Introduction to
Music in the Brain

Lectures with Center for Music in the Brain's researchers

Time:

September-December 2018

Venue:

M Auditorium and K Auditorium

Aarhus University Hospital, Nørrebrogade 44, Aarhus

Overview of the course

Date	Time slot	Title
4 Sep	13:00 - 14:00	Introduction to Center for Music in the Brain
	14:10 - 15:10	Introduction to Neurobiology/Neuroscience
M	15:20 - 16:20	Methodological critique: What is neuroimaging good for?
25 Sep	13:00 - 14:30	Clinical applications of music: An introduction
M	14:50 - 16:20	The performing brain: How we become musical experts
2 Okt	13:00 - 14:30	Musical expectations and the brain
K	14:50 - 16:20	Music, language and the brain
23 Okt	13:00 - 14:30	Sound before the brain
K	14:50 - 16:20	Sound in the brain – the auditory system
6 Nov	13:00 - 14:30	Decoding creativity during jazz improvisation: a neuroimaging approach
K	14:50 - 16:20	Computational modelling of music
20 Nov	13:00 - 14:30	Groove and auditory-motor interactions
K	14:50 - 16:20	Clinical applications of music: Chronic pain and Parkinson's
04 Dec	13:00 – 14:30	fMRI studies in music research
M	14:50 – 16:20	The origins and evolution of musicality: an empirical approach
18 Dec	13:00 – 15:00	Clinical applications of music: Music and autism
M	15:20 – 16:20	Plenary session: Perspectives of music and neuroscience

M Auditorium, Nørrebrogade 44, Building 3A, 2. floor

K Auditorium, Nørrebrogade 44, Building 7, basement

Tuesday 4 September 14.10-15.10

Victor Pando: Introduction to neurobiology/neuroscience

Learning outcomes

Students will gain the following:

- An understanding of the basic properties of neurons and other cell types of the nervous system
- An overview of neuroanatomy
- An understanding of the neural basis of perception, motion, cognition, and emotion
- An understanding of the basic principles of neuroimaging methods

Abstract

Neuroscience is the scientific study of the nervous system. It is a multidisciplinary branch of biology than combines physiology, anatomy, molecular biology, psychology, and computational and mathematical modelling. This multi-modal approach has allowed neuroscientist to study the nervous system in all its aspects: structure, function, development, malfunctions, and treatments. Through this course, you will gain a comprehensive understanding of basic biology, neuroanatomy, neurochemistry, neural processes, and how to measure them.

Background literature

Kandel, E. R., Schwartz, J. H. (James H., & Jessell, T. M. (2000). Principles of neural science. McGraw-Hill, Health Professions Division.

Woo, C. W., Chang, L. J., Lindquist, M., & Wager, T. D. (2017). Building better biomarkers: brain models in translational neuroimaging. Nature Neuroscience, 20(3). https://doi.org/10.1038/nn.4478

Tuesday 4 September 15.20-16.20

Marianne Tiihonen: Methodological critique: What is neuroimaging good for?

Learning outcomes

Students will gain knowledge of the following:

- The main technical limitations of fMRI, MEG, EEG and PET from the perspective of cognitive neuroscience
- Indirectness of imaging and brain physiological measures
- The most common justified and unjustified points of critique on neuroimaging
- Common methodological issues when linking neurophysiological data with behavioural data

Abstract

In the past two decades there has been a large increase in the variety of scientific disciplines applying neuroimaging and neurophysiological methods resulting in thousands of publications. Simultaneously, the increased amount of studies has been faced with critique blaming scientists of new phrenology, of jumping to conclusions and of unnecessary application of neuroscientific methods.

In this short introduction it will be briefly demonstrated which of the critique is adequate from the perspective of cognitive neuroscience and which is outdated or otherwise not applicable. Furthermore, it will be discussed which problems are related to the technological limitations of the imaging devices and their functional properties, and which are related to the interpretation and reporting of the results.

Background literature

Faux, S. F. (2002). Cognitive neuroscience from a behavioral perspective: A critique of chasing ghosts with Geiger counters. Behavior Analyst, 25(2), 161–173. http://doi.org/10.1007/BF03392055

Rose, S. (2012). The need for a critical neuroscience: From neuroideology to neurotechnology. In S. Choudhury & J. Slaby (Eds.), Critical Neuroscience - A handbook of the social and cultural contexts of neuroscience (pp. 53–66). Malden, Oxford, West Sussex: Wiley-Blackwell.

Tuesday 25 September 13.00-14.30

Kira Vibe Jespersen: Clinical applications of music: An introduction

Learning outcomes

Students will gain the following:

- Insight into different ways of applying music for health outcomes (e.g. music therapy and music medicine)
- Knowledge on the disorders and healthcare settings where there is good evidence for using music interventions
- An understanding of the neurobiological mechanisms underlying the positive effects of music interventions
- The ability to evaluate the study quality of studies on music interventions

Abstract

This lecture will focus on the use of music for improving health. We will consider different ways of using music in healthcare settings and the use of music for improving wellbeing in everyday life. In recent years, increasing evidence has demonstrated beneficial effects of music for both somatic and psychiatric disorders. We will discuss the quality of the evidence as well as the underlying neurobiological mechanisms.

Background literature

Gebauer, L. & Vuust, P. (2014). Music Interventions in Healthcare. White paper produced in collaboration with Danish Sound, SoundFocus, Widex, and DKsystems. http://issuu.com/danishsound/docs/whitepaper_digital_enkelsidet

Sihvonen et al. (2017). Music-based interventions in neurological rehabilitation. Lancet Neurology, 16(8), 648-660.

Tuesday 25 September 14.50-16.20

Boris Kleber: The performing brain: How we become musical experts

Learning outcomes

Students will gain the following:

- Knowledge about how sensory feedback interacts with motor learning
- An understanding of how the brain controls the singing voice
- An understanding of how singing training can change your brain's organisation
- An understanding of how your mind interacts with your body in the context of performance anxiety

Abstract

This course presents you with an introduction on how your brain is involved in motor control and demonstrates how your mind and body interact when you get nervous. First, I'll provide you with basic information about how your brain controls your voice, how it reacts when your sensory feedback is not what you expected, and how the strategies your brain may show differ in trained singers. The same principles also apply to instrumentalists.
Then, I'll switch to the topic of performance anxiety and give you some hands-on possibility to test how your mind and body are related in the face of a challenging task, which may either be real or imagined. This demonstration uses a biofeedback device that can visualise physiological responses of your autonomous nervous system.

Background literature

Kleber B, Zarate JM. The Neuroscience of Singing. In: Graham W, Nix J, editors. The Oxford Handbook of Singing. Oxford, UK.: Oxford University Press; 2014. https://www.researchgate.net/publication/282612720_The_Neuroscience_of_Singing

Kleber B, Friberg A, Zeitouni A, Zatorre R. Experience-dependent modulation of right anterior insula and sensorimotor regions as a function of noise-masked auditory feedback in singers and nonsingers. Neuroimage 2017; 147: 97-110.

Link to bio/neurofeedback applications in the arts: https://youtu.be/B9jqeheeoms?t=28s

Tuesday 2 October 13.00-14.30

David Quiroga: Musical expectations and the brain

Learning outcomes

Students will gain the following:

- An understanding of the fundamental role of expectations in music perception and emotion
- An understanding of the relationship between expectations and the structural elements of music, such as tonality and meter
- An overview of the behavioural and neurophysiological research on musical expectations and its consequences for our understanding of music listening and music making

Abstract

When we listen to music, we constantly create expectations about the sounds that will follow, based on the patterns that we extract from the music and our life-long listening experience. These expectations are essential for our understanding of the music itself and the emotional experiences that we derive from it. In this lecture we will review studies addressing musical expectations, ranging from the early work on tonality to the most recent neuroimaging approaches to musical pleasure. We will discuss these studies in the framework of novel theories which place prediction at the core of human behaviour and brain function.

Background literature

Salimpoor, V. N., Zald, D. H., Zatorre, R. J., Dagher, A., & McIntosh, A. R. (2015). Predictions and the brain: How musical sounds become rewarding. *Trends in Cognitive Sciences*, *19*(2), 86–91.
http://doi.org/10.1016/j.tics.2014.12.001

Huron, D. (2006). Sweet anticipation: Music and the Psychology of Expectation. Exposure (Vol. 443).
http://doi.org/10.1525/mp.2007.24.5.511

Tuesday 2 October 14.50-16.20

David Quiroga: Music, language and the brain

Learning outcomes

Students will gain the following:

- Knowledge about the differences and similarities of music and language processing in the brain
- A critical understanding of theories suggesting that music and language share common cognitive and neural resources
- A critical understanding of the evidence showing that musical training can be beneficial for language development

Abstract

Music and language have remarkable similarities. For example, both make extensive use of the auditory system and consist of highly structured sequences of events that unfold in time. However, they also have important differences. For instance, in music there is not such a thing as a verb or a noun and musical sounds do not convey meaning as accurately as words do. This interesting relation has motivated some researches to propose that music and language share cognitive and neural resources. In this lecture we will review critically the evidence for the resource-sharing hypothesis and explore the idea that musical training might enhance domain-general abilities which in turn might have positive consequences for language development.

Background literature

Patel, A.D. (2012). Language, music, and the brain: a resource-sharing framework. In: P. Rebuschat, M. Rohrmeier, J. Hawkins, & I. Cross (Eds.), Language and Music as Cognitive Systems (pp. 204-223). Oxford: Oxford University Press.

Koelsch, S. (2005). Neural substrates of processing syntax and semantics in music. Current Opinion in Neurobiology, 15(2), 207–12.
http://doi.org/10.1016/j.conb.2005.03.005

Tuesday 23 October 13.00-14.30

Ole Adrian Heggli: Sound before the brain

Learning outcomes

Students will gain the following:

- An understanding of fundamental properties of sound waves
- An insight into how method of delivery influences sound
- The ability to correctly use audio engineering terms to describe elements of sound

Abstract

Sound is all around you, at all times, and is affected by a multitude of factors. Understanding the contributions of acoustic factors, such as room structure and headphone response curve, are crucial for securing correct delivery of stimuli in auditory paradigms. This short lecture aims to introduce features and functions of sound, ranging from basic physical and electroacoustical properties of sound waves, to room acoustic contributions to the perceived sound.

Background literature

Everest, F. A., Pohlmann, F. Master Handbook of Acoustics (any edition). Mcgraw-Hill Professional, USA.

Tuesday 23 October 14.50-16.20

Manon Grube: Sound in the brain – a journey into the auditory system

Learning outcomes

Students should be able to:

- Describe the anatomy and function of the auditory sensory apparatus system (outer, middle and inner ear, with the relevant structures)
- Describe the major ascending auditory pathways and name the structures
- Describe the basic principles behind processing of the key features discussed

Abstract

Thanks to our auditory system, humans are able to process and distinguish a remarkable range of sounds, allowing us to perceive and respond to our environment, including musical activities.
This course will feature a neurobiologically based journey into the auditory system with focus on the human brain, and on how we process key features of sound and music: pitch, rhythms, timbre and spatial location. It will cover the sensory and neural mechanisms underpinning our abilities to hear and recognize sounds. We start with the ear (outer, middle, inner), learn how sound energy is transduced into electrical signals, then get to know the intricate ascending pathways through the brainstem and into the cortex, where the neural encodings are interpreted. We may perceive a human voice, a musical phrase, or any of the range of sounds in the world around us at a particular moment, and that even for many sounds in parallel, in a noisy environment of many overlapping sounds (e.g. at a “cocktail party”). To lighten the load, the course will be a mix of theory and listening examples, including some illustrative basic ones, some auditory “illusions” and some auditory scene analysis paradigm.

Background literature

Kidd, G.R., Watson, C.S. & Gygi, B. (2007). “Individual differences in auditory abilities”. J. Acoust. Soc. Am. 122 (1).

Winkler, I., Denham, S. & Nelken, I. (2009). “Modeling the auditory scene: Predictive regularity representations and perceptual objects.“ Trends in Cognitive Sciences, 13, 532-540.

Bregman, A.S. (1990/1994). Auditory Scene Analysis. The perceptual organization of sound. Cambridge, MA: MIT Press.

Moore, B.C.J. (2007) “Introduction to the Psychology of Hearing.” Academic Press.

Tuesday 6 November 13.00-14.30

Patricia Alves da Mota: Decoding creativity during jazz improvisation: a neuroimaging approach

Learning outcomes

Students will gain understanding of the following:

- The neuroscience of creativity
- How musicians can help us in understanding the neural signatures of creativity

Abstract

Creativity comprises the interplay of multiple neural processes, including attention, mental flexibility and cognitive control. Many believe that creativity relies on real-time combination of known neural and cognitive processes. Jazz musicians are believed to be a population with strong potential for studying creativity, given its ability to spontaneously create novel music sequences that are aesthetically and emotionally rewarding. Methods of functional connectivity begin to emerge in the literature of improvisation using analysis of discrete regions in isolation. A network-based approach would help us to shed new light into the neural mechanisms of spontaneous music creation in jazz musicians.

Background literature

Limb, C. J., & Braun, A. R. (2008). Neural substrates of spontaneous musical performance: An fMRI study of jazz improvisation. PLoS ONE, 3(2), 1679.

Pinho, A. L., Manzano, O. D., Fransson, P., Eriksson, H., & Ullen, F. (2014). Connecting to create: Expertise in musical improvisation is associated with increased functional connectivity between premotor and prefrontal areas. Journal of Neuroscience, 34(18), 6156–6163.

Beaty, R. E. (2015). The neuroscience of musical improvisation. Neuroscience & Biobehavioral Reviews, 51, 108-117.

Tuesday 6 November 14.50-16.20

Christine Ahrends: Computational modelling of music

Learning outcomes

Students will gain the following:

- An overview of the notion of computational approaches to music theory
- A basic understanding of an exemplary computational music model
- The ability to critically reflect chances and limitations of computational modelling of music

Abstract

Recent approaches to music theory have presented computational models to describe and generate musical syntax. These systems greatly rely on the formation of expectations, stemming from the fields of psychology and linguistics. In this course, we will introduce the Information Dynamics of Music (IDyOM) model as an example of a cognitive model of melodic expectancy. On this basis, we will discuss ways in which computational models are applied in music research. Finally, we will reflect on current and future challenges of this field with the example of hierarchical modelling.

Background literature

Pearce, M. T. & Wiggins, G. A. (2012). Auditory Expectation: The Information Dynamics of Music Perception and Cognition. Topics in Cognitive Science, 4, 625 – 652.
http://webprojects.eecs.qmul.ac.uk/marcusp/papers/PearceWiggins2012.pdf

Rohrmeier, M. A. (2013). Musical Expectancy – Bridging Music Theory, Cognitive and Computational Approaches. ZGMTH, 10/2, 343 – 371.
http://www.gmth.de/zeitschrift/artikel/724.aspx

Tuesday 20 November 13.00-14.30

Jan Stupacher: Groove and auditory-motor interactions

Learning outcomes

Students will gain an understanding of the following:

- The relationship between musical rhythm and body movement on various levels
- The psychological construct of 'groove'
- Rhythmic and audio features that maximize movement induction in a listener
- The connection between music listening and movement on a neural level

Abstract

Music and movement are closely interwoven. When we listen to music, we often move our body in time with the rhythmic pulse. If the movement comes easily, we are in a state that can be described as 'in the groove'. Music cognition researchers and musicologists often define groove as a musical quality that makes us want to move with the underlying musical pulse. Thus, groove is a phenomenon of sensorimotor coupling and reflects the rhythm's efficiency for entrainment. Although music can capture a listener on different levels (e.g. cognitive, emotional, social) the most direct way of rhythmic entrainment is probably the interaction between auditory and motor brain areas.

Background literature

Janata, P., Tomic, S. T., & Haberman, J. M. (2012). Sensorimotor coupling in music and the psychology of the groove. Journal of Experimental Psychology: General, 141, 54-75.

Stupacher, J., Hove, M. J., Novembre, G., Schütz-Bosbach, S., & Keller, P. E. (2013). Musical groove modulates motor cortex excitability: A TMS investigation. Brain and Cognition, 82, 127-136.

Tuesday 20 November 14.50-16.20

Victor Pando: Clinical applications of music: Chronic pain and Parkinson's

Learning outcomes

Students will gain the following:

- Knowledge of disorders that benefit from music intervention
- An understanding of the effect of music on chronic pain disorders
- An understanding of the effect of music on Parkinson's disease
- An understanding of the properties of music that elicit positive effects on patients

Abstract

The interest in the study of the neurobiology of music has increased over the past few decades, thanks to the powerful tools that allow us to infer brain activity given certain stimuli, like music. These clinical contexts range from pain management to sensori-motor rehabilitation and improved sleep quality. Music is a powerful, non-invasive, inexpensive adjuvant therapy, for the management of diverse disorders, improving health and quality of life that correlates with brain activity and connectivity changes.

Background literature

Garza-Villarreal, E. A., Pando-Naude, V., Vuust, P., & Parsons, C. (2017). Music-induced analgesia in chronic pain conditions: a systematic review and meta- analysis. *Pain Physician*. http://www.painphysicianjournal.com/current/pdf?article=NDcwMw%3D%3D&journal=108

Nombela, C., Hughes, L. E., Owen, A. M., & Grahn, J. A. (2013). Into the groove: Can rhythm influence Parkinson's disease? *Neuroscience and Biobehavioral Reviews*, *37*, 2564–2570. https://doi.org/10.1016/j.neubiorev.2013.08.003

Tuesday 4 December 13.00-14.30

Pauline Cantou: fMRI studies in music research

Learning outcomes

The students should be able to:

- Describe the basic physical principles behind magnetic resonance imaging
- Explain what the BOLD-signal is and how it could be used to display neuronal activations
- Explain the basic principle of resting-state functional connectivity and describe the main resting-state networks affected by music training

Abstract

This course is an introduction to the use of fMRI studies in music research.
The lesson will introduce functional magnetic resonance imaging (fMRI), a neuroimaging technique commonly used in neurosciences and music to study brain activation while playing or listening to music. The physiological mechanisms behind fMRI and BOLD-signals will be explained, as well as a few methods and applications in the musical domain. Specifically, resting-state fMRI is a method widely used to explore functional connectivity between different regions of the brain at rest and has been proven to be a powerful tool to provide information on brain plasticity associated with music training.

Background literature

Palomar-Garcia et al. (2017). Modulation of Functional Connectivity in Auditory–Motor Networks in Musicians Compared with Nonmusicians
https://doi.org/10.1093/cercor/bhw120

Ellis et al. (2013). Training-mediated leftward asymmetries during music processing: a cross-sectional and longitudinal fMRI analysis
https://www.ncbi.nlm.nih.gov/pubmed/23470982

Tuesday 4 December 14.50-16.20

Massimo Lumaca: The origins and evolution of musicality: an empirical approach

Learning outcomes

Students will gain the following:

- An overview of the key issues in the study of musicality.
- An understanding of the interdisciplinary approach (or "multi-component" approach) recently adopted by top scholars of music and language evolution to address these issues.

Abstract

Research shows that all humans exhibit a predisposition for perceiving, appreciating, and making music, which seems to be unique to our species. This capacity, known as 'musicality', is distinct from 'music', defined as a socio-cultural construct that relies on musicality. One question is how did music predisposition originate and evolve. In this lesson, we will briefly examine some of the issues in the study of the biological evolution of musicality, and an empirics-theoretical approach recently adopted by the newborn field of music evolution to address these issues. We will discuss questions like: Is musicality grounded in our biology? Is it a functionally specialised domain (of one or more traits) or a by-product of more general-domain mechanisms? Is musical behaviour a uniquely human capability, or instead a perceptuo-cognitive function shared with other non-human animals?

Background literature

Honing, H., ten Cate, C., Peretz, I., & Trehub, S. E. (2015). Without it no music: cognition, biology and evolution of musicality.
Doi: 10.1098/rstb.2014.0088

Honing, H. (2018). On the biological basis of musicality. Annals of the New York Academy of Sciences.

Tuesday 18 December 13.00-15.00

Patricia Alves da Mota and Rasmine Mogensen: Clinical applications of music: Throwing light on perception of music in individuals with Autism Spectrum Disorder

Learning outcomes

Students will gain the following:

- Knowledge about Autism Spectrum Disorder (ASD)
- A broad understanding of how music is perceived/processed by individuals with ASD
- An understanding of how basic research investigating music can contribute to the development of interventions for individuals with ASD
- Neuroimaging studies of individuals with ASD

Abstract

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder associated with stereotyped, repetitive behaviours and deficits in social communication and social interaction. In the last decades a lot of research has been examining individuals with ASD, but the causes of this disorder are still mostly unknown. In-vivo MRI studies have provided many important insights into the neural substrates underlying ASD.
Neuroimaging findings could provide biomarkers that facilitate diagnosis of and treatment for individuals with ASD. This lecture aims to give a broad introduction to this field of research i) addressing perception and processing of music; and ii) how music can be used to unravel the neural signatures of brain function in ASD. The session will combine presentations and discussions in groups/plenary.

Background literature

Morimoto, C., Hida, E., Shima, K., & Okamura, H. (2017). Temporal Processing Instability with Millisecond Accuracy is a Cardinal Feature of Sensorimotor Impairments in Autism Spectrum Disorder: Analysis Using the Synchronized Finger-Tapping Task. Journal of Autism and Developmental Disorders, 0(0), 1–10.
https://doi.org/10.1007/s10803-017-3334-7

Grecucci, A., Siugzdaite, R., and Job, R. (2017). Editorial: Advanced Neuroimaging Methods for Studying Autism Disorder. Frontiers in Neuroscience 11.

Tuesday 18 December 15.20-16.20

Marianne Tiihonen: Plenary session: Perspectives of music and neuroscience

Learning outcomes

The students will

- Summarize current topics in the field of music and neuroscience
- Be able to put scientific work from the field into a broader context
- Understand future challenges and perspectives of this research area

Abstract

The purpose of the plenary session is to take a look at the new insights gained during the whole course. The last session will consist of a short recapitulation and the main "take home messages" of the lectures which then will be discussed together. The thematic focus will be to inspect the role and function of music in the context of neuroscience. Finally, we will reflect about future perspectives of the field of music and the brain.

Background literature

Peter Vuust (2017). Musik på hjernen.