

LAKSHMI RAJAGOPAL, Ph.D.

Research Assistant Professor

Department of Psychiatry & Behavioral Science

Northwestern University, Feinberg School of Medicine

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E-mail: Lakshmi.rajagopal@northwestern.edu

Personal Details

Degree: Ph.D. in Neuropsychopharmacology

Gender: Female

Nationality: Indian on O1 visa; EB1 in progress

Areas of Expertise

Neuropsychopharmacology, Neuropharmacology, Behavioral pharmacology, cognition, psychosis, Major Depressive disorder, Alzheimer's disease, animal behavior test experimental designs, Pharmacology of Preclinical, statistical analyses, and molecular and neuropathology, and Neuroinflammation

Technical Expertise

Behavioral analyses in rats and mice:

- Setting up, optimizing, and testing preclinical behavioral assays
- Use several behavioral assays to investigate cognition in schizophrenia, including: Novel object recognition, spatial novel object recognition, spontaneous alternation behavior (Y-maze), Morris water maze, attentional set-shifting, H-maze, elevated plus maze, and operant reversal learning paradigm.
- Use of open field to gauge locomotor activity [a measure of psychoses].
- Expertise in other behavioral assays such as passive avoidance, fear conditioning and forced swim test, marble burying, and nestlet shredding paradigms.
- Expertise in immunohistochemistry, western blot analysis, Q and RT-PCR (used predominantly for genotyping and for gene expression studies), in-situ hybridization, and basic knowledge in cell culture, ELISA, and confocal microscopy.
- Expertise in overall conception, designing, testing, statistically analyzing, and writing technical reports [for internal as well as peer review publications] of behavioral and molecular studies in both rats and mice.

People Skills

- Strong supervisory and managerial skills. Manage laboratory personnel, undergraduates, masters, and PhD candidates, interns, and summer students. Ability to design and execute studies independently as well as collaboratively as a team.

Summary of Research Expertise

Basic Research: Integral part of Meltzer lab, funded in part by NIMH and other industry grants [such as Allergan, Aptinex, Naurex, DSP, Sunovion, Janssen and Janssen, Acadia, Lilly, Neurocrine, Takeda, etc] to conduct innovative research to unravel receptor mechanisms: 5-H_{1A}, 5-HT₇, 5-HT_{2A}, 5-HT_{2C}, 5-HT₆, alpha 7, GABA_A, GABA_B, D₁, D₂, receptors in mechanism of medicines for neuropsychiatric disorders such as schizophrenia, bipolar disorder, depression, et al. (systemic, local drug administration/ behavioral/neuropathological analyses in C57BL/6J and genetically modified mice). My research investigates the effect of receptor mechanism(s) of interest on neurotransmitter release thereby affecting behavioral and molecular changes [see Rajagopal et al. 2018, 2017], including cognitive, positive and negative symptomatology of schizophrenia and other neuropsychiatric disorders such as Alzheimer's, Parkinsons, Tardive Dyskinesia and Major depressive disorders.

Preclinical Research for Drug development:

[Contracts, shown as the names of drug and Pharmaceuticals]- Ongoing

Lurasidone /Blonanserin/Tandospirone	Dainippon Sumitomo, Japan
SEP856	Sunovion
Genetic mice model of schizophrenia	Astellas
GLYX	Naurex
RP5063	Reviva
Rapastinel	Allergan
AGN251	Allergan
D1-PAM	Lilly
Pimavanserin	Acadia
Prevagen; Apoaequorin	Quincy

Clinical Research:

Completed Institutional Review Board (IRB) training (February 2015).

Study team member/coordinator for, "Improving Outcome in Schizophrenia Through

Identification of Genetic Risk Factors" and "Magnesium Threonate (MgT) on cognitive impairment in schizophrenia" studies. My roles were - a) to identify functional changes pre, during, and post magnesium threonate administration using validated protocols. b) was assigned to a board-certified psychiatrist, as part of the patient interview process - pre, during, and post drug treatments.

PROFESSIONAL EXPERIENCE

1. Department of Psychiatry & Behavioral Science, Northwestern University, Feinberg School of Medicine, Chicago, IL

Postdoctoral Research Fellow [Jan 2012 to Jan 2019] & Research associate [Feb 2019 – June 2022]

Research Assistant Professor [June 2022 – present]

Research area Experience:

Setting up and managing the Behavioral Core of the laboratory.

Paradigms set up and currently using: NOR, spatial NOR, SAB, reversal learning, LMA, MWM, H-maze, PPI, marble burying, Nestlet Shredding, forced swim and tail suspension tests,

Setting up Western Blot, immunohistochemistry (Nissl Body and Fluoro-Jade C) assays.

Breeding, genotyping, and maintaining genetically modified mice.

Generating constitutive and conditioned 5-HT7R knock-out mice - based on our crucial findings from pharmacological manipulations in rats, I initiated and successfully produced several generations of constitutive and conditional 5-HT7 knock-out mice [x 4 first author research manuscripts in progress]

DEA liaison - Point person to handle controlled substances in the laboratory.

Writing, reviewing, obtaining approval for all the IACUC Protocols

Working on grant applications, contracts, reports and research papers

Supervising Medical interns, graduate, masters, and PhD candidates and summer interns

2. Quality Manager (Medical Transcription): (Nov 1999-Sep 2003)

Worked as a quality manager in LG Medical Transcription unit managing 500+ editors/transcriptionists, and 5 companies in total.

EDUCATION AND TRAINING

Graduate (Ph.D.)

January 2008—December 2011

Major: Neuropsychopharmacology

University of Bradford, School of Pharmacy, Bradford, United Kingdom.

Dissertation Title: Neonatal Phencyclidine (PCP) induced deficits in rats: A behavioral investigation of relevance to schizophrenia

Techniques used: *Behavioral testing & immunohistochemistry*

Advisors: Professor Joanna Neill (Manchester University, UK) and Dr. Michael Harte (Manchester University, UK)

Masters Degree (MEP) - June 1995-May 1997

Major: Environmental Protection; Delhi University, Delhi, India

B.Sc degree - Sep 1992-May 1995

Major: Zoology; allied: Botany/Chemistry; Women's Christian College, Chennai, India

Honors and Awards

- Awarded certificate of recognition by the United States Army, Navy, and Air Force for mentorship of a summer intern - Junior Science & Humanities Symposium, semi-finalist (2016)
- Received "Service Excellence Award" from Northwestern University, Feinberg School of Medicine for excellence in research, mentorship, and knowledge (2017)
- Awarded Travel Award from British Association of Pharmacology for poster presentation (2009; 2010);
- Awarded full Travel Award for abstract/poster presentation at CINF, Florence, Italy (2010).
- Awarded full Travel Award for abstract/poster presentation at ECNP conference, France (2008).
- Nominated and included in Marquis Who's who top researchers in America (2017).

Invited Talks

- Invited speaker - 34th CINF World Congress of Neuropsychopharmacology – 2023 [May 7-10, 2023].
- Friday Digest 2012-2013, Northwestern University, Abbott Hall, Chicago, IL.
- Departmental Grand Rounds 3rd Annual NUIN Student/Postdoc Neuroscience Research Data Blitz Feb-18-2015, Northwestern University, Chicago, IL. Topic
- Friday Digest 2016-2017 (11-18-2016), Northwestern University, Abbott, Hall, Chicago, IL.

Positions and Professional Memberships

2022 – present: Guest reviewer at International Neuropsychopharmacology

2021 – present: Editor at Frontiers in Pharmacology

2020 [Feb] – present: Associate Editor at Frontiers in Aging Neuroscience

2019-present: Guest Editor – Schizophrenia Research

2018- Lead guest editor for a special issue at Neural Plasticity Peer review journal

2016-present: Guest Editor – Psychopharmacology

2015-present: Editorial Board Member at Journal of Neuropsychiatry

2015-2020: Editorial Board Member at Frontiers in Aging Neuroscience

2013-present: SfN (Society for Neuroscience), USA

2008-2012 BAP (British Association of Psychopharmacology) UK

Publications

2024

Rajagopal L, Huang M, Mahjour S, Ryan C, Elzokaky A, Svensson KA, Meltzer HY. The dopamine D1 receptor positive allosteric modulator, DETQ, improves cognition and social interaction in aged mice and enhances cortical and hippocampal acetylcholine efflux. *Behav Brain Res.* 2024 Feb 29;459:114766. doi: 10.1016/j.bbr.2023.114766. Epub 2023 Dec 3. PMID: 38048913.

2023

Rajagopal L, Mahjour S, Huang M, Ryan CA, Elzokaky A, Csakai AJ, Orr MJ, Scheidt K, Meltzer HY. NU-1223, a simplified analog of alstonine, with 5-HT_{2c}R agonist-like activity, rescues memory deficit and positive and negative symptoms in subchronic phencyclidine mouse model of schizophrenia. *Behav Brain Res.* 2023 Oct 2;454:114614. doi: 10.1016/j.bbr.2023.114614. Epub 2023 Aug 10. PMID: 37572758.

2022

Rajagopal, Lakshmi and Huang, Mei and He, Wenqi and Ryan, Chelsea and Elzokaky, Ahmad and Banerjee, Pradeep and Meltzer, Herbert Y. [2022] Repeated Administration of Rapastinel Produces Exceptionally Prolonged Rescue of Memory Deficits in Phencyclidine-Treated Mice. *BBRES-D-22-00157*, SSRN: <https://ssrn.com/abstract=4042881> or <http://dx.doi.org/10.2139/ssrn.4042881>

2021

L. Rajagopal, C. Ryan, A. Elzokaky, E. Burstein and H. Meltzer [2021]. Pimavanserin augments the efficacy of atypical antipsychotic drugs in a mouse model of treatment-refractory negative symptoms of schizophrenia. *Behavioural Brain Research* 2021 Pages 113710

L. Rajagopal, H. R. Kim, H. Y. Meltzer and M. Martina [2021]. Depolarizing GABAA current in the prefrontal cortex is linked with cognitive impairment in a mouse model relevant for schizophrenia. *Science Advances* 2021 Vol. 7 Issue 14 Pages eaba5032.

Hideo Hagihara, Hirotaka Shoji, Giovanni Sala, Yoshihiro Takamiya, Mika Tanaka, Yoko Hagino, Hiroko Kotajima-Murakami, Kazutaka Ikeda, Hikari Otabi, Atsushi Toyoda, Mohamed Darwish, Hirofumi Nishizono, Keizo Takao, Kei Hori, Mikio Hoshino, Hyopil Kim, Bong-Kiun Kaang, Takao Kohno, Mitsuharu Hattori, Ken-ichi Matsumoto, Shigeo Okabe, Michiru Ida-Eto, Masaaki Narita, Haruki Fujisawa, Yoshihisa Sugimura, Tadahiro Numakawa, Hiroshi Kunugi, Katsuhiko Tabuchi, Yuta Katayama, Keiichi I Nakayama, Masayuki Matsushita, Johji Inazawa, Tohru Yamamoto, Haruko Nakamura, Yoshio Goshima, Hikari Hatakama, Nozomi Asaoka, Shuji Kaneko, Tetsuya Tatsukawa, Matthieu Raveau, Kazuhiro Yamakawa, Masafumi Ihara, Kyosuke Yamanishi, Kiran Sapkota, Kazutoshi Nakazawa, Isabella A Graef, Shuji Wakatsuki, Toshiyuki Araki, Kota Tamada, Toru Takumi, Iori Ohmori, Nanette Deneen Hannah, **Lakshmi Rajagopal**, Herbert Y Meltzer, Ikuo Nobuhisa, Tetsushi Kagawa, Tetsuya Taga, Akito Nakao, Yasuo Mori, Shota Katori, Takuya Sato, Takuji Iwasato, Noboru H Komiyama, Seth GN Grant, Anja Urbach, Lea J Becker, Ipek Yalcin, Tsuyoshi Takagi, Takaoki Kasahara, Tadafumi Kato, Yoshio Hoshiba, Ryuhei Miyake, Kisho Obi-Nagata, Akiko Hayashi-

Takagi, Mihiro Shibutani, Izuhō Hatada, Shunsuke Ishii, Atsuko Hayata-Takano, Hitoshi Hashimoto, Noriko Takahashi, Haruo Kasai, Emiko Okuda-Ashitaka, Freesia L Huang, Tadayuki Shimada, Kanato Yamagata, Tsuyoshi Miyakawa. Systematic analysis of brain lactate and pH levels in 65 animal models related to neuropsychiatric conditions [2021]. *BioRxiv*. <https://doi.org/10.1101/2021.02.02.428362>.

2020

H. Meltzer, **L. Rajagopal**, M. Huang and K. Svensson [2020]. The D1 Positive Allosteric Modulator, DETQ, Improves Cognition in Aged Mice and Enhance Cortical and Hippocampal Acetylcholine Efflux. *Neuropsychopharmacology*. Publisher: Nature Pages: 278-279.

M. Huang, W. He, **L. Rajagopal**, A. Kudwa, D. E. Grigoriadis and H. Y. Meltzer [2020]. Effects of NBI-98782, a selective vesicular monoamine transporter 2 (VMAT2) inhibitor, on neurotransmitter efflux and phencyclidine-induced locomotor activity: Relevance to tardive dyskinesia and antipsychotic action. *Pharmacology Biochemistry and Behavior* 2020 Vol. 190.

2019

H. Y. Meltzer, **L. Rajagopal**, F. Matrisciano, J. Hao, K. A. Svensson and M. Huang [2019]. The allosteric dopamine D1 receptor potentiator, DETQ, ameliorates subchronic phencyclidine-induced object recognition memory deficits and enhances cortical acetylcholine efflux in male humanized D1 receptor knock-in mice. *Behav brain res*.2019 Vol. 361 Pages 139-150.

H. Meltzer, **L. Rajagopal** and M. Huang [2019]. F199. The Positive Dopamine D1 potentiator, DETQ, Ameliorates Subchronic PCP-Induced Cognitive Deficits and Increases Ach Efflux in Human D1R Knock-In Mice. *Biological Psychiatry* 2019 Vol. 85 Issue 10 Pages S290.

H. Meltzer and **L. Rajagopal** [2019]. Effectiveness of Pimavanserin, a Selective 5-HT_{2A} Inverse Agonism, Alone and in Combination With Atypical Antipsychotic Drugs as Treatment for Positive and Negative Symptoms. *Neuropsychopharmacology*. Publisher: Nature. Pages: 186-186.

2018

L. Rajagopal, D. Soni and H. Meltzer [2018]. Neurosteroid pregnenolone sulfate, alone, and as augmentation of lurasidone or tandospirone, rescues phencyclidine-induced deficits in cognitive function and social interaction. *Behavioural brain research* 2018 Vol. 350 Pages 31-43

L. Rajagopal, M. Huang, E. Michael, S. Kwon and H. Y. Meltzer [2018]. TPA-023 attenuates subchronic phencyclidine-induced declarative and reversal learning deficits via GABA A receptor agonist mechanism: possible therapeutic target for cognitive deficit in schizophrenia. *Neuropsychopharmacology* 2018 Vol. 43 Issue 12 Pages 2468-2477.

H. Meltzer, M. Miyauchi, **L. Rajagopal**, N. Neugebauer and M. Huang [2018]. 257. Differential Hippocampal and Prefrontal Cortical E/I Imbalances Related to GABA_A Dysfunction Contribute to the Subchronic Phencyclidine-Induced Deficits in Mouse Memory, Social Interaction and Psychosis Readout. *Biological Psychiatry* 2018 Vol. 83 Issue 9 Pages S104.

M. Huang, S. Kwon, **L. Rajagopal**, W. He and H. Y. Meltzer [2018]. 5-HT_{1A}R partial agonism and 5-HT₇ antagonism restore episodic memory in subchronic phencyclidine-treated mice: role of brain glutamate, dopamine, acetylcholine and GABA. *Psychopharmacology* 2018 Vol. 235 Issue 10 Pages 2795-2808.

2017

L. Rajagopal, S. Kwon, M. Huang, E. Michael, L. Bhat, M. Cantillo [2017]. RP5063, an atypical antipsychotic drug with a unique pharmacologic profile, improves declarative memory and psychosis in mouse models of schizophrenia. *Behavioural brain research* 2017 Vol. 332 Pages 180-199

M. Huang, W. He, A. Kudwa, D. Grigoriadis, **L. Rajagopal** and H. Meltzer [2017]. Effect of NBI-98782, a Selective Vesicular Monoamine Transporter 2 (VMAT2) Inhibitor, on Neurotransmitter Efflux and Phencyclidine-and Amphetamine-Induced Locomotor Activity: Relevance to Tardive Dyskinesia, Psychosis, and Cognition. *Neuropsychopharmacology*. Publisher: Nature Pages: S228-S229.

2016

L. Rajagopal, B. W. Massey, E. Michael and H. Y. Meltzer [2016]. Serotonin (5-HT) 1A receptor agonism and 5-HT₇ receptor antagonism ameliorate the subchronic phencyclidine-induced deficit in executive functioning in mice. *Psychopharmacology* 2016 Vol. 233 Issue 4 Pages 649-660

L. Rajagopal, J. S. Burgdorf, J. R. Moskal and H. Y. Meltzer [2016]. GLYX-13 (rapastinel) ameliorates subchronic phencyclidine-and ketamine-induced declarative memory deficits in mice. *Behav brain res.* 2016 Vol. 299 Pages 105-110.

Book Chapter-N. M. Neugebauer, **L. Rajagopal**, M. Huang and H. Y. Meltzer [2016]. Phencyclidine (PCP)-induced deficits in novel object recognition in: *Neuropathology of Drug Addictions and Substance Misuse*. Academic Press 2016

M. Miyauchi, M. Huang, S. Kwon, **L. Rajagopal**, N. M. Neugebauer and H. Y. Meltzer [2016]. PM430. Blonanserin reversed phencyclidine-induced novel object recognition deficit and induced cortical dopamine and acetylcholine efflux through dopamine D₃ receptor antagonism. *Intl. of Neuropsychopharmacology* 2016 Vol. 19 Issue Suppl 1 Pages 56.

M. Miyauchi, M. Huang, S. Kwon, **L. Rajagopal**, N. M. Neugebauer and H. Y. Meltzer [2016]. Blonanserin reversed phencyclidine-induced novel object recognition deficit and induced cortical dopamine and acetylcholine efflux through dopamine D₃ receptor antagonism. *Intl. J. of Neuropsychopharmacology*. Publisher: Oxford Univ Press. Pages: 205-206

2015

Y. Oyamada, M. Horiguchi, **L. Rajagopal**, M. Miyauchi and H. Y. Meltzer [2015]. Combined serotonin (5-HT) 1A agonism, 5-HT_{2A} and dopamine D₂ receptor antagonism reproduces atypical antipsychotic drug effects on phencyclidine-impaired novel object recognition in rats. *Behavioural brain research* 2015 Vol. 285 Pages 165-175

M. Huang, S. Kwon, Y. Oyamada, **L. Rajagopal**, M. Miyauchi and H. Y. Meltzer [2015]. Dopamine D3 receptor antagonism contributes to blonanserin-induced cortical dopamine and acetylcholine efflux and cognitive improvement. *Pharmacology Biochemistry and Behavior* 2015 Vol. 138 Pages 49-57

2014

L. Rajagopal, B. W Massey, M. Huang, Y. Oyamada and H. Y Meltzer [2014]. The novel object recognition test in rodents in relation to cognitive impairment in schizophrenia. *Current pharmaceutical design* 2014 Vol. 20 Issue 31 Pages 5104-5114

M. Miyauchi, H. Meltzer, **L. Rajagopal**, M. Huang and Y. Oyamada [2014]. Clarifying the Role of alpha 4 beta 2 and alpha 7 Nicotinic Acetylcholine Receptors for the Ability of Lurasidone to Restore Novel Object Recognition in Sub-chronic Phencyclidine-treated Rats. *Neuropsychopharmacology* 2014. Publisher: Nature Publishing Group. Pages: S164-S164.

H. Meltzer, Y. Oyamada, **L. Rajagopal** and J. Li [2014]. Cognitive impairment and response to antipsychotic drug treatment as intermediate phenotypes in schizophrenia: Integrating animal model, genetic and clinical trial approaches. *Int. J. of Neuropsychopharmacology*. Publisher: Cambridge Univ. press. Pages: 12-12.

M.Huang, **L. Rajagopal**, S. Kwon, E. Michael and H. Meltzer [2014]. The Importance of 5-HT₇ Receptor Blockade for Cognitive Enhancement and Antipsychotic Drug Action. *Neuropsychopharmacology*. Publisher: Nature. Pages: S171-S171.

M. Huang, J. J. Panos, S. Kwon, Y. Oyamada, **L. Rajagopal** and H. Y. Meltzer [2014]. Comparative effect of lurasidone and blonanserin on cortical glutamate, dopamine, and acetylcholine efflux: role of relative serotonin (5-HT) 2A and DA D2 antagonism and 5-HT 1A partial agonism. *J. Neuro.Chem* 2014 Vol. 128 Issue 6 Pages 938-949.

2013

H. Y. Meltzer, **L. Rajagopal**, M. Huang, Y. Oyamada, S. Kwon and M. Horiguchi [2013]. Translating the N-methyl-D-aspartate receptor antagonist model of schizophrenia to treatments for cognitive impairment in schizophrenia. *International Journal of Neuropsychopharmacology* 2013 Vol. 16 Issue 10 Pages 2181-2194.

2011/2012

L. Rajagopal [2012]. Neonatal Phencyclidine (PCP) induced deficits in rats: A behavioural investigation of relevance to schizophrenia. University of Bradford 2012

2010

L. Rajagopal, M. Harte and J. Neill [2010]. Neonatal Phencyclidine induces long-term object memory deficits in male and female rats: reversal by risperidone, but not haloperidol. *Schizophrenia Research* 2010 Vol. 117 Issue 2-3 Pages 319-320

L. Rajagopal, M. Harte and J. Neill [2010]. Risperidone, but not haloperidol reverses the object memory deficits induced by neonatal phencyclidine in adult rats. *J. Psychopharm*, Pages: A46-A46.

L. Rajagopal, M. Harte and J. Neill [2009]. P. 2.19 Evaluation of neonatal phencyclidine treatment in male and female rats: a neurodevelopmental model of schizophrenia. *Eur.*

Neuropsychopharmacology Vol. 19 Pages S49.

J. C. Neill, S. Barnes, S. Cook, B. Grayson, N. F. Idris, S. L. McLean, **L. Rajagopal**, M. Harte [2010]. Animal models of cognitive dysfunction and negative symptoms of schizophrenia: focus on NMDA receptor antagonism. Pharmacology & therapeutics 2010 Vol. 128 Issue 3 Pages 419-432.

Book chapter: Neugebauer, N; **Rajagopal, L**; Huang, M; Meltzer, HY. Chapter 67: Phencyclidine (PCP)-Induced Deficits in Novel Object Recognition. In: Neuropathology of Drug Addiction and Substance Misuse, Volume 2.

List of manuscripts currently in progress/submitted and/or under review.

Lakshmi Rajagopal, Sanaz Mahjour, Mei Huang, Mahdi Arshadi, Mark Underwood, Herbert Y. Meltzer [2021]. Apoeaquorin improves cognitive and social interaction deficits in aged mice to be submitted to Neuropharmacology

Mei Huang, **Lakshmi Rajagopal**, Dominica Lange, Herbert Y Meltzer. Oral apoeaquorin increases basal monoamine and glutamate efflux and attenuates phencyclidine-induced monoamine efflux and cognitive deficits [2021]. J. of Pharmacology and Neurochemistry.

Rajagopal L, Huang M, Ryan C, Elzokaky A, Svensson K, Meltzer HY [2021]. The D₁R positive allosteric modulator, DETQ, improves cognition and social interaction in aged mice and enhances cortical and hippocampal acetylcholine efflux. Behav.Brain Res.

Extracurricular Interests/activities:

Blog: <https://www.areyoupsyched.com/> (Blog) Domain: <https://www.areyoupsyched.com/>

Websites for my paintings:

April 2021 – October 2021: Child Factor International Art Impact Exhibition, Washington DC - I had an original Painting exhibit with other artists.

October 2022 – November 2022: Our Voice. Our Power: Reflections of Resilience, Deering Library, Northwestern University, Chicago, IL: I showed 2 paintings.

Fineartamerica website: lakshmi-rajagopal.pixels.com

Artspan website: <http://rajagopallakshmi.artspan.com>.

References - Available upon request