Full-Length Article

Interprofessional Education of the Next Generation of Musician-scientists through Music Cognition Research Training: *An Innovative Platform for Health Professions and Biomedical Research*

Reyna L. Gordon[1], **Miriam D. Lense**[1]

[1] *Vanderbilt University Medical Center, United States of America*

Abstract

The growth of the music cognition field in recent years has bloomed into what can only be seen now as a highly interdisciplinary space. Laboratories conducting research on how music affects physiology and behavior have become increasingly fertile ground for interprofessional education not only in biomedical research but also across the health professions. Here we discuss how music cognition research can provide a diverse array of skill development opportunities and set the tone for productive and innovative interdisciplinary collaboration training of future clinicians and biomedical researchers.

Keywords*: music cognition, interprofessional education, communication disorders, cognitive neuroscience, biomedical research, health professions*

multilingual abstract | **mmd.iammonline.com**

"I really enjoy connecting with undergraduate and graduate-level students who work on music projects in various research labs around campus. They speak to the excitement that comes from the opportunity to participate in something that is cutting-edge and delivers an impact on people who can benefit from music. These students are taking charge of their own education and are learning information so new you can't find it in a textbook. This gives me hope — that music is still able to influence the lives of educators, researchers, parents, health care providers and students." – See endnote 1

Part I. Defining interdisciplinary music cognition research in the 21st century

Research in music cognition has increased exponentially in recent decades, outpacing the growth of research on language, memory, and art [1]. While early work focused on the psychology of music with experimental and cognitive methods [2], the music cognition field is now broadly pursuing new research on how music relates to brain, behavior, and health from a multitude of perspectives and disciplines. Wide-ranging research questions (e.g., *Do speech and music share a common neural basis? What are the biomarkers of absolute pitch? Does music listening improve outcomes in surgery patients?)* require cross-disciplinary collaborations, innovative use of cutting-edge technology, and thriving networks and professional organizations (e.g., The International Association for Music and Medicine, The Society for Music Perception and Cognition, the European Society for the Cognitive Sciences of Music). The trans-disciplinarity of music cognition is also seen in the emergence of new workshops, conferences, journals, and professional organizations. Among the nearly 100 laboratory groups [3] that self-affiliate with the field of music cognition as a central laboratory focus, research groups are most frequently affiliated with graduate training programs in music, psychology, neuroscience, linguistics, communication sciences, engineering, and computer science.

It is no surprise to the readership of *Music and Medicine* that there is promising emerging evidence for health and wellness benefits from music [4][5]. These innovations have not gone unnoticed: in the U.S., the National Institutes of Health (NIH)'s *Sound Health* Initiative in partnership with the John F. Kennedy Center for the Performing Arts and in association with the National Endowment for the Arts [6] has specifically called for research that rigorously tests the outcomes of music-based interventions, in addition to basic and mechanistic research on music including biomarkers of musicality and neural pathways underlying music engagement [7]. The inquiry into broad-based questions about how music impacts the human brain and human behavior cuts across current NIH institutes and priorities with funding for music-related work through NIH steadily rising (see Figure 1). Funded research programs for music projects (see Figure 2) have relevance for communication disorders (NIDCD),

PRODUCTION NOTES: Address correspondence to:

Reyna L. Gordon, E-mail: reyna.gordon@vanderbilt.edu | COI statement: The authors declared that no financial support was given for the writing of this article. The authors have no conflict of interest to declare.

neurological disorders and mental health and disease (NINDS and NIMH), nursing (NINR), childhood development (NICHD), music-based behavioral therapeutic applications (NCCIH, OBSSR, and NCI), and aging (NIA). To the joyful reception of long-time music cognition researchers, the first-ever RFAs from the NIH specifically targeting music research [8] were issued in Fall 2018.

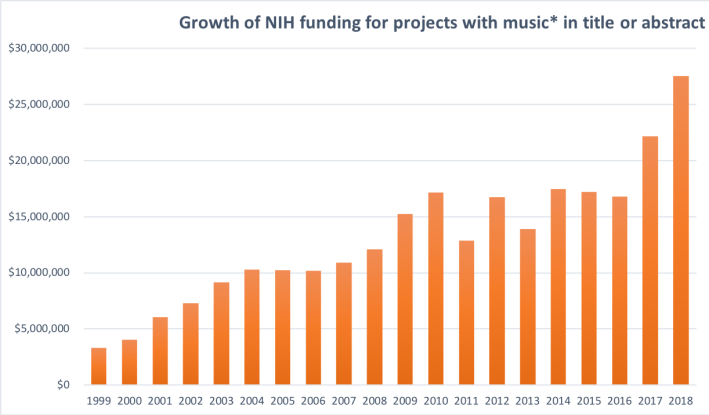

Figure 1. *NIH funding for projects with music* in title or abstract, by FY.* Note that this search only explicitly includes term music* and not other related terms like "song" or "singing" or building block terms of more basic phenomena ("rhythm", "pitch", "timbre") that might directly or indirectly link to music research. [9].

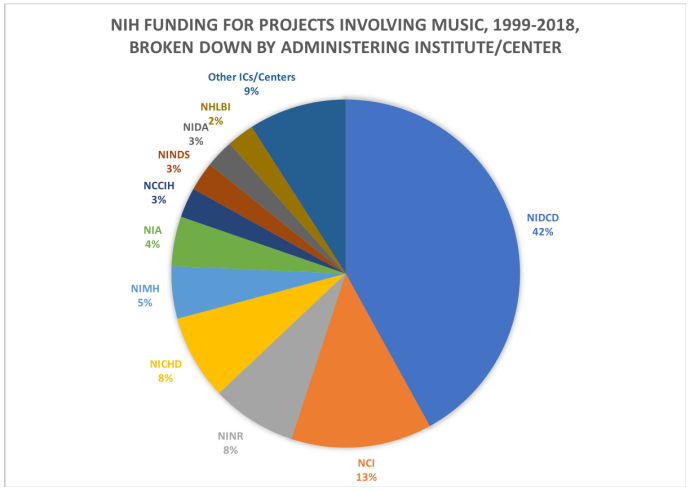

Figure 2. *Total NIH funding for research projects with music* in title or project abstract from 1999-2018, broken down by administering Institute/Center.[9]. National Institute on Deafness and Other Communication Disorders (NIDCD), National Cancer Institute (NCI), National Institute of Nursing Research (NINR), National Institute of Child Health and Human Development (NICHD), National Institute of Mental Health (NIMH), National Institute on Aging (NIA), National Center for Complementary and Integrative Health (NCCIH), National Institute of Neurological Disorders and Strokes (NINDS), National Institute on Drug Abuse (NIDA), National Heart, Lung, and Blood Institute (NHLBI)*

Who will be prepared to do this research? Cheever et al. [7] cite two goals for infrastructure and capacity-building that are particularly relevant for the topic at hand: "to promote multidisciplinary research and capacity building through networks and collaborative studies involving neuroscientists, music therapists, musicians, and biomedical, behavioral, or social scientists" and "to support the training of neuroscientists and music therapists interested in basic or clinical research on music and the brain". We argue here that this multi-disciplinary capacity can start at the undergraduate level and continue through post-baccalaureate and graduate training, and that music cognition research training can be an ideal model of training not only for neuroscientists and music therapists, but also for interested students from a broad range of majors and career paths. Interestingly, there are few degree programs explicitly focused on music science; rather, this training is usually folded into other educational paths and careers. Training opportunities for "musician-scientists" (students who have had extensive musical training and are now training in the sciences), and their peers who are appreciators of music, are needed to meet the desire to combine these seemingly disparate interests, apparent from the large number of inquiries music cognition laboratories receive from prospective students.

Part II. Skills training and interdisciplinarity in the music cognition environment

Training in the music cognition domain teaches student fundamental research skills such as problem-solving, attention to detail, short-term and long-term planning, organizational skills, teamwork, critical reading of the literature, critical thinking, and oral and written communication skills, within the motivating context of music, a topic about which musician-scientist trainees, broadly defined, tend to feel very passionate. Music cognition research requires trainees to work at the intersection of arts and science in a way that promotes and applies the rigor and creativity of the scientific process with students' motivation for participating in arts-related activities.

In addition to these skills, which are of course common to nearly any biomedical research experience, we believe that music cognition training in this era affords an unprecedented opportunity for students to work across a wide range of disciplines, to confront challenges of integrating methods and techniques across fields, and to learn to communicate about research progress to colleagues (peers, staff, and faculty from a very wide range of backgrounds and disciplines). The backgrounds of students thriving in interdisciplinary music cognition research include (but are not limited to): Psychology (Cognitive Science, Child Development, Clinical Psychology), Neuroscience, Music (Performance, Music Education, Music Theory, Musicology), Biology, Education/Special Education,

English, Communication Disorders/Hearing and Speech Sciences, Mathematics, Computer Science, Engineering, and Nursing.

Music cognition research aligns with the goals of interprofessional training, in which team members focus on common goals utilizing diverse skillsets, knowledge bases and perspectives/approaches. Interprofessional collaboration and training has become increasingly important in a range of clinical fields such as nursing [10], medicine [11], speech-language pathology and audiology [12][13], and clinical psychology [14], serving complex and collaborative healthcare environments. Interprofessional training builds professional identity and increases positive attitudes toward interprofessional and interdisciplinary learning approaches [15] and teamwork [16].

We draw upon examples of interdisciplinarity from our own music cognition lab (see endnote 2), co-directed by the authors. Through our lab group formation and our network of collaborators, the interdisciplinarity of music cognition is modeled for students and trainees. We were trained as a cognitive neuroscientist and a clinical psychologist, respectively, but over time have morphed into integrative scientists collaborating with scientists and clinicians at the intersection of Psychology, Communication Disorders, Neuroscience, Behavioral Health, Human Genetics, Linguistics, and Music. The diverse background and expertise of lab leadership and collaborators allows for the lab to provide a wide array of training opportunities at the nexus of different fields. To meet the needs of ongoing research, the training of students in our lab ranges from developing interpersonal and clinical skills for working directly with participants (including both typically developing and clinical populations), to experimental design and theoretically-grounded hypothesis generation, to computer programming skills in order to work with high-dimensional data. By nature of the collaborations, each student does not need to become an expert in every skill, but rather gains exposure to and an appreciation of a variety of perspectives and methods. These skillsets are useful for those pursuing clinical careers (e.g., medicine, allied health professions), basic or applied research in a range of disciplines (e.g., psychology, neuroscience), or for students planning to work with "big data" (e.g., publicly available or widely shared across sites/consortia) [17][18][19][20].

At any given moment, our team is applying methods and knowledge from areas as diverse as auditory processing, childhood language development, music performance, sensory-motor systems, comparative ethology, genomics, developmental psychology, special education, computational models, and other areas. Here we provide examples of music cognition projects that provide interprofessional training opportunities and skill development that connect deeply with other health professions.

Biobank approaches to developmental language disorder. One ongoing project in our lab aims to develop an automated method of identifying cases of developmental language disorder within large-scale electronic health systems data (this study is a key step in a larger line of research that examines individual differences in musical rhythm in children with speech-language disorders). A pre-Med undergraduate was paired with a Master's student in Speech-Language Pathology (from a psychology background) and a PhD student in Neuroscience (from a molecular genetics background). Co-Advised by faculty collaborators with expertise in Communication Disorders, Genetics, and Electronic Health Records, the students developed a chart review rubric for records in a large health systems biobank, conducted manual coding in a discovery sample, automated the algorithm, conducted phenome-wide association studies [21], validated and replicated the automated algorithm, and are currently preparing to conduct genome-wide associate studies on linked genetic data. The students gained knowledge and skills both specific to the characteristics of this particular disorder and much more general knowledge/exposure (bioinformatics, computer programming, ICD codes and a large amount of other medical terminology encountered in the chart reviews).

Music and Social Engagement in ASD. The SeRenade (Social and Rhythmic Engagement in Autism Spectrum Disorder) program investigates the impact of a community parent-child music program for families of preschool-aged children with autism spectrum disorder (ASD), as well as mechanisms underlying social musical engagement in ASD. A clinical psychologist and a developmental psychologist, who is also an accomplished songwriter, with input from a music therapist, behavior analyst, and caregivers of young children with ASD, designed the music program. Master's students in special education and speech-language pathology along with undergraduates in neuroscience and psychology completed didactics on ASD, child development, and behavior management strategies and were then immersed in the music class experience, where they received a hands-on education in supporting families of children with ASD under the supervision of a clinical psychologist and music therapist. Under the supervision of a clinical psychologist, one group of students worked together to create and refine a behavior coding schema to capture children's engagement in the music classes, learned and applied methods of video-based and live coding, and conducted statistical analyses and data interpretation. Another group of students, supervised by both a clinical psychologist and cognitive scientist, developed a behavior coding scheme and video-derived markers of movement, to examine interpersonal movement synchrony during musical activities. The students learned how their unique perspectives provided by their discipline-specific training could be integrated to create meaningful metrics that best characterized children's engagement and gained extensive knowledge of social behavior in young children.

Scientific Communication and Outreach. Students also gain experience with scientific communication/dissemination and public outreach. By training as part of an interdisciplinary team, students learn to translate discipline-specific terminology and perspectives and develop a common language for disseminating their scientific results to a diverse multidisciplinary audience. Music cognition provides a novel entryway for non-scientists to learn about a ubiquitous and meaningful human experience - listening to and making music - providing a context in which to educate the public about the scientific process and elucidate principles of brain and behavioral functioning. The students have organized and hosted Scientific Salon events, during which students pair their musical and scientific works in order to illustrate their scientific focuses using musical examples to create an enjoyable and informative public event. Examples of these presentations included:

- A speech-language pathology student who conducts both mechanistic and intervention research creating a musical composition using a looping pedal and drawing parallels between the iterative processes inherent in writing music and conducting research.
- A cognitive science student and an audiology student who investigate rhythm in speech and music presenting study stimuli examples from children's stories while also performing songs from the musical *Seussical*.
- Speech-language pathology students presenting their research into the impact of Suzuki violin lessons for children with language impairment, and bringing this research to life with a string quartet performance

This type of interdisciplinary scientific education embedded within public events such as the LIVELab Concert Series, Mainly Mozart series, SWSX and others, has been extremely popular, responding to the call to "galvanize public interest in the scientific investigation of the scientific investigation of music and the brain from both a fundamental knowledge and health standpoint" [6].

Part III. What comes after a music cognition lab experience?

Taken together, these immersive music research experiences build an important capacity for teamwork needed for interdisciplinary biomedical research and clinical care, and may mirror benefit from interprofessional approaches documented in the health sciences education literature [22][23][24]. Students trained in an interdisciplinary music cognition research environment also develop skills and competencies in problem-solving, attention to detail, human subjects testing, data analysis, and cross-disciplinary communication that are directly relevant for their next career steps. Feedback from students trained in this milieu suggest long-lasting benefits:

"As someone with cross-disciplinary interests, it was initially difficult to find mentors with experience navigating interdisciplinary space in academia, and training in a music research lab oriented me to an interdisciplinary research conversation much broader than my home department of developmental psychology. There is much emphasis on specializing while in graduate school, and it can be difficult to do that while maintaining and actually growing the ability to communicate broadly about using research to solve problems. Working as part of an interdisciplinary research team gave me experience with exactly that, and it's a skill that serves me well as an assistant professor of psychology at a liberal arts college. Undergraduate students' interests are not constrained by academic disciplines any more than their musical tastes are constrained by genre, and having the ability to talk about how psychologists, neuroscientists and speech pathologists approach the same problem is an asset for me as an educator and scholar." - See endnote 3

"Working in a music cognition lab was the highlight of my time in medical school— it allowed me to explore depths of my specialty (otolaryngology-head and neck surgery) in ways I had not thought possible. I once heard a well-known surgeon-scientist say, "music is the pinnacle of hearing"— I think about this often as I take care of patients affected by hearing loss and continue to pursue my research interests." - See endnote 4

"As a Speech-Language Pathologist, I serve my clients' communication needs through interdisciplinary teams because my clients' ability to effectively communicate is dependent upon how their communication is shared and supported in all contexts. My experiences in an interprofessional research team provided me with the foundational skills needed to collaborate with colleagues with varying professional perspectives in order to synthesize creative solutions towards shared goals." - See endnote 5

Endnotes

1. Natalie Wiens, M.S., CCC-SLP*, alumna of a music cognition research lab.*

2. The Vanderbilt Music Cognition lab is within the Department of Otolaryngology at Vanderbilt University Medical Center.

3. Sara Beck, PhD, *alumna of a music cognition research lab*

4. Alexander Chern, MD, *alumnus of a music cognition research lab*

5. Rita Pfeiffer, MS, CCC-SLP, *alumna of a music cognition research lab*

Acknowledgments

The authors were supported by the National Endowment for the Arts (Award #: 1844332-38-C-18) and the National Institute On Deafness And Other Communication Disorders, the Office of Behavioral and Social Sciences Research, and the Eunice Kennedy Shriver National Institute of Child Health & Human Development, of the National Institutes of Health under Award Numbers 1R21DC016710, DP2HD098859, and K18DC017383. This work was additionally supported by the VUMC Faculty Research Scholars Program. The content is solely the responsibility of the authors and does not necessarily represent the official views of the funders.

The authors would like to thank Youjua Wang for assistance with formatting.

References

1. Law LNC, Zentner M. Assessing Musical Abilities Objectively: Construction and Validation of the Profile of Music Perception Skills. *PLOS ONE*. 2012;7(12):e52508. doi:10.1371/journal.pone.0052508
2. Deutsch D, ed. *The Psychology of Music*. 1st ed. Cambridge, MA: Academic Press; 1982.
3. SMPC Resources. SMPC Web site. Available at: http://www.musicperception.org/smpc-resources.html. Accessed June 7, 2019.
4. Jensen A, Bonde L. The use of arts interventions for mental health and wellbeing in health settings. *Perspect Public Health*. 2018;138(4):209-214. doi:10.1177/1757913918772602
5. Kang J, Scholp A, Jiang JJ. A Review of the Physiological Effects and Mechanisms of Singing. *Journal of Voice*. 2018;32(4):390-395. doi:10.1016/j.jvoice.2017.07.008
6. Collins FS, Fleming R. Sound Health: An NIH-Kennedy Center Initiative to Explore Music and the Mind. *JAMA*. 2017;317(24):2470-2471. doi:10.1001/jama.2017.7423
7. Cheever T, Taylor A, Finkelstein R, et al. NIH/Kennedy Center Workshop on Music and the Brain: Finding Harmony. *Neuron*. 2018;97(6):1214-1218. doi:10.1016/j.neuron.2018.02.004
8. RFA-NS-19-008: Promoting Research on Music and Health: Fundamentals and Applications (R01 Clinical Trials Optional). https://grants.nih.gov/grants/guide/rfa-files/rfa-ns-19-008.html. Accessed June 7, 2019.
9. Query Form - NIH RePORTER - NIH Research Portfolio Online Reporting Tools Expenditures and Results. Available at: https://projectreporter.nih.gov/reporter.cfm. Accessed June 7, 2019.
10. Hovland C, Whitford M, Niederriter J. Interprofessional Education: Insights From a Cohort of Nursing Students. *Journal for Nurses in Professional Development*. 2018;34(4):219-225. doi:10.1097/NND.0000000000000466
11. Gonzalo JD, Ogrinc G. Health Systems Science: The "Broccoli" of Undergraduate Medical Student Education. *Academic Medicine*. 2019; Publish Ahead of Print. doi:10.1097/ACM.0000000000002815
12. Serpanos YC, Senzer D, Gordon DM. Interprofessional Peer-Assisted Learning as a Model of Instruction in Doctor of Audiology Programs. *Am J Audiol*. 2017;26(3):233-241. doi:10.1044/2017_AJA-17-0012
13. Interprofessional Education/Interprofessional Practice (IPE/IPP). American Speech-Language-Hearing Association. Available at: https://www.asha.org/Practice/Interprofessional-Education-Practice/. Accessed June 7, 2019.
14. Ward W, Zagoloff A, Rieck C, Robiner W. Interprofessional Education: Opportunities and Challenges for Psychology. *J Clin Psychol Med Settings*. 2018;25(3):250-266. doi:10.1007/s10880-017-9538-3
15. Hood K, Cant R, Baulch J, et al. Prior experience of interprofessional learning enhances undergraduate nursing and healthcare students' professional identity and attitudes to teamwork. *Nurse Education in Practice*. 2014;14(2):117-122. doi:10.1016/j.nepr.2013.07.013
16. Wellmon R, Baumberger-Henry M, Colby N, Knauss L, Fletcher P. Changing Student Attitudes Toward Interprofessional Learning and Collaboration: Evidence for the Effectiveness of Partnering with Healthcare Mentors in the Academic Setting. *J Allied Health*. 2017;46(4):205-212.
17. Sudlow C, Gallacher J, Allen N, et al. UK Biobank: An Open Access Resource for Identifying the Causes of a Wide Range of Complex Diseases of Middle and Old Age. *PLOS Medicine*. 2015;12(3):e1001779. doi:10.1371/journal.pmed.1001779
18. National Institutes of Health (NIH) — All of Us. Available at: https://allofus.nih.gov/. Accessed June 7, 2019.
19. The Genotype-Tissue Expression (GTEx) project. *Nat Genet*. 2013;45(6):580-585. doi:10.1038/ng.2653
20. Thompson PM, Stein JL, Medland SE, et al. The ENIGMA Consortium: large-scale collaborative analyses of neuroimaging and genetic data. *Brain Imaging Behav*. 2014;8(2):153-182. doi:10.1007/s11682-013-9269-5
21. Denny JC, Ritchie MD, Basford MA, et al. PheWAS: demonstrating the feasibility of a phenome-wide scan to discover gene-disease associations. *Bioinformatics*. 2010;26(9):1205-1210. doi:10.1093/bioinformatics/btq126
22. Rodríguez G, Pérez N, Núñez G, Baños J-E, Carrió M. Developing creative and research skills through an open and interprofessional inquiry-based learning course. *BMC Med Educ*. 2019;19(1):134. doi:10.1186/s12909-019-1563-5
23. Anderson OS, August E, Goldberg PK, Youatt E, Beck AJ. Developing a Framework for Population Health in Interprofessional Training: An Interprofessional Education Module. *Front Public Health*. 2019;7:58. doi:10.3389/fpubh.2019.00058
24. Marcussen M, Nørgaard B, Borgnakke K, Arnfred S. Interprofessional clinical training in mental health improves students' readiness for interprofessional collaboration: a non-randomized intervention study. *BMC Med Educ*. 2019;19(1):27. doi:10.1186/s12909-019-1465-6

Biographical Statements

Reyna L. Gordon is Assistant Professor, Otolaryngology, Vanderbilt University Medical Center, Assistant Professor, Psychology, Vanderbilt University, Vanderbilt Bill Wilkerson Center, Vanderbilt Genetics Institute, Vanderbilt Kennedy Center, Vanderbilt Brain Institute, and Curb Center for Art, Enterprise, & Public Policy

Miriam D. Lense is Assistant Professor, Otolaryngology, Vanderbilt University Medical Center, Vanderbilt Bill Wilkerson Center, Vanderbilt Kennedy Center, Vanderbilt Brain Institute, and Curb Center for Art, Enterprise, & Public Policy.