The impact of pulse rate, electrode location and cross-channel interaction on pith perception and frequency discrimination in CI users

Yue Zhang [1], Behnam Molaee-Ardekani [1], Rafael Attili Chiea [1], Peter T. Johannesen [2], Enrique A. Lopez-Poveda [2], Manuel Segovia-Martinez [1]

[1]Oticon Medical, Vallauris, FRA; [2] University of Salamanca, Salamanca, ESP;

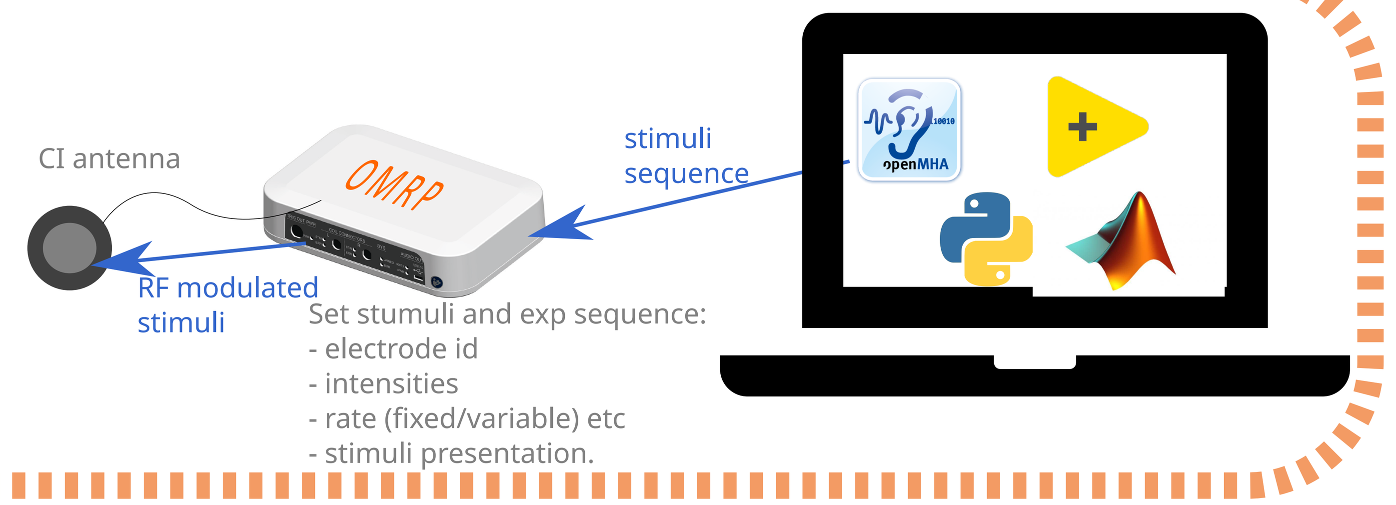
VNiVERSiDAD D SALAMANCA
CAMPUS DE EXCELENCIA INTERNACIONAL

Introduction

Currently, most commercial cochlear implants (CI) use the continuous interleaved sampling (CIS) strategies to transduce acoustic inputs into electric stimulation to convey sound to CI users. Although this envelope-based approach can transmit temporal pitch, this approach could not deliver well the fundamental frequency of speech and other low-frequency components to provide salient pitch sensation and sensitive frequency discrimination. Therefore, we propose series of clinical studies to investigate how to improve pitch perception and frequency discrimination by manipulating pulse rate (either single or a few adjacent electrodes) and its relationship with electrode location and cross-channel interaction.

Methods

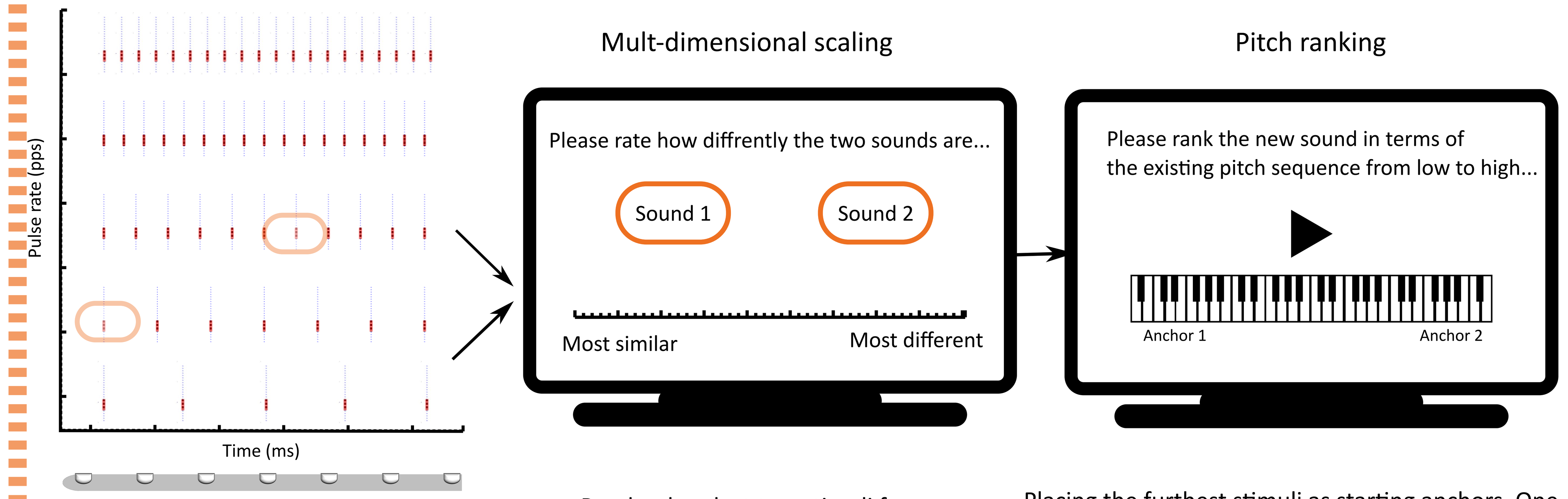
- Planning experiments with experienced post-lingually deaf OM CI users
- Stimuli will be delivered using a series of Oticon Medical Research Platforms to deliver direct stimulation with controlled experimental procedures (See poster 1637)
- Individual variability in channel interaction, auditory sensitivity and cognitive profile will be measured..



Experimental A

Aim: Capture the multi-dimensional perceptual impact from varying electrode place and pulse rate

Design:



Stimuli are 600ms pulse trains that vary diagonally in pulse rate (pps) and electrode location

Randomly select two stimuli from the pool and ask the participant to perform pair-wise comparison

Placing the furthest stimuli as starting anchors. One stimulus is presented each trial, and participants are instructed to rank the new sound in the existing sequence on any relative location.

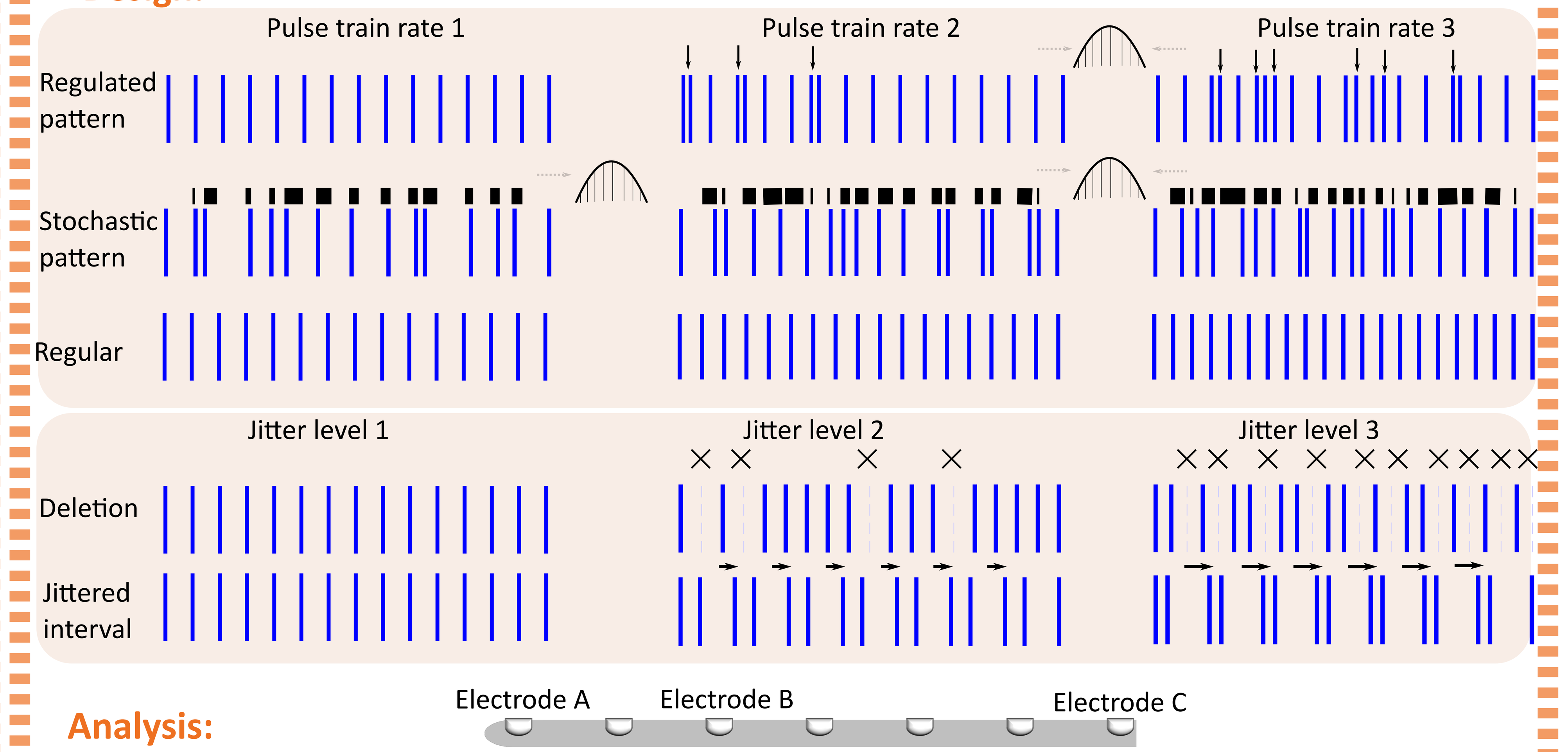
Analysis:

* Perform bootstrap MDS analysis to capture multi-dimensional distances across stimuli and pitch ranking. Examine the effect of electrode location and pulse rate;
* To link the dimensions with pitch sensation, for each participant, co-variance index are calcualted between variances in distance of each dimension and pitch ranks. Paired sampe t-tests on the index will test the alternative hypothesis that one dimension is more closely linked to pitch ranking than another dimension

Experimental B

Aim: Investigate the perceptual impact of different patterns of pulse distribution on single electrode

Design:



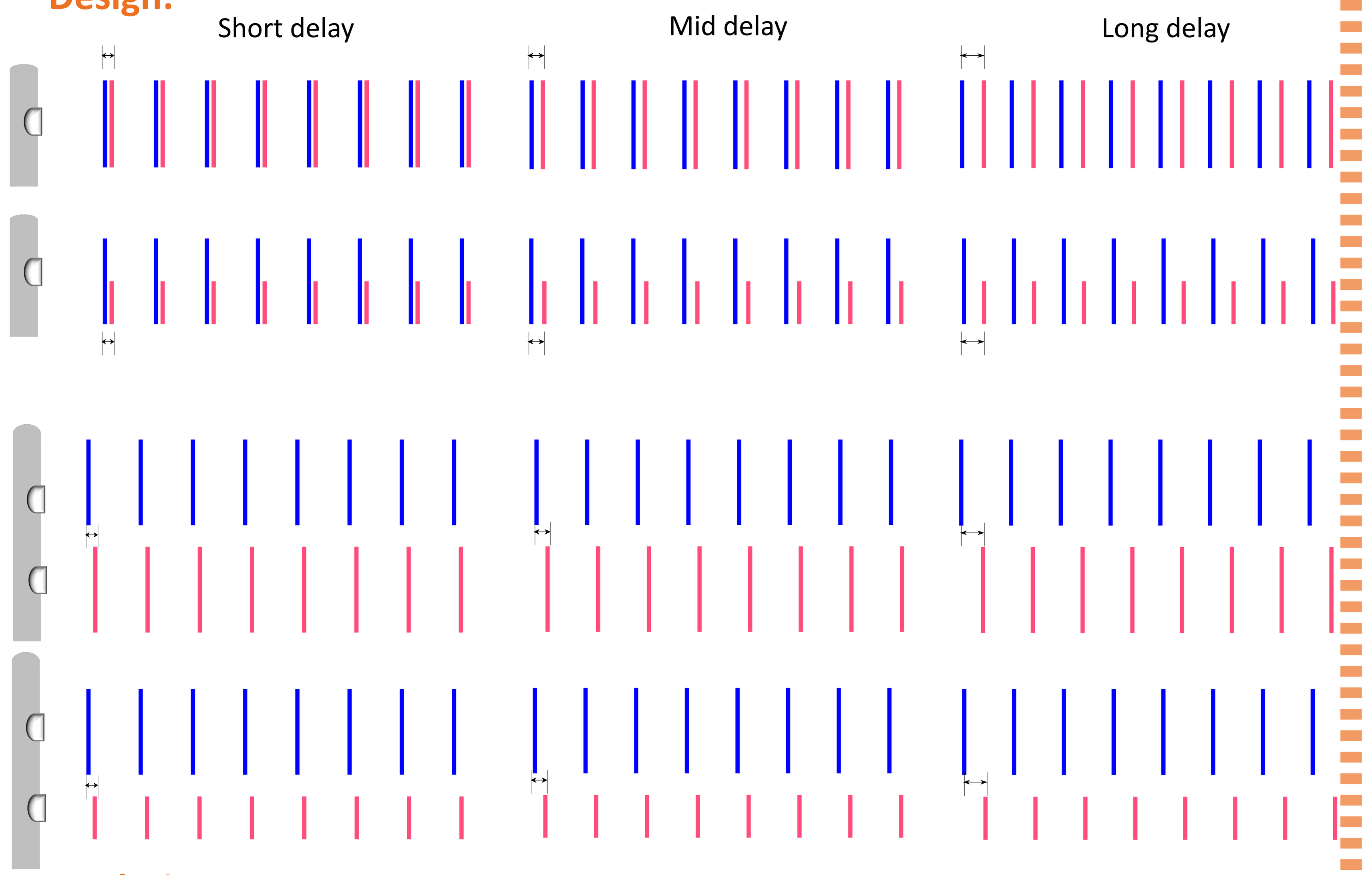
Analysis:

* Perform bootstrap MDS analysis to capture multi-dimensional distances across stimuli that vary in rate, electrode number and distribution pattern
* Examine whether different pulse patterns bring perceptual differences, and whether in the same dimension
* Investigate whether individual channel interaction affects sensitivity to different pulse patterns

Experimental C

Aim: Investigate the perceptual impact of cross-channel interference

Design:



Analysis:

* Perform bootstrap MDS analysis to capture multi-dimensional distances across stimuli that vary in electrode pair, delay and amplitude; and how individual electric-neural interface affects the sensitivity

Conclusion

Potentially, more information can be coded and transmitted to CI users. However we need to understand more the perceptual consequence of varying different stimulation parameters, and the impact of individual differences in electrode-neural interface, auditory and cognitive profile to explain the variability in the outcomes. Future synthesis of knowledge needs to incorporate both information in order to design effective next-gen speech processing strategies.

References

Guevara, N., Truy, E., Hoen, M., Hermann, R., Vandersteen, C., & Gallego, S. (2023). Electrical Field Interactions during Adjacent Electrode Stimulations: eABR Evaluation in Cochlear Implant Users. Journal of Clinical Medicine, 12(2), 605

Schatzer, R., Vermeire, K., Visser, D., Krenmayr, A., Kals, M., Voormolen, M., ... & Zierhofer, C. (2014). Electric-acoustic pitch comparisons in single-sided-deaf cochlear implant users: Frequency-place functions and rate pitch. Hearing Research, 309, 26-35.

Bissmeyer, S. R., & Goldsworthy, R. L. (2022). Combining Place and Rate of Stimulation Improves Frequency Discrimination in Cochlear Implant Users. Hearing Research, 424, 108583.

Griessner, A., Schatzer, R., Steixner, V., Rajan, G. P., Zierhofer, C., & Távora-Vieira, D. (2021). Temporal Pitch Perception in Cochlear-Implant Users: Channel Independence in Apical Cochlear Regions. Trends in Hearing, 25, 23312165211020645

Landsberger, D. M., Marozeau, J., Mertens, G., & Van de Heyning, P. (2018). The relationship between time and place coding with cochlear implants with long electrode arrays. The Journal of the Acoustical Society of America, 144(6), EL509-EL514.

Macherey, O., & Carlyon, R. P. (2010). Temporal pitch percepts elicited by dual-channel stimulation of a cochlear implant. The Journal of the Acoustical Society of America, 127(1), 339-349.

Macherey, O., Van Wieringen, A., Carlyon, R. P., Deeks, J. M., & Wouters, J. (2006). Asymmetric pulses in cochlear implants: effects of pulse shape, polarity, and rate. Journal of the Association for Research in Otolaryngology, 7, 253-266.

Because sound matters

Contact: YUZA@oticonmedical.com

oticon MEDICAL