Department of Anesthesiology
UNIVERSITY of WASHINGTON

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October 6th, 2020
Dear GPCR Selection Committee,

I am writing to apply for the GPCR Postdoctoral Seminar Series at Vanderbilt University. I am currently an Acting Instructor with Dr. Michael Bruchas at the University of Washington School of Medicine and UW Center of Excellence in Neurobiology of Addiction, Pain, and Emotion (NAPE). I am currently funded by a NIDA K99/R00 Pathway-to-Independence Award (K99DA049862).

Throughout my graduate and postdoctoral training, I have sought to understand **how neuropeptides regulate affective and motivated behaviors** in mesocorticolimbic reward circuits. My graduate research with Dr. Kent Berridge at the University of Michigan centered on understanding how discrete sites in the brain generate or modulate affective or motivated behaviors, with a strong emphasis on **systematic anatomical mapping and intensive behavioral analysis**. These studies resulted in 3 first author research papers in *Journal of Neuroscience, Neuropsychopharmacology,* and *PNAS.* My postdoctoral research with Dr. Bruchas has extended the scope of my training by expanding my scientific toolbox and developing new technologies to study peptide systems *in vivo*. My primary research focus has been to investigate **how mu opioid receptors in nucleus accumbens medial shell control motivation**. Using a combination of pharmacological disruption, receptor specific genetic deletion and rescue, in situ hybridization colocalization and mapping, *in vivo* calcium imaging, and cell-type specific CRISPR-Cas9 modulation of neuropeptides, I have discovered that mu receptors act on dorsal raphe projections to nucleus accumbens to selectively augment motivation during stressful states. This project **provides a roadmap for how to systemically and comprehensively study other peptide systems within reward circuits**. In a parallel series of experiments, I have been using 1- and 2-photon *in vivo* calcium imaging to **identify how discrete projection populations within NAc medial shell encode and transmit reward related information to downstream targets.** Lastly, I have helped to develop two next-generation wireless optofluidic platforms capable of optogenetic stimulation and drug delivery. These studies have resulted in two published manuscripts, one in *Nature Biomedical Engineering*, the second in *PNAS*.

Looking towards the future, the research program I have developed for **my own lab will use the next-generation techniques and circuit-based experimental approaches I established during my postdoc to investigate the affective systems I defined during my graduate career**. The long-term goal will be to determine how affective systems are misattributed in specific psychopathological contexts, such as during unrelenting pain in chronic pain, the loss of pleasure in individuals with depression, and the uncoupling of affect from motivation that occurs during drug addiction.

Finally, I would like to affirm my commitment to mentorship and promoting academic and social equity. As a member of the LGBTQ+ and Latinx communities, I recognize the importance of diverse representation, and the importance of using one's privilege to foster equity and inclusion across multiple domains. Scientific discovery does not occur in a vacuum, and I strongly believe that we must be cognizant of, and responsible for, our actions and the ways we interact with our colleagues.

Enclosed, please find the requested materials. If you require any additional materials or information, please let me know and I will be happy to provide it. Thank you for your consideration.

Sincerely,

Daniel C. Castro, PhD

ABSTRACT
Overdose deaths involving opioids have skyrocketed over the last 10 years. Most highly addictive opioids preferentially act on mu opioid receptors (MORs). One major site of MOR action is nucleus accumbens medial shell (NAc). Here, we sought to determine where, when, and how MORs mediate motivated behaviors. We used a food intake task in which mice had free access to sucrose pellets for one hour while either ad libitum or after 24 hours of food deprivation. Initial tests using MOR KOs indicated that MORs were selectively necessary for hunger enhanced intake, but not ad libitum intake. Local MOR antagonsim in NAc similarly decreased hunger enhanced intake. FISH experiments showed that MORs are predominately expressed on medium spiny neurons. We crossed Oprm1fl/fl mice with dynorphin or enkephalin-cre mouse lines to delete receptors from that particular cell type. Only loss of MORs on enkephalin neurons resulted in decreased intake. We also deleted MORs via local or retrograde viral injections in NAc. Only retrograde deletion resulted in reduced intake. Tracing and FISH experiments revealed that MORs are expressed on more than 50% of enkephalinergic lateral dorsal raphe (lDRN)→NAc projections, and electrophysiological experiments confirmed monosynaptic connections. Fiber photometry experiments showed that lDRN→NAc terminals dramatically reduce their activity at the onset of consumption. This inhibition is blunted by naloxone. To test MOR functionality, we injected a MOR rescue virus into DRN of MOR KO x enkephalin-cre mice, or the light-activated opto-XR oMOR, to selectively activate MORs on lDRN→NAc terminals. Both manipulations increased food intake. Ongoing experiments using in vivo 1-photon microscopy indicate that local NAc D2/enkephalin neurons may be the endogenous source for MORs in this circuit. Complimentary experiments using DREADDs and cell-type specific caspase or CRISPR guided deletion of specific opioid peptides further lends support for local NAc D2/enkephalin populations as the source.

FUTURE RESEARCH

As an advanced postdoc, I am in the process of designing my own unique research program. Below I briefly describe some of the experiments I plan to pursue upon starting my lab. **The overall goal of my research program is to identify what neural substrates generate, modulate and coordinate positive and negative affect in the brain.**

Previous work has demonstrated that MOR activation in NAc medial shell can enhance both motivated 'wanting' for food and affective 'liking' for sucrose. Suprisingly, MOR enhancement of 'liking' is limited to the rostral half of NAc (hedonic hotspot), whereas the enhancement of 'wanting' extends into caudal sites that coincide with the hedonic coldspot. It has also been shown that MOR stimualted enhancements of 'liking' in one hotspot (e.g., NAc) requires functional MORs in another hotspot (e.g., ventral pallidum). In contrast, MOR stimulated 'wanting' for food in NAc remains intact regardless of MOR availabliity in the other hotspots. The dissociation between the anatomically restricted and functinally linked hedonic 'liking' circuits versus the relatively independent motivated 'wanting' circuits points to separable biological mechanisms. Therefore, *my lab will apply the molecular, genetic, imaging, and CRISPR approaches I developed during my postdoc to determine what mechanisms underlie mu opioid receptor control of affect in nucleus accumbens*.

Specifically, we will use local pharmacology and genetic deletions/rescues to comprehensively map the boundaries of the hedonic hotspot and coldspot, utilizing viral, in situ, and tissue clearing approaches to systematically designate their boundaries. Through the use of *in vivo* calcium imaging and selective receptor deletion or rescue, we will isolate specific neural ensembles and evaluate how mu receptors contribute to endogenous encoding of affect. Finally, the development of molecular tools via CRISPR-Cas9 will allow for a complementary investigation into the molecular mechanisms of MORs. We will determine the contribution of G-protein versus beta-arrestin signaling within the hotspot and coldspot, which may have implications for how mu-opioid mediated changes in affect are signaled. It may also allow for more restricted localization studies, as we could use specialized viral vectors to selectively augment receptor/G-protein/neurotransmitter expression on cell bodies versus axon terminals. In a parallel set of experiments, my lab will investigate how nucleus accumbens processes 'disgust'/aversion. Though significantly less is known about 'disgust' neurocircuitry, there is bourgeoning evidence for an anatomically restricted 'disgust' hotspot, located in the same site as the hedonic coldspot. While these sites overlap, it is likely that separate neurochemical systems mediate positive and negative affect. *My lab will seek to establish how nucleus accumbens encodes and generates negative 'disgust', and how it is embedded within a larger 'disgust' network.* Overall, I am interested in uncovering the blueprints for how affect is generated, manipulated, and encoded in nucleus accumbens, as this is the first step towards developing more direct and efficacious treatments for those who are unable to experience pleasure (anhedonic depression), have difficulty abstaining from or avoiding unhealthy foods (obesity), or suffer from prolonged agony (chronic pain).

Daniel C Castro, PhD

Updated September 2020

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EDUCATION AND TRAINING

2020- Acting Instructor
Department of Anesthesiology and Pain Medicine
University of Washington, Seattle, WA
Mentor: Michael Bruchas, Ph.D.

2018-2020 Senior Postdoctoral Fellow
Department of Anesthesiology and Pain Medicine
University of Washington, Seattle, WA
Mentor: Michael Bruchas, Ph.D.

2016-2018 Postdoctoral Research Scholar
Department of Anesthesiology
Washington University in St. Louis, St. Louis, MO
Mentor: Michael Bruchas, Ph.D.

2011-2016 Graduate Student
Psychology/Biopsychology (M.S., 2014), Psychology/Biopsychology (PhD, 2016)
University of Michigan, Ann Arbor, MI
Thesis Advisor & Mentor: Kent Berridge, Ph.D.

2008-2011 Undergraduate
Psychology, B.S., Honors
University of Washington, Seattle, WA
Mentors: Jeansok J. Kim, Ph.D. and Sapna Cheryan, Ph.D.

RESEARCH SUPPORT

2020-present **K99/R00 Pathway to Independence Award – K99DA049862**
- *Agency:* National Institute on Drug Abuse (NIDA)
- *Title:* Physiological and molecular mechanisms of mu opioid receptors in motivation
- *Total Support:* $141,997/year

2018-2020 **F32 Individual Postdoctoral Fellowship - DA043999-02**
- *Agency:* National Institute on Drug Abuse (NIDA)
- *Title:* Dissecting the role and mechanisms of mu opioid receptors in nucleus accumbens
- *Total Support:* $61,610/year

2017 **W.M. Keck Fellowship (awarded)**
- *Institute:* Washington University in St. Louis, Division of Biology and Biomedical Sciences

2017 **McDonnell Center for Cellular and Molecular Neurobiology Fellowship (awarded)**
- *Institute:* Washington University in St. Louis

2016-2017 **T32 Neurosciences Individual Postdoctoral Training Grant – NS007205**
- *Agency:* National Institute of Neurological Disorders and Stroke (NINDS)
- *Title:* Examining the role of ventral striatal neuropeptides in pain and motivation
- *Total Support:* $43,692
- *Principal Investigator:* David M. Holtzman, Ph.D.

2016 **Rackham One Term Dissertation Fellowship**
- *Institute:* University of Michigan, Rackham Graduate School
- *Total Support:* $10,200

2012-2014 **T32 Hearing, Balance and Chemical Senses Predoctoral Training Grant – DC00011**

- *Agency:* National Institute on Deafness and Other Communication Disorders (NIDCD)
- *Title:* Examining the role of ventral striatal neuropeptides in pain and motivation • *Total Support:* $22,032/year

HONORS AND AWARDS

2020 ACNP Travel Award
2019 Judy Su Travel Award
2019 Judy Su Award for Basic Science Research
2016 Rackham ProQuest Distinguished Dissertation Award, Honorable Mention
2016 Psychology Marquis Dissertation Award
2016 Biopsychology Wyvell Dissertation Award
2013 SSIB New Investigator Travel Award
2013 Rackham Graduate Student Research Grant, University of Michigan
2012-2015 Rackham Graduate School Travel Grant, University of Michigan

RESEARCH INTERESTS

Neural circuits and mechanisms of positive and negative affect:

- What neurochemical systems control or modulate affective behaviors?
- How do neuropeptides shape neuronal encoding of affect and motivation in the brain?
- How do affect-encoding sites in the brain communicate to produce holistic affective experiences?
- How does dysfunction of affective systems result in psychopathologies, such as depression, chronic pain or drug abuse?

PUBLICATIONS

See also Google Scholar
**indicates equal contributions*

Peer Reviewed Manuscripts

1. Zhang, Y.*, **Castro, D.C***., Han, Y., Wu, Y., Guo, H., Weng, Z., Xue, Y., Ausra, J., Wang, X., Li, R., Wu, G., Vazquez-Guardado, A., Xie, Y., Xie, Z., Ostojich, D., Peng, D., Sun, R., Wang, B., Yu, Y., Leshock, J.P., Qu, S., Su, C., Shen, W., Hang, T., Banks, A., Huang, Y., Radulovic, J., Gutruf, P., Bruchas, M.R., Rogers, J.A. (*2019*). Battery-free, lightweight, injectable microsystem for in vivo wireless pharmacology and optogenetics. *PNAS.* PMID: 31601737

2. Qazi, R.*, Gomez, A.M.*, **Castro, D.C.**, Zou, Z., Sim, J.Y., Xiong, Y., Abdo, J., Kim, C.Y., Anderson, A., Lohner, F., Byun, C.L., Lee, B.C., Jang, K.I., Xiao, J., Bruchas, M.R., Jeong, J.W. (*2019*). Wireless optofluidic brain probes for chronic neuropharmacology and photostimulation. *Nature Biomedical Engineering.* (8):655-669. PMID: 31384010

3. **Castro, D.C.**, Bruchas, M.R. (*2019*). A motivational and neuropeptidergic hub: anatomical and functional diversity within nucleus accumbens shell. *Neuron.* 102(3):529-552. PMID: 31071288

4. Corder, G.*, **Castro, D.C.***, Bruchas, M.R., Scherrer, G. (2018). Endogenous and Exogenous Opioids in Pain. *Annual Reviews in Neuroscience.* 41:453-473. PMID: 29852083

5. **Castro, D.C.,** Berridge, K.C. (*2017*). Opioid and orexin hedonic hotspots in rat orbitofrontal cortex and insula. *PNAS.* 114(43):E9125-E9134. PMID: 29073109

6. **Castro, D.C.,** Terry, R.A., Berridge, K.C. (*2016*). Orexin in rostral hotspot of nucleus accumbens enhances sucrose 'liking' and intake but scopolamine in caudal shell shifts 'liking' toward 'disgust' and 'fear'. *Neuropsychopharmacology*. 41(8):2101-11. PMID: 26787120

7. **Castro, D.C.,** Cole, S.L., Berridge, K.C. (*2015*). Lateral hypothalamus, hunger and reward: interactions between regulatory and limbic circuitry. *Frontiers in Systems Neuroscience*. 9:90. PMID: 26124708

8. **Castro, D.C.**, Berridge, K.C. (2014). Advances in the neurobiological bases for food 'liking' and 'wanting'*. Physiology and Behavior*. 136:22-30. PMID: 24874776

9. **Castro, D.C.,** Berridge, K.C. (2014). A single opioid hedonic hotspot in nucleus accumbens shell: comparing mu, delta and kappa mechanisms of intense appetite and sensory pleasure. *Journal of Neuroscience*. 34(12):4239-50. PMID: 24647944 **Featured in "This Week in the Journal"**

10. Richard, J.M., **Castro, D.C.**, Difeliceantonio, A.G., Robinson, M.J., Berridge, K.C. (2013). Mapping brain circuits of reward and motivation: in the footsteps of Ann Kelley. *Neurosci Biobehav Rev*. 37(9 Pt A):1919-31. PMID: 23261404

INVITED TALKS

2021 **A dorsal raphe to nucleus accumbens medial shell circuit underlies mu-opioid receptor control of motivation.** *Society for Neuroscience, Minisymposium.* Washington, D.C.

2020 **A dorsal raphe to nucleus accumbens medial shell circuit underlies mu-opioid receptor control of motivation.** *American College of Neuropsychopharmacology.* Virtual Meeting.

2020 **Nucleus accumbens medial shell mediates distinct aspects of reward and motivation**. Neurobiology and Anatomy Seminar Series. Drexel University, Philadelphia, PA

2020 **Nucleus accumbens medial shell mediates distinct aspects of reward and motivation**. Neurosciences Series Seminar and Neurobiology Division Lecture. University of California, San Diego, CA

2019 **A dorsal raphe to nucleus accumbens medial shell circuit underlies mu-opioid receptor control of motivation.** Pharmacology Student/Postdoc Seminar. University of Washington, Seattle, WA

2019 **A dorsal raphe to nucleus accumbens medial shell circuit underlies mu-opioid receptor control of motivation.** B. Raymond Fink Memorial Research Conference. University of Washington, Seattle, WA

2019 **Developing next-generation wireless optofluidic platforms for in vivo pharmacology and optogenetics.** Neurolux Illuminate Workshop. University of Washington, Seattle, WA

2017 **Mu opioid signaling in nucleus accumbens amplifies motivation.** Anesthesiology Research Retreat, Washington University in St. Louis, MO

2016 **Insula and orbitofrontal cortex: Novel sites for taste hedonic impact**. Kresge Hearing Research Institute/ Hearing, Balance and Chemical Senses Trainee Forum, University of Michigan, MI

2016 **Two novel cortical hedonic hotspots: Orbitofrontal and insular sites of sucrose 'liking' enhancement.** Pat Gurin Distinguished Lecture Series, University of Michigan, MI

2015 **Pleasure in the brain: A neuroanatomical approach to understanding the Brain and behavior.** Undergraduate Psychology Society, University of Michigan, MI

2014 **Two novel cortical hedonic hotspots: Orbitofrontal and insular mechanisms of food pleasure and motivation**. Society for the Study of Ingestive Behaviors, Seattle, WA

2014 **Cortical taste pathway contributions to taste pleasure processing.** Kresge Hearing Research
Institute P30 Core Meeting, University of Michigan, MI

2013 **Dorsal and ventral taste pathway contributions to taste hedonic processing.** Hearing Balance and Chemical Senses Training Fellowship Seminar University of Michigan, MI

2013 **Enhancement of sensory taste pleasure using optogenetic and pharmacological techniques.** Lawrence-Hawkins Lecture, University of Michigan, MI

2013 **Optogenetic enhancement of food 'liking' versus 'wanting' in the ventral pallidum hotspot and lateral hypothalamus.** Society for the Study of Ingestive Behaviors, New Orleans, LA

2012 **Neuroanatomical and neurochemical substrates of pleasure.** Biopsychology Colloquium, University of Michigan, MI

2012 Neuroanatomical and **neurochemical substrates of pleasure.** Hearing Balance and Chemical Senses Training Fellowship Seminar, University of Michigan, MI

TEACHING EXPERIENCE

Laboratory Mentorship

Graduate Students

2019 – Pierce Eggan
2018 – Madelyn Gray, Bioengineering
2017 – Christian Pedersen, Bioengineering
Eric Zhang, Bioengineering
Andrew Luskin, Neuroscience
2016 – Skylar Spangler, Biomedical Engineering

Undergraduate Thesis Students:

2019-	Corinna Oswell
2016-2018	Anthony Guglin
2014-2015	Amelia Stone
	Dema Fawaz
2013-2014	Michael Wu
	Nathan Chesterman
	Rachel Terry
	Katherine Jester

- 20 additional undergraduate research assistants

Teaching Positions

2015 Graduate Student Instructor: Psychology 436, Drugs of Abuse
Invited Talk: Nicotine and Acetylcholine
2014 Graduate Student Instructor: Psychology 230, Intro to Biopsychology

Invited Reviewer for Journals:

Appetite
Behavioral Brain Research
Biological Psychiatry
Brain Sciences
Journal of Neuroscience Resarch
Nature Neuroscience
Nature Reviews Neuroscience

Neuron
Neuropsychopharmacology
Neuroscience
Progress in Neuropsychopharmacology

PROFESSIONAL SERVICE

2015 **Department of Psychology Graduate Student Orientation Committee**
Biopsychology Graduate Student Representative
2014-2015 **Biopsychology Graduate Student Admissions Committee**
Graduate Student Liaison
2014-2015 **Hearing, Balance, and Chemical Senses Training Grant Selection Committee**
Graduate Student Representative
2014-2015 **Departmental Fellow**
Graduate Student Liaison
2013-2014 **Student Academic Affairs Committee**
Graduate Student Liaison
2013-2014 **Michigan Associate of Psychology Scholars**
Undergraduate Student Mentor

PROFESSIONAL MEMBERSHIPS
2016-present International Narcotics Research Conference
2013-2014 Eastern Psychological Association
2012-2014 Society for the Study of Ingestive Behaviors
2011- present Society for Neuroscience

ABSTRACTS

Castro, D.C., Oswell, C., Zhang., E.T., Rossi, M., Hunker, A., Guglin, A., Moron-Concepcion, J., Zweifel, L., Bruchas, M.R. (2020). **A dorsal raphe to nucleus accumbens medial shell circuit underlies mu-opioid receptor control of motivation.** *American College of Neuropsychopharmacology.* Virtual Meeting.

Castro, D.C., Zhang., E.T., Oswell, C., Hunker, A., Guglin, A., Zweifel, L., Moron-Concepcion, J., Bruchas, M.R. (2019). A dorsal raphe to nucleus accumbens medial shell circuit underlies mu-opioid receptor control of motivation. *American College of Neuropsychopharmacology.* ***Selected for Data Blitz Presentation**

Castro, D.C., Zhang., E.T., Oswell, C., Hunker, A., Guglin, A., Zweifel, L., Moron-Concepcion, J., Bruchas, M.R. (2019). A dorsal raphe to nucleus accumbens medial shell circuit underlies mu-opioid receptor control of motivation. *University of Washington Postdoc Association Research Symposium*. University of Washington, Seattle, WA

Castro, D.C., Zhang, E.T., Guglin, A., Moron-Concepcion, J., Bruchas, M.R. (2019). Mu opioid receptors in nucleus accumbens medial shell mediate stress enhanced motivated behaviors. *Kappa Therapeutics*.

Castro, D.C., Zhang, E.T., Guglin, A., Moron-Concepcion, J., Bruchas, M.R. (2018). Mu opioid receptors in nucleus accumbens medial shell mediate stress enhanced motivated behaviors. *Society for Neuroscience*.

Pedersen, C.E., **Castro, D.C.**, Zhang, E., Bruchas, M.R. (2018). Functional role of projection-specific subpopulations of nucleus accumbens medium spiny neurons in reward behavior. *Society for Neuroscience.*

Castro, D.C., Zhang, E.T., Guglin, A., Moron-Concepcion, J., Bruchas, M.R. (2018). Mu opioid receptors in nucleus accumbens medial shell mediate stress enhanced motivated behaviors. *Optogenetic Approaches to Understanding Neural Circuits and Behavior GRC*.

Castro, D.C., Zhang, E.T., Guglin, A., Katritch, I., Onyeador, T., Moron-Concepcion, J., Bruchas, M.R. (2018). Nucleus accumbens mu-opioid receptors are recruited and necessary for the enhancement of motivated behaviors. *Anesthesiology Academic Evening*.

Zhang, Y., Gutruf, P., **Castro, D.C**., Bruchas, M.R., Rogers, J.A. (2018). Injectable, Brain Interfaced Optofluidic Device for Programmable Fluid Delivery and Optogenetics. *American Institute of Chemical Engineers.*

Castro, D.C., Guglin, A., Onyeador, T., Bruchas, M.R. (2017). Nucleus accumbens mu-opioid receptors are recruited and necessary for the enhancement of motivated behaviors. *Neuroscience Retreat.*

Castro, D.C., Guglin, A., Katrich, I., Onyeador, T., Moron-Concepcion, J., Bruchas, M.R. (2017). Nucleus accumbens mu-opioid receptors are necessary for the enhancement of motivated behaviors. *Society for Neuroscience.*

Castro, D.C., Guglin, A., Onyeador, T., Bruchas, M.R. (2017). Nucleus accumbens mu-opioid receptors are recruited and necessary for the enhancement of motivated behaviors. *International Narcotics Research Conference.*

Zhang, Y., Gutruf, P., **Castro**, D., Bruchas, M.R., Rogers, J.A. (2017). Wireless, Battery-Free Optofluidic Device for Programmable Fluid Delivery and Optogenetics. *American Institute of Chemical Engineers.*

Castro, D.C., Onyeador, T., Guglin, A., Bruchas, M.R. (2017). Mu opioid receptors are necessary for amplifying incentive motivation. *Anesthesiology Academic Evening.*

Castro, D.C., Onyeador, T., Guglin, A., Bruchas, M.R. (2017). Mu opioid receptors are necessary for amplifying incentive motivation. *Postdoc Research Symposium.*

Warlow, S.M., **Castro, D.C.**, Naffziger, E.E., Berridge, K.C. (2016). Central amygdala controls choice and amplifies motivation for sucrose and cocaine without altering 'liking'. *Society for Neuroscience.*

Castro, D.C., Berridge, K.C. (2015). Optogenetic stimulation versus inhibition of orbitofrontal and insular cortical hotspots on hedonic and motivated behaviors. *Society for Neuroscience.*

Castro, D.C., Chesterman, N.C., Wu, M.H.K., Berridge, K.C. (2014). Two cortical hedonic hotspots: Orbitofrontal and insular sites of food pleasure enhancement. *Society for Neuroscience*.

Chesterman, N.S., **Castro, D.C.**, Berridge, K.C. (2014). Mapping a hedonic hotspot in insular cortex. *Society for Neuroscience, Chicago Chapter.*

Castro, D.C., Berridge, K.C. (2013). Optogenetic enhancement of food 'liking' versus 'wanting' in the ventral pallidum hotspot and lateral hypothalamus. *Society for Neuroscience*.

Castro, D.C., Berridge, K.C. (2013). Optogenetic enhancement of food 'liking' versus 'wanting' in the ventral pallidum hotspot and lateral hypothalamus. *Kresge Hearing Research Institute P30 Core Meeting.*

Castro, D.C., Berridge, K.C. (2012). Comparing mu, delta or kappa opioid receptor activation in the nucleus accumbens hotspot: enhancement of food 'liking' versus 'wanting'. *Society for Neuroscience Abstracts.*

Castro, D.C., Graham, L.K., Kim, J.J. (2011). The role of prefrontal cortex in decision making. *Psychology Honors Symposium.*