: Mutagenesis. Mishra R, editor. InTech.

## Abstracts (last 5 years)

- Xu K, Orio P. Diversity of neuronal activity is provided by mixed (chemical plus electrical) synapses. XIV Annual Meeting of the Chilean Society for Neuroscience. Puerto Varas, Chile, November 2018.

- Palma-Espinosa J, Coronel C, Gatica-Briceño M, Castro S, Orio P. Multi stable dynamics in a brain inspired network model of Wilson Cowan oscillators depends on structural, connectivity and noise properties. XIV Annual Meeting of the Chilean Society for Neuroscience. Puerto Varas, Chile, November 2018.

- Astudillo A, Orio P, Kotz S, Trujillo-Barreto N, El-Deredy W. Resting-state brain switching dynamics in Parkinson's Disease. XIV Annual Meeting of the Chilean Society for Neuroscience. Puerto Varas, Chile, November 2018.

- Madrid R, González A, Ugarte G, Restrepo C, Herrera G, Piña R, Orio P, Pertusa M. Role of the excitability brake potassium current IKD in damage-triggered cold hypersensitivity. XIV Annual Meeting of the Chilean Society for Neuroscience. Puerto Varas, Chile, November 2018.

- Castro S, El-Deredy W, Battaglia D, Orio P. Connectivity structures shape bistable collective cortical dynamics on a largescale model. XIV Annual Meeting of the Chilean Society for Neuroscience. Puerto Varas, Chile, November 2018.

- Madrid R, Herrera G, Orio P. Innocuous and noxious cold specificity emerge from the variability of slowly inactivating Shaker-like current density in a TRPM8-dependent model of peripheral receptor. XIV Annual Meeting of the Chilean Society for Neuroscience. Puerto Varas, Chile, November 2018.

- Orio P, Gatica M, Coronel C, Herzog R, Xu K, Castro S, Maidana JP. Chaos versus Noise as Drivers of Dynamic Functional Connectivity in Neural Networks. Sixth Biennial Conference on Resting State and Brain Connectivity, Montreal, Canada, September 2018.

- Astudillo A, Weinstein A, Orio P, Mendez-Campos JI, Trujillo-Barreto N, El-Deredy W. Loss of Resting State EEG switching dynamics at high geographical altitude: Evidence for loss of cognitive flexibility? Sixth Biennial Conference on Resting State and Brain Connectivity, Montreal, Canada, September 2018

- Castro S., El-Deredy W, Battaglia D, Orio P. Connectivity structures drive multistability of global brain activity. Sixth Biennial Conference on Resting State and Brain Connectivity, Montreal, Canada, September 2018

- Orio P, Villar E, Castro S, Maidana JP. Chaos versus Noise as drivers of Multistability in Neural Networks. 4th International Conference on Mathematical NeuroScience (ICMNS). Antibes-Juan Les Pins, France. June 2018.
- Castro S, Fernandez M, El-Deredy W, Orio P. Local topology of connectome stabilizes the critical range in a model of global neural dynamics. XIII Reunión Anual de la Sociedad Chilena de Neurociencia. Castro, Chile. October 2017
- Medina L, Castro S, Palma J, Escobar MJ, Orio P. Model quantification of direction selectivity in starburst amacrine cells in the mammalian retina. XIII Reunión Anual de la Sociedad Chilena de Neurociencia. Castro, Chile. October 2017
- Maidana J, Gatica M, Nicolis O, Orio P. Comparison of Different Diffusion Approximation Implementations in a Conductance-Based Model of Slow Wave Parabolic Bursting. Reunión Anual de la Sociedad Chilena de Neurociencia. Castro, Chile. October 2017
- Xu K, Orio P. Is chaos making a difference? Synchronization transitions in chaotic and nonchaotic neuronal networks Reunión Anual de la Sociedad Chilena de Neurociencia. Castro, Chile. October 2017
- Olivares J, Orio P, Canales-Johnson A, Valdés J, Schmachtenberg O. Synchrony of neural oscillations in the olfactory system of rainbow trout (*Oncorhynchus mykiss*). Reunión Anual de la Sociedad Chilena de Neurociencia. Castro, Chile. October 2017
- Orio P, Castro S, Xu K, Maidana JP. The interplay between Neural dynamics, Connectivity and Network Dynamics. Reunión Anual de la Sociedad Chilena de Neurociencia. Castro, Chile. October 2017
- Xu K., Maidana JP., Orio P. How chaos in neural oscillators determine network behavior. 26<sup>th</sup> Annual Computational Neuroscience Meeting. Antwerp, Belgium July 2017. doi: 10.1186/s12868-017-0372-1
- Castro S., Fernandez M., El-Deredy W., Orio P. Local topology of connectome stabilizes critical points in mean field model. 26<sup>th</sup> Annual Computational Neuroscience Meeting. Antwerp, Belgium July 2017. doi: 10.1186/s12868-017-0372-1
- Castro S., Fernandez M., Battaglia D., El-Deredy W., Orio P. Effects of the Structural Connectivity on the Critical Transitions of Brain Functional Dynamics. 2<sup>nd</sup> FALAN Congress. Buenos Aires, Argentina. October 2016.
- Herrera G., Ugarte G., Madrid R., Orio P. Modulation of the response properties of skin cold sensitive receptors by slowly-inactivating Shaker-like currents.
- Xu K., Caviedes M., Olivares E. and Orio P. Is chaos making a difference? Synchronization transitions on chaotic and nonchaotic neuronal networks. 2<sup>nd</sup> International Conference on Mathematical Neuroscience. Antibes (France) June 2016. 2<sup>nd</sup> FALAN Congress. Buenos Aires, Argentina. October 2016.
- González, A., Ugarte, G., Restrepo, C., Herrera, G., Piña, R., Gómez-Sánchez, J.A., Pertusa, M., Orio, P. and Madrid, R. Role of the excitability brake potassium current IKD in cold allodynia induced by chronic peripheral nerve injury. Ion Channels Gordon Research Conference: Molecular Basis for Electrical Signaling in the Nervous System and Beyond, South Hadley, USA. 2016.
- González, Alejandro; Ugarte, Gonzalo; Restrepo, Carlos; Herrera, Gaspar; Piña, Ricardo; Pertusa, María; Orio, Patricio and Madrid, Rodolfo.. Role of the excitability break potassium current IKD in cold allodynia. Annual RECI. Barcelona, Spain. 2015
- González, Alejandro; Ugarte, Gonzalo; Restrepo, Carlos; Herrera, Gaspar; Piña, Ricardo; Pertusa, María; Orio, Patricio and Madrid, Rodolfo. 2015. Role of the excitability break potassium current IKD in cold allodynia. Ion channels in the valley. Montegrande, Chile.

- Herrera Pacheco G., Olivares E, Madrid R, Orio P Modeling The Sensitivity Of Cold Thermoreceptor Neurons and Cold Nociceptors In Terms Of ITRPM8 And IKd Current Expression. XI Reunión Anual de la Sociedad Chilena de Neurociencia. Coquimbo, Chile. Septiembre 2015
- Caviedes M, Maidana JP, Quero D, Aguirre P, Orio P. Characterization of chaos in a bursting neuronal model and its interaction with noise. XI Reunión Anual de la Sociedad Chilena de Neurociencia. Coquimbo, Chile. Septiembre 2015.
- Salgado S, Castro S, Escobar MJ, Orio P. Direction selectivity in a network of non-homogeneous Starburst Amacrine Cells (SAC). XI Reunión Anual de la Sociedad Chilena de Neurociencia. Coquimbo, Chile. Septiembre 2015.
- Palma-Espinosa J, Orio P, Rojas P. Change in the position of the action potential initiation site in Granule Cells of the Dentate Gyrus during repetitive firing. XI Reunión Anual de la Sociedad Chilena de Neurociencia. Coquimbo, Chile. Septiembre 2015.
- Piñero M, Mena W, Orio P, Ewer J. Properties of the neural circuit associated to the CCAP AN1-AN4 and motoneurons during the ecdysis into pupa of the *Drosophila melanogaster*. XI Reunión Anual de la Sociedad Chilena de Neurociencia. Coquimbo, Chile. Septiembre 2015.
- Maidana, JP; Caviedes, M.; Gatica, M; Orio P. Unique effects of Channel Noise in a conductance-based model of slow wave parabolic bursting.. 1<sup>st</sup> International Conference on Mathematical Neuroscience. Antibes (France) June 2015.
- Caviedes M., Orio P. Caos en un modelo matemático de terminación nerviosa sensible a frío. XIX Simposio Chileno de Física. Concepción, November 2014
- Castro, S.; Salgado, S.; Escobar, MJ; Orio, P. BUILDING A MATHEMATICAL MODEL OF THE DIRECTION SELECTIVITY IN A STARBURST AMACRINE CELLS NETWORK. X Annual Meeting Sociedad Chilena de Neurociencia. Valdivia, October 2014
- Madrid, R., Restrepo, C., Ugarte, G., González, A., Piña, R., Herrera, G., Orio, P. and Pertusa, M. 2014. Role of IKD current in painful hypersensitivity to cold induced by chronic peripheral nerve injury. IX Fens Forum of Neuroscience, Milan, Italy.
- Herrera-Pacheco, G.; Maidana, J.; Olivares, E.; Madrid, R.; Orio, P. Balance between TRPM8 and Kv1.1-1.2 conductances sets the threshold for cold detection. A modeling study on cold sensitive nerve endings. X Annual Meeting Sociedad Chilena de Neurociencia. Valdivia, October 2014.
- González, A.; Parra, A.; Acosta, MC; Ugarte, G.; Piña, R.; Pertusa, M.; Orio, P.; Viana, F.; Gallar, J.; Belmonte, C.; Madrid, R. Título (Idioma original) : INCIDENCE AND FUNCTIONAL CHARACTERISTICS OF TRIGEMINAL COLDSENSITIVE NEURONS WITH PARADOXICAL RESPONSE TO HEAT. X Annual Meeting Sociedad Chilena de Neurociencia. Valdivia, October 2014
- Building A Mathematical Model Of The Direction Selectivity In A Starburst Amacrine Cells Network. Castro S, Salgado S, Escobar MJ, Orio, P. Reunión Anual de la Sociedad Chilena de Neurociencia. Valdivia, Chile. (Octubre 2014)
- Different ion channels involved in cold transduction: how do we put them together? Orio P, Olivares E, Herrera G, Madrid R. Reunión Anual de la Sociedad Chilena de Neurociencia. Valdivia, Chile. (Octubre 2014)
- The Role Of IKD Current In Painful Hypersensitivity To Cold Induced By Chronic Peripheral Nerve Injury González A, Ugarte G, Restrepo C, Herrera G, Piña R, Pertusa M, Orio P, Madrid, R. Reunión Anual de la Sociedad Chilena de Neurociencia. Valdivia, Chile. (Octubre 2014)