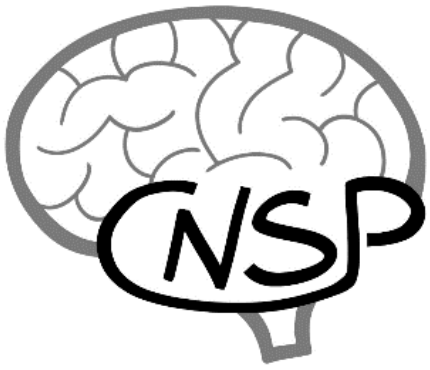
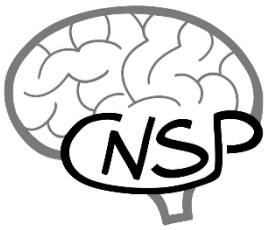


Cognition and Natural Sensory Processing Workshop 2022

(18–20th July)



Cognition and Natural Sensory Processing Workshop

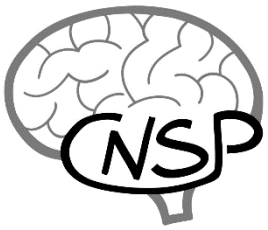
Workshop programme (Irish standard time)*

Day 1 (Monday 18th July)		
Session 1	**(3.45pm)**	*Investigating auditory processing with natural sound listening paradigms* *Chair:* ***Mick Crosse***
Intro	(3.45pm)	**Mick Crosse** – The CNSP-Initiative and CNSP2022: What, why, and how
Keynote	(4.00pm)	**Liberty Hamilton** – Understanding auditory processing of naturalistic stimuli using linear encoding models (40 + 20 Q/A)
Talk 1	(5.00pm)	**Giovanni Di Liberto** – Introducing the tutorials and CNSP resources. Environment setup.
Break	(5.20pm)	
		(please set up the CNSP resources before Session 2, if you haven't done so already)
Session 2	**(6.00pm)**	*Hands-on tutorials: Encoding and decoding models for neural signal analysis*
Track 1	(6.00pm)	**First-time users** – Encoding and decoding models, introduction to multivariate analysis (Mick Crosse, Giorgia Cantisani, Stephanie Haro)
Track 2	(6.00pm)	**Intermediate users** – Models validation, multivariate analysis, canonical correlation analysis (Aaron Nidiffer, Nate Zuk, Giovanni Di Liberto)
End time	(8.00pm)	

Day 2 (Tuesday 19th July)		
Session 3	**(4.00pm)**	*Novel directions on models for neural signal analysis in natural sensory scenarios:* *Chair:* ***Aaron Nidiffer and Stephanie Haro***
Keynote	(4.00pm)	**Narayan Sankaran** – The multidimensional representation of melody in human cortex (30+10)
Talk 1	(4.40pm)	**Michael Thornton** – Deep neural networks for assessing cortical responses to speech (20+5)
Talk 2	(5.05pm)	**Joshua Kulasingham** – Algorithms for estimating TRF components from M/EEG responses to continuous speech (20+5)
Break	(5.30pm)	
Session 4	**(6.00pm)**	*Hands-on tutorials: Encoding and decoding models for neural signal analysis* *Chair:* ***Nathaniel Zuk and Giorgia Cantisani***
Track 1	(6.00pm)	**Michael Thornton** – Deep neural networks for assessing cortical responses to speech
Track 2	(6.00pm)	**Joshua Kulasingham** – Introduction to Encoding/Decoding Analysis using Python and Eelbrain
End time	(8.00pm)	(2h max. The duration will depend on the Q/A)

Day 3 (Wednesday 20th July)	
Session 5 (4.00pm)	*Current challenges, Best practices, and Future directions* *Chair:* ***Giovanni Di Liberto***
Invited Talk (4.00pm)	**Giacomo Baruzzo** – Data standardisation and sharing - A lesson from bioinformatics (30+10)
Break (4.40pm)	
Discussion (4:45pm)	Part I: Standardisation and open science. Future directions for the CNSP initiative. Part II: Current challenges with TRF analyses (e.g., dealing with noisy data, small datasets)
Q/A (5:30pm)	*Q/A session (any topic e.g., theory, CNSP scripts, CND, datasets, project, questions on new experiments you might run)*
Closing (6:30pm)	

***4.00PM Irish standard time** / 8:00AM PST / 11:00AM EST / 4:00PM UK / 5:00PM CET / 6:00PM IST / 12:00AM JPS



Cognition and Natural Sensory Processing Workshop

The CNSP initiative aims to develop and collect resources, such as analysis scripts and publicly available neural data, for the study of cognition and natural sensory perception. In doing so, we propose a standardised pipeline for recording, analysing, storing, sharing, and comparing datasets involving natural sensory processing, such as speech/music perception and watching movies. The CNSP workshop 2022 will provide the fundamental insights on the standardised pipeline and analysis scripts via a set of tutorials delivered by organisers, as well as giving space to other tutorials from researchers in the field, providing a comparison of current methodological techniques, as well as proposing new approaches for the field. This second edition of the CNSP workshop will also feature two international keynote speakers, who have contributed significantly to the field. The workshop will also include a discussion of future directions, both on the methodological development and on the standardisation and data sharing aspects, defining future directions for the CNSP initiative. Please visit our website at https://cnspworkshop.net.

Background:

In recent years, research in that domain demonstrated the importance of studying perception in real-world scenarios involving naturalistic tasks. Recent advances in computational resources, neural signal processing and machine learning led to the development of research frameworks to quantify neurophysiological activity under such naturalistic conditions. The possibility of carrying out these realistic experiments is ground-breaking, as it leads to datasets that are particularly information rich and suited to being re-analysed from a variety of angles. Recent attempts to share that type of datasets led to a valuable yet heterogeneous set of publicly available resources, whose strengths are diminished by the lack of a clear domain-specific standardised pipeline and resource sharing approach. The CNSP initiative is collecting and standardising that set of resources, as well as developing and sharing numerous original standardised analysis scripts that serve as tutorials and blueprint for researchers that are transitioning into this rising field of research. This material is designed to be accessible to researchers from a variety of disciplines. Nevertheless, while this makes it easier to analyse the data, researchers must have the appropriate understanding of the core methodological aspects of this analysis pipeline, which is provided in the form of tutorials during the CNSP workshop. In addition, the CNSP workshop 2022 will host international two keynote speakers at the top of this field of research, two talks that have been selected based on an open call for submission, and an invited speaker who is an expert in open science from the neighbouring area of bioinformatics.

Keynote speakers

Understanding auditory processing of naturalistic stimuli using linear encoding models

Liberty Hamilton is an Assistant Professor at the University of Texas at Austin with a joint appointment in the Department of Speech, Language, and Hearing Science and the Department of Neurology. She also holds an adjunct appointment in the Department of Neurosurgery at Baylor College of Medicine in Houston, TX. Broadly, her lab studies how sounds are represented in the auditory cortex during natural speech perception and production, and how these representations change as a function of development, attention, and multimodal interactions with other sensory modalities. Her group uses a combination of intracranial recordings in children and adult patients with epilepsy, scalp EEG, and computational modeling to understand this process.

The multidimensional representation of melody in human cortex

Narayan Sankaran is a postdoctoral fellow in the lab of Edward Chang within the department of Neurosurgery at UCSF. Prior to his appointment at UCSF, he completed his PhD from the University of Sydney under the supervision of Simon Carlile. Broadly, his research seeks to understand the neural computations and specializations that underlie our perception of music. To do this he uses a combination of intracranial recordings in neurosurgical patients and MEG recordings in formally trained musicians.

Invited talk

Data standardisation and sharing - A lesson from bioinformatics

Giacomo Baruzzo is a postdoctoral research fellow at the Department of Information Engineering at University of Padova. His research is aimed at developing algorithms, methods and software for the preprocessing and analysis of biological data from high-throughput sequencing technologies, especially single cell RNA-Sequencing, bulk RNA-Sequencing, DNA-Sequencing and 16S rDNA-Sequencing.

Tutorials

Deep neural networks for assessing cortical responses to speech

The cortical response to continuous speech has been shown to track fluctuations in the envelope of the speech stream. Cortical speech tracking can be assessed by using backward linear models to relate EEG recordings to the speech stimulus envelope, in a fashion similar to that of the TRF approach to forward modelling [1]. We propose to use deep neural networks (DNNs) to assess cortical speech tracking. We compare a recently-proposed convolutional neural network (CNN) against the method of linear backward modelling for reconstructing the speech envelope from EEG recordings [2,3]. We consider several types of speech stimuli: clean speech; speech in babble noise; speech in a foreign language; and competing-speaker conditions. We also show how backward modelling via DNNs can be used to decode auditory attention. The proposed goals and structure of this workshop are:

1. To learn how subject-specific linear models and DNNs can relate EEG recordings to the envelope of clean speech. We will cover practicalities such as the selection of hyperparameters and optimisers.
2. To compare the performance of the CNN against that of the linear model at reconstructing the envelope of clean speech from EEG recordings. We will compare the mean reconstruction scores (Pearson correlation coefficients) as well as their variability.
3. To study how a CNN can be used to analyze EEG data recorded under various noisy listening conditions, and how it can be used to decode auditory attention to one of two competing talkers. We will discuss different metrics for quantifying the performance of the CNN, such as the effective bit rate employed by De Taillez et al..

[1] O'Sullivan JA et. al., “Attentional Selection in a Cocktail Party Environment Can Be Decoded from Single-Trial EEG”. Cereb Cortex. 2015.

[2] Lawhern VJ et. al., “EEGNet: A Compact Convolutional Network for EEG-based Brain-Computer Interfaces” J. Neural. Eng.. 2018.

[3] Thornton M., Mandic D., Reichenbach T., “Robust decoding of the speech envelope from EEG recordings through deep neural networks”. J. Neural. Eng.. 2018. UNDER REVIEW.

Michael Thornton received his MPhys in physics from the University of Oxford in 2020 before starting his PhD at Imperial College under the supervision of Tobias Reichenbach and Danilo Mandic. He researches how the neural processing of continuous stimuli such as speech is reflected in a listener's electroencephalogram. Mike is particularly interested in attention and low-density wearable montages such as ear-EEG. He is a keen runner in his spare time.

Algorithms for Estimating TRF Components from M/EEG Responses to Continuous Speech

TRFs to speech envelopes have distinct components that have provided several insights into the cortical processing of speech. Accurate estimation of these TRF components from noisy neuroimaging data is essential for subject-specific investigations into speech processing. These components may also provide insights into the underlying neural mechanisms. TRF studies often utilize measures of model fit (e.g., correlation), which may not be suitable for evaluating TRF component estimation. Here, ridge regression and boosting are investigated on a simulated dataset using several metrics of component estimation accuracy. Ridge and boosting perform comparably in most metrics. We also propose algorithms based on Subspace Pursuit (SP) and Expectation Maximization (EM) that utilize prior knowledge of component time windows to directly estimate component amplitudes, latencies and topographies. The SP and EM algorithms outperform ridge and boosting in simulations, but not on real data possibly due to invalid assumptions on component characteristics. This work highlights the importance of utilizing prior knowledge for more meaningful TRF estimation.

J. P. Kulasingham and J. Z. Simon, 'Algorithms for Estimating Time-Locked Neural Response Components in Cortical Processing of Continuous Speech'. bioRxiv, 2022. doi: 10.1101/2022.01.18.476815

Joshua Kulasingham is a Postdoc at the Department of Electrical Engineering, Linköping University, Sweden. He completed his PhD at the University of Maryland, College Park, USA, under the supervision of Prof. Jonathan Z. Simon. He is interested in neural processing of continuous speech and has worked with MEG responses to low-level and high-level speech features. He is currently working on encoding models to investigate the neural processing of speech using EEG.

The Organisers

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Ireland

Nathaniel Zuk, PhD

Postdoctoral Fellow
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Hebrew University
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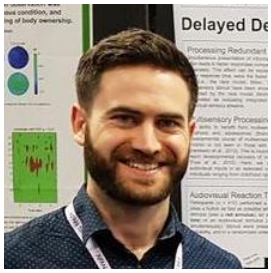

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Resources

Check out our resource page at https://cnspworkshop.net
We will do our best to continue updating and maintaining that web page in the future.

Resource preparation guidelines: You should all have been invited to the document already. If not, please contact us. Here is the link to the document.

Datasets and scripts: Click here to download the zip file containing the folder structure archive and click here to to download the CNSP dependencies. Unzip the archive. The datasets and scripts that you will download should be placed into this folder structure. We are also sharing the following datasets: LalorNatSpeech, LalorNatSpeechReverse, diliBach, musicImagery and many others. Please download at least the datasets *LalorNatSpeech* and *diliBach*, which will be used on Day 1. Please refer to the resource preparation guidelines for further information.

Tutorial scripts: These scripts will be available on our resource page at https://cnspworkshop.net

Zoom webinar: You will receive an invitation to the scheduled Zoom calls on Monday, Tuesday and Wednesday.

Video recordings will be available after the workshop on the CNSP website (only for the presentations where the speakers agreed to the recording).

Follow us at:

cnspworkshop@gmail.com
https://cnspworkshop.net
Twitter: @*CnspWorkshop*

https://community.cnspworkshop.net

and on the CNSP google group (the link is on our website). We will keep up to date about future developments as well as future editions of the CNSP-Workshop.

Acknowledgements

We thank mBrainTrain for sponsoring for their generous contribution to the CNSP workshop 2022, which will be used to support a student or postdoc to visit TCD (or another institution) and carry out a project in the CNSP domain. We also thank Trinity College Dublin for offering their resources for managing the registration for the workshop.

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We thank Jasmine Florentine for designing the CNSP logo! Check out her work on her website

We would like to thank Edmund Lalor, who has supervised four out of six organisers at some point in their careers and has greatly influenced the work that led to this workshop. We would like to thank Jonas Obleser, Nima Mesgarani, Jonathan Simon, Jens Hjortkjær, Lien Decruy, and Usha Goswami for their early feedback and support in CNSP2021, as well as all the speakers of CNSP2021, whose contribution is now part of the CNSP resources (see video section). We would also like to thank all the speakers of CNSP2022 for their key contributions to this workshop. We also thank Jeremy Yeaton and Sara Carta for their help with the testing of the tutorial scripts and guidelines. Finally, thank you all for your participation! We really hope that this initiative and workshop have been helpful and will continue to be helpful with future editions. We aim to maintain and update such resources in the foreseeable future with the help of the CNSP community. Please get in touch if you would like to contribute in any way to this initiative. Thank you!